Anatomical and Physiological Study of Bones: A Case Study of Buddhist Monastery of Badalpur, Taxila Valley

By

Hadiqa Imtiaz

TAXILA INSTITUTE OF ASIAN CIVILIZATIONS

QUAID-I-AZAM UNIVERSITY, ISLAMABAD

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Dedicated To:

My parents and teachers

Candidate's Declaration

I hereby declare that this M.Sc thesis currently submitted bearing the title, "**Anatomical and Physiological Study of Bones: A Case Study of Buddhist Monastery of Badalpur, Taxila Valley**", is a result of my individual research, and that has not been submitted concurrently to any other University for acquiring any other degree.

Hadiqa Imtiaz

M.Sc. Candidate

Supervisor's Declaration

I hereby recommended that the thesis proposed under my supervision by Hadiqa Imtiaz titled as: "**Anatomical and Physiological Study of Bones: A Case Study of Buddhist Monastery of Badalpur, Taxila Valley**", be accepted in partial fulfillment of the requirement for the degree of Master of Science in Archaeology from Taxila Institute of Asian Civilizations (TIAC), Quaid-i-Azam University, Islamabad.

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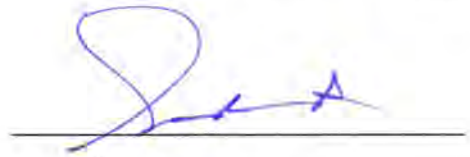

Dr. Sadeed Arif

(Assistant Professor)

Taxila Institute of Asian Civilizations,

Quaid-i-Azam University, Islamabad

Abstract

Taxila Valley is famous for housing a large number of archaeological sites. These sites tell about human activities in relation to their environment in past times. And the antiquities of their use are now accommodated in different museums. As the present research deals with the Anatomical and Physiological Study of Bones of Buddhist Monastery of Badalpur, that's why it unveils various myths behind their presence in a Buddhist Monastery. This will also reveals that to which animals these bones belong and why these faunal remains are found in monastery area. The field of zooarchaeology is suffering from obstacles in Pakistan. Inversely speaking, the issues related to this field are also elaborated in the present research.

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First of all, I would like to submit my humble praises and gratitude to Allah Almighty who has given a man the power of reasoning and thinking. Then I would like to praise the greatness and holiness of His messenger and prophet (PBUH) without whom the World would have been in the darkness of ignorance.

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Introduction

Pakistan carries two gigantic civilizations in its lap, the Indus and the Gandhara. Indus Valley Civilization is important for burnt brick architecture, well planned cities and trade networks but dignity of Gandhara Civilization cannot be neglected in this regard. It is strongly tethered with geography, history, art and architecture, religion, culture and politics. Hundreds of Buddhist structures were erected in Peshawar Valley, Kohat, Dir, Bajaur, Malakand, Swat, Taxila Valley and in Eastern Afghanistan (Khan and Lone, 2004:7), (Zwalf.W 1996:14-17).

Taxila is one of the significant cities from archaeological point of view. It is declared as a World Heritage site by UNESCO (Kakar, 2008:38). It carries important Gandharan architectural and artistic fragments (Dar 1983: 133). Various Buddhist dynasties had governed this place. Being a central point of Buddhism, several cult objects were collected from different archaeological sites of Taxila Valley. Taxila was scrutinized by Alexander Cunningham in 1863 and after him Sir John Marshall carried out regular and extensive excavations in Taxila Valley (Cunningham 1871: 63-65). He excavated three oldest cities Bhir Mound, Sirkap and Sirsukh besides various Buddhist stupas and monasteries. After those well-known archaeologist, a series of excavations lasted and Taxila was further dug out by Sir John Marshall, Sir Mortimer Wheeler, Gosh, J.Woson, Konow, Fleete (linguists and epigraphists) M.A.Hlim, Gulzar Muhammad Khan, Saifur Rehman Dar, Muhammad Sharif, Bahadur Khan, Muhammad Ashraf Khan Sadeed Arif (Khan et al 2012:15).

As Sir John Marshall laid the foundation of Taxila Museum (Khan and Lone 2012:15).Various antiquities which are found from different sites in Taxila Valley are placed in Taxila museum. These include pottery, terracotta figurines, stucco and schist sculptures, stupa models, paintings (Jinan Wali Dheri), metal objects (copper, iron, gold, silver), precious and semi-precious stones and jewelry as well as bones (not displayed) (Malik 2008:13).

Badalpur is an important Buddhist Monastery, situated about 10 km North East of Taxila Museum and 2.5 km North West of Julian Village (Khan et al 2007: 41). It yielded many antiquities including pottery, grinding stones, copper and gold coins, iron nails, Buddha sculptures and bone objects (Khan et al 2007: 41). The animal bones which are found from the floor of the monastery are to be taken under research by the researcher. Although these bones are

in fragile condition but their anatomical and physiological study will reveal some hidden evidences regarding their presence in monastery. There are different methods which are devised for the identification of bones. DNA Testing/Genetic Testing and Comparative study of sample bones with standard bones are majorly applied methods. For DNA Testing usually samples are collected from teeth because DNA is more preserved in teeth bones. If bones are once identified then a researcher can estimate the phylogeny, dating, species of animals, dietary patterns and other related facts. It is helpful in reconstruction of history.

Statement of Problem

The current research focuses on physiology and anatomy of bones. This area is covered by zooarchaeologists but the issues of identification with respect to their anatomy are rarely covered and very little is known about the implementation of scientific methods in order to identify as well as to study physiology and anatomy of bones. As Badalpur is my case study, and as a pioneer, I am going to conduct my research to find anatomy and physiology of selected bones and in turn, will propose respective animals.

Significance of the study

The scope of this research is to analyze the historical dimensions of life by identifying bones through comparative study and then to propose their taxonomy. The research deals with the finding of different aspects of life like diet of the people, availability of environmental resources, subsistence practices, development and characteristics of past agricultural and food production systems.

Hypothesis

This research is conducted in order to analyze anatomical and physiological study of bones which are collected from Buddhist monastery of Badalpur. This area has not been covered yet. It is estimated that these bones would be of some domestic animals. Usually such animals were reared by monks living in that monastery for the sake of their own necessities.

Research Questions

The research objectives are as follows:

1. To find the chronology of the site from where bones are collected.
2. To find the species, to which identified animal bones belong.
3. To find the subsistence practices carried out in the Buddhist Monastery of Badalpur.
4. To find the dietary patterns of animals as well as of Buddhist Monks.
5. To find the analytical dimensions of bone modifications.

Literature Review

"A guide to Taxila": (1960) written by John Marshall. In this book he has explained topography, political history and brief description of all the archaeological sites of Taxila Valley.

"A short guide to Taxila": (2000), written by Ahmad Hassan Dani. He discussed prehistoric Taxila to the history of Muslims period and brief introduction of Taxila museum.

"*Gandhara art in Pakistan*": (1992) by A.H.Dani. He wrote about geography, invasion of westerns, rise and fall of Gandhara art with an eminent focus on sculptures.

"Crafts of Gandhara": (2014) by M. Ashraf Khan and Ifqat Shaheen. This book reveals ancient and modern history of Taxila, its culture, art and also tells about crafts of Taxila.

"Taxila home of stucco art": (2002) written by M.Ashraf Khan and A. G. Lone In this book writers have described historical background of Taxila, its archaeological perspectives, evolution of stucco art along with technique and materials used. He further demonstrates Iconography, chronology and diffusion of stucco art. At the end he gives brief introduction of Taxila museum.

"The cultural Geography of Gandhara": (2008) written by Michael Jansen. This article includes geographical and historical background as well as destruction of Gandhara civilization by Talban's.

"Towns and monasteries": (2008).This is an article written by Michael Jansen. In this article he gives a brief account of stupas and monasteries of Gandhara as well as importance of cities like Bhir Mound, Sirkap and Sirsukh.

"The Ancient Cities of Taxila": (1984).This is an article written by Katusmi Tanabe. In this article the writer gives detail of ancient and present day importance of Taxila. He gives ideas about three main cities: Sirkap, Sirsukh and Bhir Mound. He also describes work of previous scholars.

"Historic city of Taxila": (1999) by A.H.Dani. He tells about culture of Asia, archaeological sites of Taxila and mentioned illustrations at an end.

"Excavations at Badalpur Monastery, District Haripur, Khyber Pukhtunkhwa, Pakistan: A *Preliminary Report of Season 2013"* (2013) by M. Ashraf Khan et al. This report deals with an introduction to Buddhist Monastery of Badalpur, its location, present status, plan, previous investigations, aims and objectives of present excavations along with pictures of Badalpur Monastery.

"*Fascinating Discoveries from Buddhist Sanctuary of Badalpur, District Haripur, Taxila"* (2006) by M. Arif and Habib-ullah-Khan Khattak. This article deals with present status of Buddhist Monastery, Previous Investigations, and current excavations along with pictures of the monastery.

"Identification, Classification and Zooarchaeology" (2011) by Jonathan C. Driver. In this article identification, classification and typologies have been mentioned. The writer further elaborates methods of identification and their effects on bone groups, identification systems, taxonomic diversity, identification in association and procedures for zooarchaeological identification.

"The Excavation of Faunal Skeletal Remains from Archaeological Sites" (2005) by T. Kausmally & A. G. Western. This article deals with the brief introduction to faunal remains, what can faunal remains tell us, disarticulated remains, articulated remains, identification of bones of mammals, birds, fish, typhonomy/preservation, sampling strategies, excavation and recovery methods, sieving, bagging and processing and sorting the sieving.

"The Artistic Anatomy of Cattle and Sheep" (1868) by B. Waterhouse Hawkins. This book discusses the artistic anatomy of cattle and sheep with regard to labeled diagrammatic description of each part of their bodies.

"Identification Guide for Ivory and Ivory Substitutes" (1991) by Edgard O. Espinoza & Mary-Jacque Mann. This article is published in the form of a booklet which deals with Ivory introduction, Ivory identifications of Elephants, Mammoth, Walus, Sperm Whale, Killer Whale, Narwhal, Hippopotamus and Wart Hog. It further tells about natural ivory substitutes like bone, shell, helmeted hornbill and vegetable ivory. Procedures and equipment for manufacturing of ivory and ivory substitutes are also mentioned.

"The Nature of Teaching, Common Indiana Mammals" (2016) by Robert N. Chapman &Rod N. Williams. This article discusses biological details of different mammals which include Virginia Opposum, Northern Short-tailed Shrew, Eastern Mole, Little Brown Bat, Eastern Pipestrelle, Big Brown Bat, Red Bat, Eastern Cottontail, Eastern Chipmunk, Wood chunk, Thirteen-lined Ground Squirrel, Plains Pocket Gopher, American Beaver, Western Harvest Mouse, White-footed Mouse, Allegheny Wood rat, Meadow Vole, Muskrat, Southern Bob Limming, Meadow Jumping Mouse, Coyote, Red Fox, Gray Fox, Raccoon, River Otter, Least Weasel, American Mink, Striped Skund, Bobcat and White-tailed Deer.

"Osteological research in Classical Archaeology" (2007) by Michael Mackinnon. This article mentions historical overview of human and non-human osteological studies in classical archaeology, examination of current status of research in human osteology and zooarchaeology in classical context and directions of future outlines that how zooarchaeologist and osteologistss will make ties with classics, anthropology and archaeology.

"A Comparative Study of analytic techniques for Skeletal part profile interpretation at El Miran Cave (Cantabria, Spain)" (2009) by Ana Belen Marin Arroyo. This article deals with introduction of faunal remains, materials and methods, the bone assemblages, quantification, analytical techniques, results and criticism upon analytical techniques.

"Archaeology of the Body" (2005) by Rosemary A. Joyce. This article deals with body ornaments to ornamented bodies, inscribing the body's surface, performing the

archaeological bodies, Archaeology of embodied personhood, theorizing the body in Archaeology.

"Archaeology, Anthropology and Interstellar Communication" (2014) by Douglas A. Vakoch. This book discusses the reaches done by physicists, computer scientists, engineers and astronomers those who are busy to detect extraterrestrial civilizations.

"Osteonecrosis of femoral head of Laboratory Animals: The Lessons Learned from a Comparative Study of Osteonecrosis in Man and Experimental Animals" (2003) by J. H. Boss & I. Misselevich. This article deals with introduction, spontaneous osteonecrosis in laboratory animals, surgically induced osteonecrosis, animal models of Leg-Calve-Parthes Disease, corticosteroid-indued osteonecrosis, traumatic osteonecrosis, lipopolysaccarides, immune-reaction induced osteonecrosis, physical injury induced osteonecrosis, role of apoptosis in experimental osteonecrois and their results.

"Zooarchaeology and Historical Archaeology: Progress and Prospects" (2005) by David B. Landon. This article discusses current status of Zooarchaeology in Historical archaeology, analytical issues in recovery of bone samples, its identification, quantification and interpretation. And writer further elaborates about past diet, food production systems, archaeological interpretations and social and cultural variations.

"Zooarchaeology (Second Edition)" (2009) by Elizbeth J. Reitz & Eizabeth S. Wing. This book deals with identification of animal remains and specially emphasizing on those faunal remains which give information regarding the relationship of animals with humans and with their natural environment. It also discusses the recent developments in zooarchaeology like, incremental analysis, enamel ultrastructure, stable isotope and trace elements, environmental reconstruction and issues regarding care of faunal materials.

"Zoology" (1879) by Alex. Macalister, M.D. This book mentions Nature of life, systems, symmetries of animals and distribution of animals in Natural Environments. The writer further elaborated Classification System and Nomenclature of animals along with discussion of each Sub-kingdom.

"The Zooarchaology of Charlotte Harbor's Prehistoric Maritime Adaptation: Spatial and Temporal Perspectives" (1992) by Karen Jo. Walker. This book discusses introduction to Maritime, spatial and temporal perspectives on resource heterogeneity, integration of spatial and temporal perspectives along with appendices which include zooarchaeological data tables and aquatic vertebrates and invertebrates of archaeological sites and of modern habitats.

"Historic Zooarchaeology, Some Methodological Considerations" (1985) by Pam J. Crabtree. This article discusses merits and demerits of common zooarchaeological techniques, calculation of number of species and relative dietary contributions of various species.

"Zooarchaeology: Past, Present and Future" (1996) by Kenneth D. Thomas. This article clarifies introduction to zooarchaeology and its past, present and future aspects, faunal analysis and its study along its new approaches and theory.

"Introduction to Zooarchaeological Methods and Theory: A Special Issue honoring R. Lee Lyman" (2013) by Christyann M. Darwent et al. This article deals with introduction, research productivity and its focus, research typhonomy, quantitative methods, Biogeography and paleoecology, butchery studies, predator-prey interaction, conservation biology and applied zooarchaeology and professional service and teaching.

"Olsen and Olsens Identity Crisis in Faunal Studies" (1982) by Peter T. Bobrowsky. This article discusses potential of relationship between humans in fauna from archaeological perspective.

"A Comment on Nomenclature in Faunal Studies" (1981) by Sandra L. Olsen and John W. Olsen. This article deals with nomenclature of faunal remains collected from archaeological sites including critiques on zooarchaeology, archaeolozoology, ethnozoology and osteoarchaeology.

"Zooarchaeology: Methods, Theory and Goals" (1992) by Douglas J. Brewer. This article discusses faunal analysis, taxonomic lists, subsistence studies, paleoenvironmental

reconstruction, and explanation on zooarchaeology, the nature of the record along with quantitative methods.

"Regional Zooarchaeology and Global Change: Problems and Potentials" (1996) by Thomas Amorosi et al. It deals with introduction, problems and discussions, all archaeofaunas are not equal, recovery concerns, integrating older collections, different questions, samples and applications, samples issues, quantification forever, proxy data and indirect evidence, difference between investigators, archaeology in zooarchaeology, seals, cod fish and global change and practical protocols.

"Applied Zooarchaeology: The Relevance of Faunal Analysis to Wildlife Management" (1996) by R. Lee Lyman. It deals with introduction, populations threatened with extirpation, re-establishment of extirpated populations, identifying exotic animals, biological preserves and planning for the future, discussions and conclusion.

"Bone Surface Modifications in Zooarchaeology" (1995) by John W. Fisher Jr. This articles tells about an introduction, significance of bone surface modifications, bone surface modifications in zooarchaeology, bone modifications by humans, scrape marks, chopmarks, percussion pits and percussion striations, incipient fracture cracks, crushing, punctures, tooth marks, gouge marks, polish, weathering, abrasion and polish, trampling, digestion, root etching, rock fall, ice movement, vascular grooves, excavation of preparation damage, discussion and conclusion

"Data Quality in Zooarchaeological Faunal Identification" (2013) by Steve Wolverton. It deals with introduction, validity and faunal identification, quality assurance, quality control, quality assessment and conclusion.

"Quantitative Units and Terminologies in Zooarchaeology" (1994) by R. Lee Lyman. It deals with introduction of methods and materials, basics, quantitative units use and meaning, problems, elements and specimens, MNI and MAU per skeletal portion, hidden synonymy, concordance and clarity.

"Applications of Allometry to Zooarchaeology" (1987) by Elizabeth J. Reitz et al. It deals with introduction, allometric relationships, sample size, sample range and validity, inherent variability, phylogenetic variability and conlusion.

"Zooarchaeology and Complex Societies: Some Uses of Faunal Analysis for the Study of Trade, Social Status and Ethnicity" (1990) by Pam J. Crabtree. It discusses introduction, zoology and trade, exchange of animals between producers and consumers, long-distance trade in animal products, faunal remains and social status, faunal analysis and ethnic descriptions, methodological considerations, future directions, historical sources, pictorial representations, simulation studies and conclusion.

"Zooarchaeology at Pirincay, a Formative Period Site in Highland Equador" (1990) by George R. Miller and Anne L. Gill. It deals with introduction, archaeological background, methodology, early cultures, identity of *Pirincay Camelids, guanacos, alpaca, waris, llamas* and conclusion.

"Zooarchaeology: The Study of Animal Bones and How it is Done" (2016) by Autumn Painter. This article reveals show to identify faunal remains.

Research methodology

Current research will be of analytical as well as of descriptive nature. For collection of data Natural history museum, physiologists as well as veterinary specialists will be consulted. This research is of preliminary nature. As a primary source for a gathering of data, Buddhist monastery will be visited and bones will be observed and compared with standard (identified) bones in order to identify the sample bones of Badalpur site. Secondary sources for reviewing of data will be relied like consulting different books on physiological and anatomical study of bones for proposing authentic history. My research will enhance and extend the archaeological and cultural views on Badalpur site. This research will evidently prove actual dating of the site. By studying the stratigraphy, I chose to study different layers.

Organization of research

1. Introduction
2. Geography and History of Taxila
3. History, location and previous researches on Badalpur Monastery
4. Methods of Identification
5. Physiology and Anatomy of bones
6. Biological Classification of animals
7. Conservation/Preservation of bones
8. Zooarchaeological Issues
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Chapter # 1

Origin, Geography, Legendary History and Archaeological Discoveries in Taxila Valley

Origin

Taxila is a valley which is positioned at 31km from Islamabad in western direction, from Rawalpindi it is about 36.40 km. Taxila is situated on the periphery of Potohar plateau. Hassanabdal, Wah and Khanpur are in the neighborhood of Taxila. Taxila is holding rich archaeological sites in its lap. Population of Taxila comprises of 151000 people which is an approximate estimation of 1998 census (Arif et al 2005:27).

Anciently Taxila was known by a Sanskrit word named *"Takshashila"*. *"Tashasila"* or *"Takkasila"* both were the local names of Taxila. Rulers of Taxila were called *"Takshakas"* and their offspring belonged to *"Taka"* tribe. *"Taka"* name is derived from *"Taksha"* means *"serpent"*. And in this way, "Taxila" name is originated. Persian translation of "Taxila" is Margalla i.e. Mar (serpent), Qila (fort) because Taxila is located in western side of Margalla hills (Dani 2000:1). In *Ramayana*, it has been written that *Bharata* laid the foundation of Taxila by the name of his son *"Taksha"*. So the place got the same name. Later, at the time of Greeks it was called "Taxila" (Prasad 197:72). *Mahabharta* was firstly recited in Taxila. Its date can be traced back to 5th century BCE. In Buddhist literature Taxila is mentioned as a capital of Gandhara (Parker 2012: 295). Written record of Taxila is found from 6th century BCE, at that time Gandhara was a part of Achaemenian Empire of Persia (Marshall 1951:01).

Certainly the name of Taxila is older than Greeks accounts. There are several myths related to its terminology. Like, it is considered that *Bodhisattva* gave his head in charity to a man at this place. As Sung-Yun mentioned the same story and said that *Tathagata* gave sacrifice of his head in the presence of twenty priests. According to Hiuen Tsang, here *Tathagata* practiced disciplines of *Bodhisattva* and he was called Chen-ta-lo-po-la-po (Chandraprabha). He cut off his head for the sake of acquiring *Bodhi* (Dani 1986: 2).

Geography

Taxila is situated at the drive of 35 km from Islamabad. Taxila is sandwiched between two districts; Rawalpindi (Punjab) and Haripur (Khyber Pukhtunkhwa). Taxila Valley consists of productive plains, fruit orchards and lush green fields. This fertile land is irrigated with several streams, Lundi nala, Tamra nala, Kala nala and Haro river (Khan and Lone 2004: 13).

According to a Chinese pilgrim Hwen-Thsang, Taxila was 333 miles or 2000 *li* in circuit. It is bounded by Indus on the west, district Urasa on the north, and district Simhapura in the south and river Jehlum and Behat in the east (Dani 1986: 9).

Legendary History

History of Taxila can be traced back in *Ramayana,* an ancient Hindu literature. It threw light that Taxila was founded at the same time when Pushkalavati was laid by *Bharata*, son of *Kaikayi* and a brother of *Rama*. He appointed two of his son in *Takshashila* and *Pushkalavati*. According to *Mahabharata*, the city was triumphed by king *Janamejaya* who ruled *Hastinapura*. There is a great epic related to him that he performed here a great snake sacrifice. In Buddhist literature particularly in *Jatakas*, Taxila was considered as a place of learning and was home of great teachers. As Jains says that Taxila was firstly visited by *Rishaba,* who was the first of *Tirthamkaras* (Marshall 1960: 10).

In earlier times this area was ruled by Achaemenians then Alexander the Great came who conquered this area. After him Mauryan dynasty reigned here. *Ashoka* was the great king of this dynasty who was a grandson of *Chandragupta Maurya.* In his time Buddhism reached its peak. After this dynasty Bactrian Greeks, Sakas, Parthian, Kushans and White Huns came successively (Ibid 1960: 11-18).

Map.1, Location Map of Taxila and its surrounding, (www.globeholidays.net › Asia › Pakistan › Taxila)

Archaeological Discoveries in Taxila Valley

Taxila is surrounded by rich archaeological sites which comprises of prehistoric, Buddhist, Sikhs, Islamic and British monuments (Khan 2000: 503). A number of archaeologists unearthed these material remains in order to add to our knowledge (Khan and Shaheen 2015:111).Taxila covers an area of two provinces, Punjab and KPK.

Sir Alexander Cunningham as a pioneer, mentioned Taxila in 1863. But latter on regular excavations were carried out by Sir John Marshall (Khan and Lone 2004: 15).

Further excavations were carried out by Sir Mortimer Wheeler at Bhir Mound site in Taxila Valley. After the creation of Pakistan Department of Archaeology and Museums carried out excavations at several sites such as Bhir Mound, Hathial, Saraikhola, Khanpur Cave, Jinan Wali Dheri, Badalpur and Bhamala by M. Sharif, Bahadur Khan, Farid Khan, G.M. Khan, M.Ashraf Khan, Abdul Samad and Sadeed Arif respectively (Kakar 2008:42).

It is evident from archaeological records that Taxila is as old as 6th century BCE. But excavations at Saraikhola and Hathial revealed historical position of Taxila backed to (3200-1000 century BCE) (Khan and Shaheen 2015: 112).

Map 2, Map of Archaeological sites of Taxila Valley (Khan Ashraf and Lone 2002)

Saraikhola

Saraikhola is supposed to be one of the oldest sites of Taxila Valley. It is a site of 3200-1000 Century BCE. On the basis of cultural sequences it is divided into following categorizations:

1. Neolithic (3200-2800 BCE)
2. Early Bronze Age Culture (2800-1500 BCE)
3. Late Bronze Age and Early Iron Age Culture (1000 BCE)

(Khan et al 2004:16)

Hathial

(G.M Khan 1983)

This site is situated at a distance of 100 meters from Taxila Museum. It can be traced back up to 1200-1000 BCE. Following occupational level is reported at Hathial:

1. Gandhara grave culture (1200-1000BCE)

Bhir Mound

(Cunningham 1871, Marshall 1918-45, Gosh 1945, M. Sharif 1969, Dani 1999, Bahadur Khan 2002, Ashraf Khan 2004)

Bhir Mound is first urban site in Taxila Valley. It is positioned on the pivotal point of Tamra Nala and railway intersection, divulged by Sir Alexander Cunningham during his survey to Taxila Valley (Marshall 1960:4). Layout of the city is irregular in nature. When Sir John Marshall started excavation at Bhir Mound then he found four strata which belonged to different periods (6^{th} to 1^{st} Century BCE). He indicated the IV strata to be an oldest one. He mentioned that the first, second and third strata belong to 3^{rd} Century BCE, Mauryan time and period prior to Mauryans respectively (Jansen 2008:284).

Sirkap

(Cunningham 1871, Marshall 1918-45, Gosh 1948, Dani 1999, Behrendht 2003)

Sirkap is also called a Greek city. In the mid of second century Bactrian Greeks moved from Bhir Mound to Sirkap (Jansen 2008: 285). It is situated on northern side of Kacha Kot and western side of Hathial. Sirkap is built on chess design (Greek). It (Sirkap) is surrounded by a fortification wall which is made up of fragmented stones (Marshall 1960: 5). Sirkap is a diversified site because it consists of sun temple, Jain temple, double-headed eagle stupa (Saka-Parthian), Apsidal and palace area. It shows that people of different sects were living under the same roof. A large number of antiquities are collected from Sirkap which include pottery, coins, seals, agricultural tools, stone sculptures, metal objects, relic caskets, jewelry and bones.

Dharmarajika Monastery

(Cunningham 1871, Marshall 1918-45, Dani 1999)

Dharmarajika Monastery is located three kilometers from Taxila Museum. It consists of main stupa surrounded by monk cells and votive stupas. A Jain temple is also found in front of main stupa. It was built by King Asoka. He was a Buddhist devotee, because of his religious interests he was called "Dharmaraja" and monastery got the same name "Dharmarajika". Dharmarajika Monastery was excavated by Ghulam Qadir in 1912-16 and by Siddiqui in 1934-36 under the supervision of Sir John Marshall. They uncovered human skeletons, Buddha sculptures and cult objects (Khan and Shaheen 2015: 129).

Jinan Wali Dheri

(Ashraf Khan and Mahmood-ul-Hassan 2016)

Jinan Wali Dheri is situated 10km in north-west from Taxila Museum. It is 3rd to 5th Century CE (Khan and Lone 2004: 24). Regular excavations were started under the supervision of M. Ashraf Khan, Fedral Department of Archaeology and Museums in 2002-2005 with financial assistance of American embassy (Khan and Lone 2015: 169). During excavations total nine layers have been reported which yielded antiquities including pottery, grinding stones and pestles, bones and copper coins. Cells of the monastery are repaired by replacing kanjaur stone with terracotta tiles

on the edge of water tank. A significant discovery of the site is mural paintings which were found on the main entrance of monastery (living cells) (Fazal Dad Kakar and M. Bahadur Khan 2008; Ashraf Khan Mahmood-ul-Hasan 2010: 149-158).

Badalpur

(Cunningham 1871, Aiyar 1915-16, Khan et al 2013-14)

Badalpur is located 10km from Taxila Museum. It is located near a small village "Bhera". It is a site of 3rd Century BCE according to charcoal dating done by Professor Mark Kenoyer of Wisconsin University, America (Khan and Lone 2004: 25). This site consists of main stupa surrounded by monasteries (Khan and Shaheen 2015:182). Sir Alexander Cunningham was the first person to mention this site during his survey to India (1863). Later on, Natisa Aiyar denuded main stupa for the sake of antiquities. Excavations on regular intervals were started in 2005-2009 by Federal Department of Archaeology. Excavations were under taken by M. Ashraf Khan and Sadeed Arif. They stumble upon a lot of antiquities which include pottery, grinding stones, pestles, iron nails, gold and copper coins, Buddha Sculptures in red sand stone, Maitreya in stone and bones. Excavations were revived in 2011-2016 by M. Ashraf Khan (Ashraf Khan et al 2013; M. Arif and Habib-ullah-Khan Khattak 2006: 119-126; Khan and Shaheen 2015: 182)

Chapter # 2

Climate, Environment and fauna/flora of Taxila Valley

Besides having important trade routes, position of Taxila is bestowed with natural resources. It is also mentioned by various writers of different times. *Arrian* said that Taxila was the great and flourishing city at the time of Alexander the Great. According to Hydaspes, Taxila is greatest city between Indus and Jhelum. *Strabo* remarked, on dense population and extreme fertility of the land. *Plutarch* mentioned richness of soil of Taxila Valley and *Hsuan Tsang* wrote about land fertility, pleasant climate, abundant harvests, flowers and fruits along with flowing streams and fountains. It is adjoined on one end with Punjab and on other end with KPK (Marshall 1960: 3)

Average elevation of Taxila above sea level is 1700ft and 1800 ft. On east it is bounded with Murree (8000 ft), north by *Sarda* (3985 ft) and on south joined with Margalla spur. In between Sarda and Margalla spurs, there lies Hathial which transect valley into two unequal parts. Hathial consists of rocky patches precipitated with lime stone formation. Due to this unequal division, north became larger rather than south. Northern part is more fertile and there is remarkable production of crops irrigated by Haro river, streams and artificial canals. But southern part is less fertile and houses many ancient ruins consisting of stupas and monasteries (Ibid 1960: 3)

Climate is a long term changes in temperature while weather is a short term changes in temperature. Climatic conditions of Taxila Valley are very pleasant. Usually January and February are cold, March has occasional rainfall, April is hot but not unpleasant, May and June are hot and dusty. An increment in heat, felt after the cutting of spring crops. But due to close proximity of hills and humid environment, an effect of scorching heat will be lessened. June is followed by heavy monsoon rainfall of July and August also is moderate in hotness and from mid of August up to September weather cools down. October, November and December gradually move towards cold. There are two peculiar rainy seasons (summer rainfall and winter rainfall) of this region. One is called *"Barsat"* or *"Monsoon"* which starts in second week of July and lasts to the second week of September (summer rainfall). The other one starts in January and lasts till March (winter rainfall).

Taxila is a tehsil of Rawalpindi district. Inversely speaking, it might have same **fauna and flora** as the whole district is occupying. The fauna of the region includes buffaloes, bullocks, cows, donkeys, mules, horses, goats, sheep and camels which were domesticated for their household needs. While wild animals comprises of leopard, cheetah, tiger, bear, porcupine, pigs, hurial (wild sheep) and guri (wild goat).

Fauna

Chikors, hares and *sisi* are found on the low hill spurs of the region. There are jungle fowls and pheasants in an area beside Murree. Migratory birds consist of snips, duck, bustard, geese, *obara*, coulon, sandgrouse and quail. Ducks are found in lakes, ponds and rivers. Coulon and geese are also present in Soan Valley, Kanshi and on the Indus besides Taxila Valley. Groups of quail come in spring and autumn season. There might be plentiful game in the region if there wouldn't be a large number of shooting, snaring and netting of the native ones. Hawking and fishing are the favorite sports by elite class of the region. Snaring of birds is a common practice.

Taxila Valley contains a large number of snakes. Because its climate is moist this gives a room to flourish snakes. Cobras and kraits are found in plains. Brown Viper snake is common on higher hills. Russel's viper has also viper like appearance but comes in autumn and occupies lower hills. Some non-venomous species of snakes can also be seen here. Scorpions are evenly scattered in plains as well as in hills. Other insects are common elsewhere. White ants are also native of the same region.

Flora

Grasses have great importance because there are various areas in district Rawalpindi where excess of fodder is not available and grasses use to compensate the need of fodder for cattle. *Dub* is an uncommon grass in this region. *Barun* is a long grass which ripe in *kharif* harvest but injurious to cattle when unripe. *Khabbul* is a short green grass and usually fund in plains and boundaries of fields. Its availability is profound round the year and all kind of animals including horse, sheep, cattle and goats eat this. *Sawak* is a longer grass and its production is good near water. It ripe at the time of *kharif* harvest and it is sown as a crop when rain ceased to fall and it is good to use when it is fully ripen because afterwards it dries up. *Paran is* a grass which is

found in moist places and is useful for cattle and horses. *Sarala* is an autumn grass, found on hilly tracts and can be only eaten when it is green.

Lundar is an inferior hilly grass. *Puluana* is a fine grass, reaches a height of 2 to 3 feet and ripen with autumn harvest. It is cut in October and November for winter, usually found in hilly areas and is not sown. *Babbar* is fodder grass which is not much good for grazing but is valuable for making ropes. It is also found in hilly areas. *Dab* is a grass of bright green color and is only eaten by cattle when nothing is available. *Akar* is a weedy grass which is poorly used for grazing purpose but majorly used for making mud roofs.

(Gazetteer of District Rawalpindi 1893-94)

Among trees *Dalbergia sissoo (Tali)* and *Dendro calmusstricla* (bamboos) use to be grown on lower hills and are seen on southern slopes of the Margalla spur. *Morus alba* (White Mulberry) is found in the orchards of Taxila Valley. *Broussonetia paprifera* (Paper Mulberry) has very strong fibers and are helpful for manufacturing of high quality paper (Nazir Khizar et al 2016: 1214). *Malia azedarach* (*Dhrek*) is the most common tree. It is profoundly found in Taxila and its surrounding areas. *Albizzia labek* (Sirris) is useful for animal fodder, to produce timber and in medicines. *Esculus indica* (Horse chestnut) is fairly common plant of the region which assists to cure skin ailments, for cattle fodder and to make dishes. *Acer cultratum* (Maple) is an ornamental tree. *Cassia fistula* (Amaltas) is an ornamental plant which is used in medicines.

Cretaegus oxyacantha (Hawthorn) is also call thorn apple and is used in medicine for curing heart and blood vessels diseases. *Euphorbia royleana* (Cactus) is helpful in medicines to cure viral infections. *Ficus religiosa* (Pepal) earns importance from religious perspective. It is profoundly found in Buddhist monasteries of Taxila Valley. Besides these it assists to cure various ailments including epilepsy, skin problems and fertility problems etc. *Grewia oppositifolia* (Dhaman) and *Grewia vestita* (Farri) are much prized fodder for animals. *Olea cuspidate* (Olive), *Populas alba* (Sufeda), *Pinus excelsa* (Blue Pine) are abundantly found in the Valley. *Zizyphus nummularia* (Bheri) and *Zizyphus oxyphylla* (Jand) are two different species, leaves of which are used for fodder.

(Gazetteer of District Rawalpindi 1893-94)

A large number of archaeological sites in Taxila Valley are found at the top of the hills, along the rivers and plain which means that people in past time had selected this place because this was the place which fulfilled their needs as it is blessed with an abundance of natural resources.

As Buddhist Monastery of Badalpur is my case study, then location of the site is an important factor. The landscape of Taxila is a significant factor in monastery construction. Usually the Buddhist sites are constructed on elevated areas, hill tops, river banks and rich fertile plains surrounded by orchards and agricultural fields. Because they use to engage themselves in worship and to attain the mental peace and concentration, they select the places away from the urban areas.

Chapter # 3

Methods of Identification, Anatomical and Physiological Study of bones: A Case Study of Buddhist Monastery of Badalpur, Taxila Valley

Badalpur

Badalpur is an important archaeological site which is located between 35 °46'56" N and 720 52' 09" E and it is about 524 meters above sea level. It is situated at a distance of 10 km North East of Taxila Museum and 2.5 km North West of Julian Village near Village Bhera, on the left bank of the Haro River in District Haripur. A non-cemented road from Julian Village leads towards west of Badalpur site. Haro river is the chief river of the Valley which takes its origin from natural springs of Murree Hills. Haro river along with its tributaries, streams and nalas are the main source of irrigation for the entire valley. Its water was the major source for watering the agricultural fields (Khan et al 2007: 41).

The site of Badalpur is roughly rectangular in shape covering an area of 2.9 acres. It is protected under the antiquity act of Pakistan, 1975 [1] and owned by the Government of Pakistan since 1930s (Ibid).

[1] After the devolution of the Federal Department of Archaeology and Museums, Directorate of Archaeology KP has passed the antiquity act of KP (2017).

Map. 3, Location map of Badalpur, Taxila Valley, (monastic-asia.wikidot.com/Badalpur)

Previous Archaeological Researches

Firstly, Sir Alexander Cunningham mentioned an archaeological site of Badalpur during his archaeological survey in ancient Gandhara region in 1863-64. As he observed the stupa; he came across a human skeleton which was considered to be a skeleton of a (apostle) monk (Cunningham 1916-17: 2). For the first time Stupa complex was excavated by Natisa Aiyar, the then Superintendent of Frontier Circle and Archaeological Survey of India in 1916-17 (Marshall 1960). Natisa Aiyar was the colleague of Sir John Marshall. In the absence of Sir John Marshall, Natisa Aiyar took an advantage and excavated the main stupa and other few cells in the monastery area. The stupa complex was illegally dug before the visit of Alexander Cunningham (Arif el al 2006: 119).

The Federal Department of Archaeology and Museums (DOAM) undertook excavations in 2005 and lasted for four seasons till 2009. Excavations were headed by Muhammad Arif, Shakir Ali, Mohen Lal, Director Exploration Branch Karachi and Muhammad Ashraf Khan (Khan et al 2007: 41). The main purpose of excavations was to expose monastery area where 64 trenches (5x5) were marked. The Director General of Archaeology and Museums, Government of

Pakistan, authorized to preserve the site for the sake of Exploration and Excavations (Arif et al 2006: 120). During first season of excavations in Badalpur Monastery eight cells on western and southern sides of a ruined monastery were denuded (Khan et al 2007: 41). Each room was measured 3.07x3, 1.6m with decreased width at entrance. The walls were coated with mud plasters both on the interior and exterior sides. The maximum height of walls was approximately 2m to 2.3m. Mostly religious and settlement sites were excavated by Sir John Marshall in the Taxila Valley during 1913-14. As majorly the monasteries were unearthed by John Marshall, that's why he indicated that no mud plaster has still in existence in the monasteries of Taxila Valley (Marshall 1960: 117). In this scenario, the mud plaster present in the Buddhist Monastery of Badalpur is a distinguishing feature. So it is an important step to be taken for the sake of its preservation. The artifacts recovered include pottery consisting of storage jars, pots, bowls, terracotta oil lamps and a heart shape schist stone lamp (ibid 29), cult objects, hoard of 128 sealings, hoard of 188 copper coins, copper plates, copper strainers, a ritual copper pot, copper pendants, a copper bell, a unique and rare gold coin, five complete chatras of votive stupas, big iron pan, iron objects and a surgical instrument (Arif et al 2005:28).

Mr. Mohan Lal, the then Director of the Exploration and Excavation Branch and Mr. Shakir Ali, Deputy Director during the period 2006-07 carried out further excavations in the same monastery. During excavations, the remnants of southern, northern and western side of the monastery were uncovered. A large number of pottery, metal objects and coins were unearthed (Khan et al 2009: 41).

In 2008 the excavations on the site were conducted by Muhammad Ashraf Khan, the then Director Exploration and Excavation Branch. Federal Department of Archaeology excavated the Mathura red sand stone sculpture of Buddha in *Dhyanimudra*, Maitreya, stupa model, terracotta oil lamps, grinding stones and a large number of bones.

Excavations were resumed again in 2011-2017 by Taxila Institute of Asian Civilizations, Quaid-i-Azam University Islamabad under the supervision of Muhammad Ashraf Khan and Sadeed Arif. This excavation also yielded a great number of archaeological materials including pottery, grinding stones, sculptures, iron objects and coins.

Structural Remains

Structural remains of the site comprise of a main stupa, two votive stupas and an enclosure around the stupa consisting of chapels of different sizes. Chapels accommodated individual Buddha sculptures. A large monastery contains 40 cells, two gateways, assembly hall, kitchen and a water bath in the center. The area on the periphery of the kitchen is cultivated (Ibid 2009: 42).

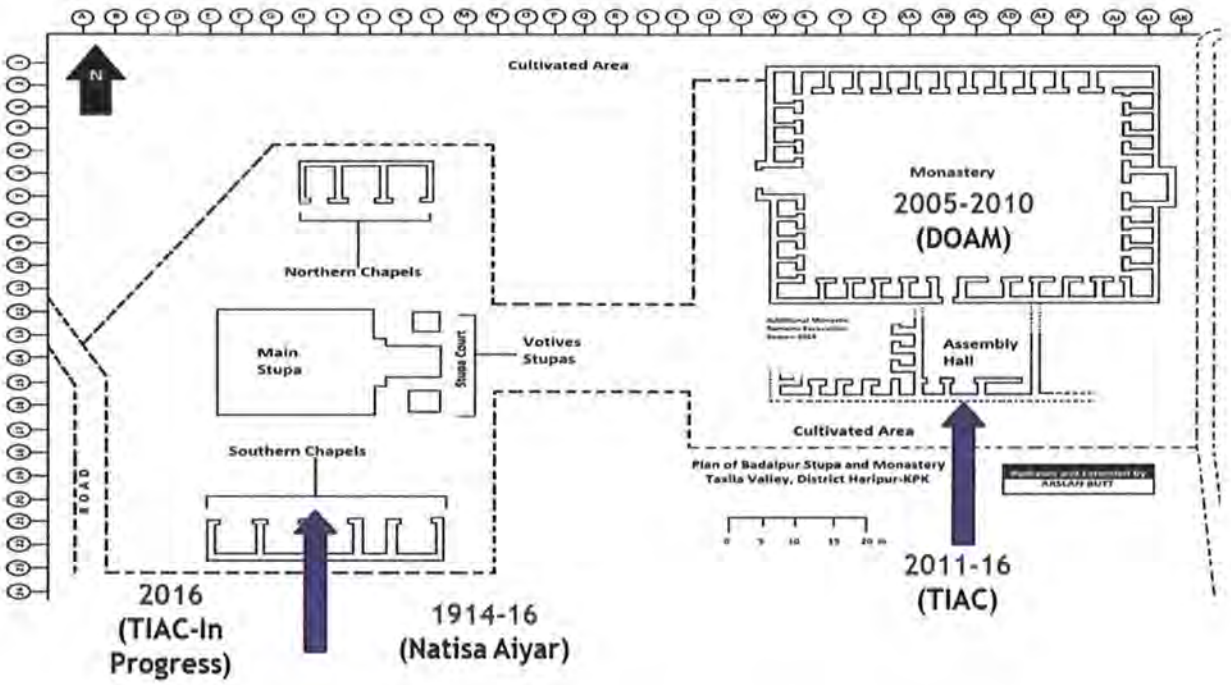

Fig.1, Plan of Buddhist Monastery of Badalpur, Taxila Valley (Arslan 2014)

Historic Background of Monasteries

Buddhism was patronized by Mauryan and Kushan dynasties. Monasteries found at the time of Mauryans have no kitchen area like in Dharmarajika monastery. So, it can be concluded that the Buddhist monks totally relied on begging. But the monasteries constructed at the time of Kushans have kitchens. This dynasty allotted agricultural land to Buddhist monks to carry out agriculture and also awarded other grants. Monasteries were constructed under the same pattern by the government. So, in historic scenario, it might be said that the bones found from the

Buddhist Monastery of Badalpur are of domestic animals which were reared or domesticated. But begging was done by Buddhist monks as it is the basic religious aspect in order to be humble or to abolish an ego. On the other hand, Buddhist monks also utilized meat in their diet along with vegetables. According to sectorial views, Buddha himself allowed to eat chicken, fish and pork meat. And as the cultural materials collected from Badalpur monastery, a large pan of 1× 1 meter was also recovered as shown in Fig.2. That might be used for cooking purposes (Mukherjee 1982).

Same sort of domestication also occurred along the Indus river and its tributaries. Zabu cattle, water buffalo, sheep, goat, donkey, horse, camel and chicken were domesticated and crops were grown. The earliest evidence of it came from aceramic Neolithic levels at Mehrgarh (Meadow H. Richard 1987: 51).

Fig. 2, A metallic pan from Buddhist Monastery of Badalpur, (Photo courtesy Ashraf Khan)

(A) Methods of Identification

Previous Zooarchaeological literature emphasized the use of faunal remains for the sake of archaeological interpretations. These are valuable tools for probing the life styles, patterns of animals exploitation, subsistence practices and dietary patterns of animals which is indirectly related to the availability of natural resources. But the misconceptions in zooarchaeology sometimes restrict the usefulness of faunal analysis in archaeological perspective (Crabtree 1985: 76). Zooarchaeology is actually a practicing field in theoretical paradigm (Brewer 1992: 195).

In historical Zooarchaeology, Robison recognized three different periods in the development of Zooarchaeology; Formative period (1860-1951), Systematization period (1951-69) and Integration period (1969- present). During Systematization Period, Paul, W. Parmalee, Stanley j. Olsen and John E. Guilday emerged. And Deetz corporate to find the food ways with regard to life styles (Landon 2005: 2).

The possibility of faunal remains to be left in any archaeological site can be a cause of several reasons. Like because of disposal practices, environmental disasters, butchering process, by trampling or sometimes encounter to scavenging animals. These mentioned practices will impart their respective marks on bone surfaces (Painter 2016).

There are several zooarchaeologists who made their contributions in the field of zooarchaeology. Like Bogan and Robison (1978, 1987) gathered information regarding the history and development of zooarchaeology in Eastern North America, Jolley studied the state of zooarchaeology in early 1980s and Deagan (1996) added her assessment of zooarchaeological studies in environmental archaeology. To sum it up, the results of various zooarchaelogists, the status of zooarchaeology in historical archaeology, methods used in faunal analysis and their merits and their limitations can be acquainted (Landon 2005: 2). To begin with it, broadly speaking there are two methods which can be applied in the field of zooarchaeology to identify faunal remains; DNA Analysis/Genetic Testing and Comparative Study of sample bones with standard skeletal parts.

DNA Analysis

The field of Ancient DNA was established in 1984. When for the first time DNA sequences of quagga (a relative of zebra) were recovered. With the introduction of PCR (Polymerase Chain Reaction) this field got shaped. Then advancements came in the field of DNA Analysis and the way of revolutionizing zooarchaeology was achieved (Fulton 2012: 1).

For the sake of identifying samples and then proposing environmental history from the derived data, DNA analysis or genetic analysis is an appropriate method to apply. In this method there are various techniques which are used to separate ancient DNA. Although it is difficult to dissociate an ancient DNA from trampled bone fragments. Intact DNA can be obtained from tooth sample because an ancient DNA is more preserved in teeth.

First step in DNA analysis is its extraction from the sample. And extraction can be done through various ways. And most probably genetic analysis can be implemented to hair, paleofeces, keratin, chitin and bones (most likely from teeth) etc. The next and the most imminent step is its sequencing in which the base sequences are compared with previously reported sequences of animals. From this, we can say that to which specie it belongs, which sample is under taken for research, dietary patterns, diseases and other practices or other things related to that organism. For example from Jeju Island (Korea) several ancient bone samples were found. Their mitochondrial DNA control region was partially sequenced and then compared with the previously reported data. The results confirmed that these samples were related to family Cervidae (Kang et al 2007: 1).

Comparative Study of Sample Bones with Standard Bones

The first step in comparative study is to sort a sample (bone) by its class whether it belongs to mammals, birds, reptiles, amphibians or fishes. This difference in classes can be easily observed by zooarchaeologists. The next step to take is sorting the skeletal elements of the samples. And the last step is to identify its specie. Then a complete classification of the animals can be proposed (Painter 2016).

In order to distinguish between two species a morphometric technique can be used. It is critical to differentiate between two closely related species as in the case of sheep and goat. Driver said

that one must take measures before differentiating samples of closely related taxa. Few researchers devised criteria to make a difference between rats, pigeons and domestic dogs from other canids. Besides symmetry of an animal, weight, fusion state of epiphysis, weathering, burning, bone surface modifications, tooth eruption and wear and other means of age and sex determinations and bone measurements can also be under taken.

Merits and De-Merits

The semi side of these used procedures is; DNA analysis is not yet possibly in providing precise information about the past populations. And a substantial amount of bone sample is required in order to derive the results. And sometimes other techniques like elemental analysis through isotopes is used which are also responsible for incorrect information. As Rose Drew, an osteoarchaeologist mentioned that if nitrogen content is found to be more in a sample then generally it might be considered that it will be a result of protein rich diet. But on the other hand it is to be noted that may be that organism starved to death because of insufficient food supply and its body used muscular protein (Hagelberg 1989: 8). Comparative Study of bones with standard bones is also problematic from an aspect that we can mistakenly identify a bone and propose incorrect details.

(B) Anatomical and Physiological Study of Bones

Bone is a rigid organ and constitutes the vertebrates skeleton. It is made up of hard connective tissues. And it functions in mobility, protect soft and delicate organs, store minerals, produce red and white blood cells. It gives a structural support to an organism which in turn provides an erected posture. Number of bones is different in different organisms. Bones also have varying shapes according to the need of the body parts.

Bones sometimes encounter modifications which are evoked by humans and by non-humans sources as well. These bone modifications will assist the researcher or zooarchaeologists to make approximations about the subsistence practices or past life styles, site formation processes, economic and social patterns and ritual behaviors. The study of bone modifications is of fundamental importance. The elicited human modifications on bone surfaces include cut marks by stone tools, scraping marks, chop marks, conchoidal flake scars and bone flakes, incipient fracture cracks, percussion pits and striations, tooth marks, puncture, crushing, polish and gouge marks. The non-human modifications on bone surfaces caused by weathering, abrasion and polish, trampling, tooth marks, digestion, root etching, ice movement, rock fall, vascular grooves and excavations or preparation damage (Fisher 1995).

Several bone modifications produced by humans and non-humans are given below:

Human Modifications on bone surfaces

Cut marks by Stone Tools

The cut marks will be educed when the animals will be put to slaughter. This practice is done to remove the soft bodied tissues from compact bones. The carcass products are disposed of and various useful products are used for human needs. One can get meet two major needs; nutrition (meat, organs, brain, bone marrow) and clothing and ornamentals (hides, teeth, tendons, ligaments). These practices will produce cut marks on bones. Various researchers indicated the shapes of cut marks e. g Bunn, 1981, 1983b; Cook, 1986; Lyman, 1987; Shipman, 1983; Shipman and Potts, 1981; Shipman and Rose, 1983a; Walker and Long, 1977) (Fisher 1995).As cut marks described by scholars are elongated, linearly striated and narrow. These are "V" shaped in cross section but cross sectional shape varies with regard to their width. The fine

striations in the edges of the cut marks when examined under electron microscope will reveal that the shape of the cut marks will be same as the tool which is used to produce these marks. It can also provide an estimation that at which angle the tool is applied and by which force (Shipman and Rose 1983a). As an example attributes of cut marks are examined on the dorsal spine of thoracic vertebrae of bison. This vertebra belongs to Koepke site (Fisher 1989) in U.S.A. When its cross section is examined then it was found that there were multiple striations which meant that tool was applied with different forces at different angles (Fisher 1995). Sometimes there are several marks diverging from the same point usually it occur at the end of the cut marks or where originating marks will run parallel. This happens in extreme cases (Eickhoff and Herrmann 1985: 269).

Fig.3, Cut marks on bone surface, (Fisher 1995: 13)

Scrap Marks

Scrap marks comprises of closely spaced, parallel, elongated and linear striations. These marks are imposed when the tool is perpendicular to the bone surface. These marks are so harshly produced that the membrane of the bone called periosteum is badly removed in order to achieve the fruitful breakage (Newcomer 1974: 149; Shipman 1988: 266). But sometimes sedimentary abrasion also produce marks similar to scrap marks (Shipman 1988: 266).

Fig.4, Scrap marks on bone surface, (Fisher 1995: 18)

Chop Marks

Chop marks are linear, shorter in shape and are broader depressions of V-shaped in cross section, which are produced when the carcass dried up and become resistant to cutting tools, frozen or when the articulated bones are separated (Binford 1984: 110-150).

Fig.5, Chop marks on bone surface, (Fisher 1995: 20)

Conchoidal Flake Scars and Bone Flakes

Chonchoidal flake scars or their corresponding bone flakes are produced when the bone is susceptible to a strong force like to hammer. These flakes are produced for acquiring bone marrow or to obtain a piece of raw bone to make another tool. A fine green bone is more resilient to break (Haynes 1991: 145-46).

Fig.6, Conchoidal Flake Scars and Bone Flakes, (Fisher 1995: 22)

Percussion Pits and Percussion Striations

These are the small holes which are visible on the surface of the bones and sometimes if minorly observed then there are short striations in the grooves or around them. These are produced by a slippage of bone on stone anvil or by hammer on bone (Blumenschine and Selvaggio 1988; White 1992).

Fig.7, Percussion Pits and Percussion Striations, (Fisher 1995:26)

Incipient Fracture Cracks

Incipient fracture cracks or lines are substantial lines which extend across the bone surface. These are produced by any process of fragmentation (White 1992: 137-38).

Crushing

It consists of inwards crushing of compact bone into soft interior of the bone. This is usually done when the bone is subjected to any carnivorous activity. It can also be happened by a rock fall (White 1992:138).

Punctures

Punctures are partly or completely penetrating marks which are observed in the bones of humans and non-humans from the pre-historic site of Peru. These are produced when the bones are stroked with sharp or pointed tools (Verano 1986).

Tooth Marks

Tooth marks are produced when humans and carnivores chew the bones. On experimental basis it is observed that in Namibia, Hottentots use to eat the fifteen tail vertebrae, limb bones such as femur and metapodials of goats (Binford 1981:36-148).

Gouge Marks

Elongated gauge marks expose the cancellous bone. These marks are usually applied when the bones are disarticulated by wedge or by other material (Shipman and Rose 1983).

Polish

Polish is the smoothing of bone surface or rounding its edges. It can be done intentionally or unintentionally. In latter category if the bone is boiled in a ceramic vessel then it will encounter an abrasion from the walls of the vessel (White 1992).

Fig.8, A polished bone artifact, (Photograph taken by researcher)

In Fig.14, there is an artifact which is found from Buddhist Monastery of Badalpur and is made from spongy bone. Its surface has been polished and is made to use as a knitting tool. It might be used to create holes in hides or other stuff.

Bone Modifications by Non-Human Processes

Weathering

Weathering is caused by some physical and chemical processes. Their consequences include splitting, cracking, exfoliation and damaged. The extent of weathering depends that up to how long the bones were exposed. The rate of bone weathering varies with moisture, shade and temperature (Behrensmeyer 1978).

Fig.9, Weathering on bone surface, (Riga and Astini 2007)

Abrasion and Polish

Abrasion and polish results in the removal of bone surface details. It is described in different ways by different scholars as banishment of external laminar bone (Behrensmeyer 1982: 220) or an erosion of bone surface by some physical force (Bromage 1984: 173). The terms of abrasion and polish are interchangeable. Polish provides an outer smooth and glossy surface (Shipman and Rose 1988: 312-14).

Fig.10, Abrasion and polish on bone surface, (Gumrukcu 2017)

Trampling

Trampling causes polish, striations and conchoidal flakes. This is the act of forcibly treating the bone (Haynes 1988: 147).

Tooth Marks

Many herbivores, rodents and carnivores chew the bones and their teeth produce striations, pits, punctures, cracks, bone flakes and conchoidal flakes (Binford 1981: 157-63).

Fig.11, Tooth marks on bone surface, (Fisher 1995: 38)

Digestion

In this process the animals sometimes ingest bones and during digestion stomach and other organs involved in digestive system impart pits, perforations, dissolving, scalloping and smoothing marks on bone surfaces. Then excrete these undigested bones in excreta (Andrews 1990).

Root Etching

Sometimes when the bones are buried under the earth then acids produced by plants will evoke marks on bones in the form of shallow lines (Andrews and Cook 1985).

Fig.12, Root etching on bone surface, (Fisher 1995:44)

Rock Fall

When rocks accidently fall on bones then these will produce several marks similar to stone tool marks such as cracks and percussion marks on bone surfaces (Dixen 1984).

Ice Movement

When the river ice breaks, then its movement will yield marks on bones when encountered. These marks include striations, breakage, abrasion, polish and irregular flaking (Thorson and Guthrie 1984:178).

Vascular Grooves

These are the small grooves which are produced when the blood vessels come in contact with bone surfaces (Morlan 1984).

Excavation and Preparation Damage

These marked are caused by the tools used during excavations. When the antiquities are brought to laboratory for some sort of chemical treatments then marks can also be produced (White and Toth 1989).

Anatomy and Physiology

Anatomical study reveals how an organism's skeleton is aligned to support the flesh. There are two major categories of anatomy. One is related to the whole skeleton of an organism and the other one is related to the further cross section of each organ in order to analyze its details. If we talk about skeletons of all organisms then the basic parts of the skeletons are same like these include skull, ribs, sternum, vertebrae, fore limbs and hind limbs. But the arrangements of these constituents of skeleton are different in different organisms. An interior (anatomy) of each bone is also of similar compositions like a bone has diphysis and epiphysis. Former is the tubular shaft while the latter one is the swollen portion found at both ends of the bone and named as proximal epiphysis and distal epiphysis. The cavity occupied by diphysis is called medullary cavity and this is filled with yellow marrow while epiphysis is filled with spongy bone which produce red marrow. An exterior of the bone consists of compact or hard bone. Both diphysis and epiphysis meet with each other at a narrow portion called metaphysic which comprises of epiphyseal plate,

a cartilage in growing bone. As adolescence reached then this plate will become a line and replaced by osseous cells.

The bones are lined with membranes named endosteum and periosteum. Former lines the interior of the bone where repair, growth and remodeling occur and latter lines an exterior where nerves, blood vessels and lymphatic vessels use to nourish compact bone. As periosteum covers the whole bone, that's why ligaments and tendons also attached to periosteum. Only the point where joints are formed, periosteum is absent and articular cartilage is present which reduces friction and acts as a shock absorber.

There are three general classes of bone markings which house bone surfaces; articulations, projections and holes. Articulations form the joint where one bone end is rounded and the other one is cupped shaped to be fixed in that part. Projections project from the bone surface and are the points which facilitate an attachment of tendons and ligaments. And holes are responsible for entrance of blood vessels and nerves in bones. And relatively larger depressions accommodate projected portions of the bones like femur bone use to be fixed in pelvis through a groove.

Bone houses a small amount of cells embedded in collagen fibers. The salt crystals adhere to the surface of these collagen fibers. The salt crystals form when calcium carbonate and calcium phosphate combine to form hydroxyapatite which incorporates other minerals such as fluoride, magnesium hydroxide and sulphate. Then crystallization and calcification occur. In this way hydroxyapatite crystals give strength to bones and collagen fibers give them flexibility.

Bone Cells

Further, there are four types of cells in the bones; osteogenic cells, osteoblasts, osteocytes and osteoclasts. Osteoblasts are the non-dividing cells, are responsible for forming new bones and found in growing portions of the bones. These are also involved in synthesizing and secreting collagen matrix. As these cells secrete matrix around themselves and trapped in that and resultantly converted into a structure called osteocyte. In turn osteocytes are the primary cells for forming a mature bone. Each osteocyte is present in a space called lacuna and is surrounded by bone tissues. Osteocytes suffered from scarcity of mitotic division. Bones constantly go through a cycle of repair and breakdown and osteoclasts are responsible for this task. Osteogenic cells are the stimulants to become osteoblasts.

Compact Bone

The compact bone assists in supporting the skeleton and protecting the organs. It is strong, dense and lies under periosteum. The functional unit of compact bone is osteon. Each osteon is composed of concentric calcified rings called lamellae. And there is a central canal called Haversian canal which contains blood vessels, lymphatic vessels and nerves. The nerves branch off at right angle through Volkmann canal.

Spongy Bone

The osteocyte cells in spongy bone are housed in lacunae. And these lacunae are arranged in lattice network in spike like matrix called trabeculae. The hollow spaces between trabeculae make bone lighter in order to be moved by the attached muscles. Red marrow is also produced in spongy bones.

Blood Supply

The parts of the bones receive blood from the arteries of compact bone. These arteries enter through an opening called nutrient foramen in the interior of the bone. Osteocytes in spongy bone are nourished by blood vessels of periosteum. Then this blood circulates in the marrow cavities of the spongy bone. As blood flows through the marrow then it is collected by veins. Nerves follow the same path as blood.

Nerves are abundantly present in metabolically active regions of the bone. Therefore, these have role in bone growth, regulations of blood and sensing pain. Physiology means the study of functions that how the organs and systems work in coordination with each other. And in case of bones, here researcher will mention the physiology of bones that how bones are inter-linked with each other and how these work in collaboration. Like cranium use to protect fore, mid and hind brain, rib cage defend delicate organs (heart, lungs), fore limbs helps in handling things and hind limbs are involved in locomotion.

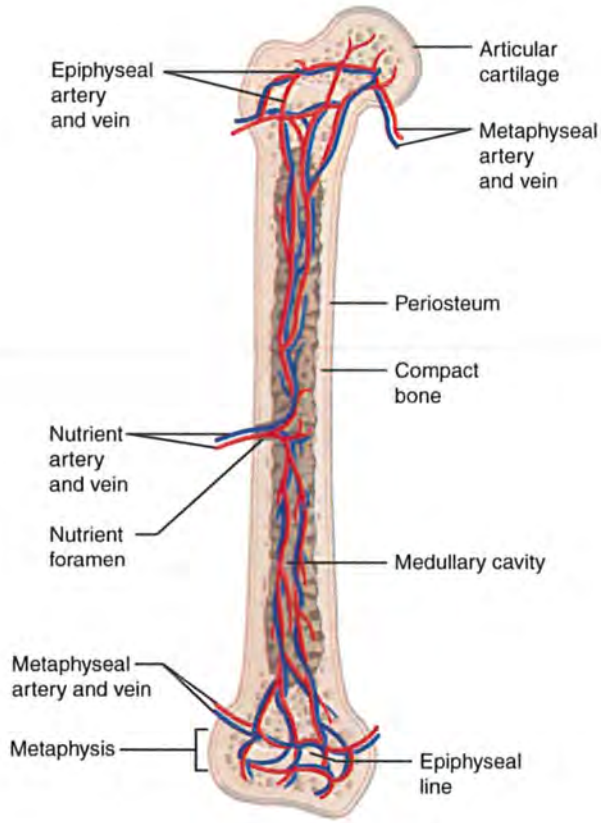

Fig.13, A view of blood supply in bones, (Gray Henry 1858)

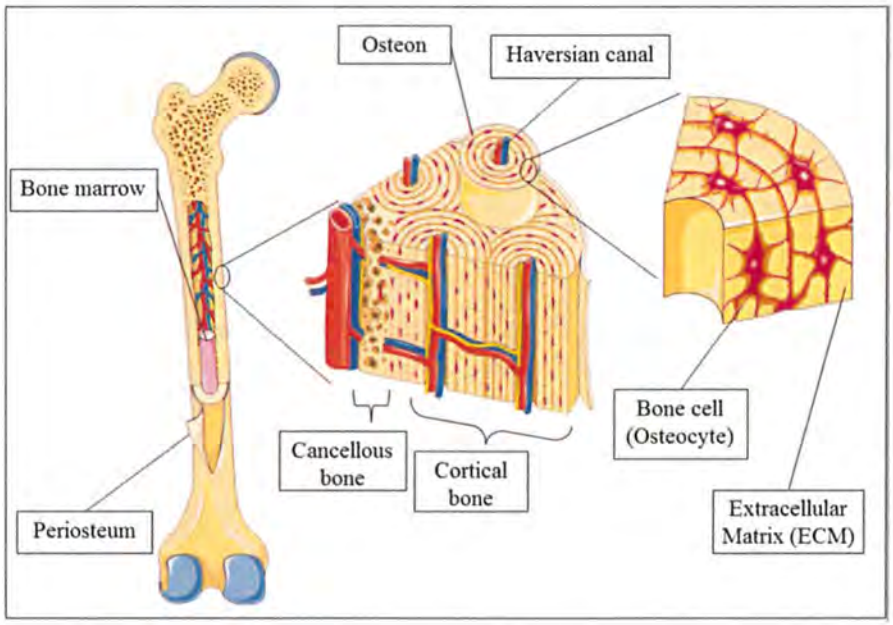

Fig.14, A view of structure, blood supply and bone cells, (Chan K.Y. Gerry 2013)

Cat

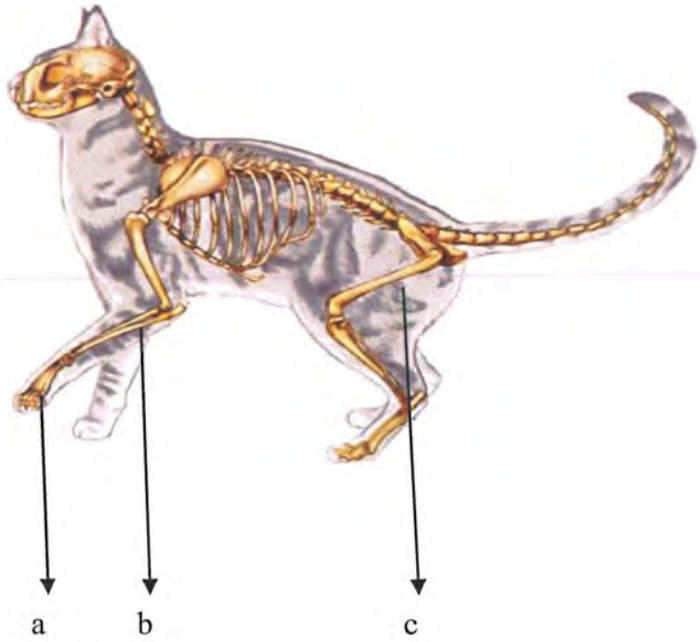

Fig.15, A skeleton of Cat, (Rae Jacqueline 2009)

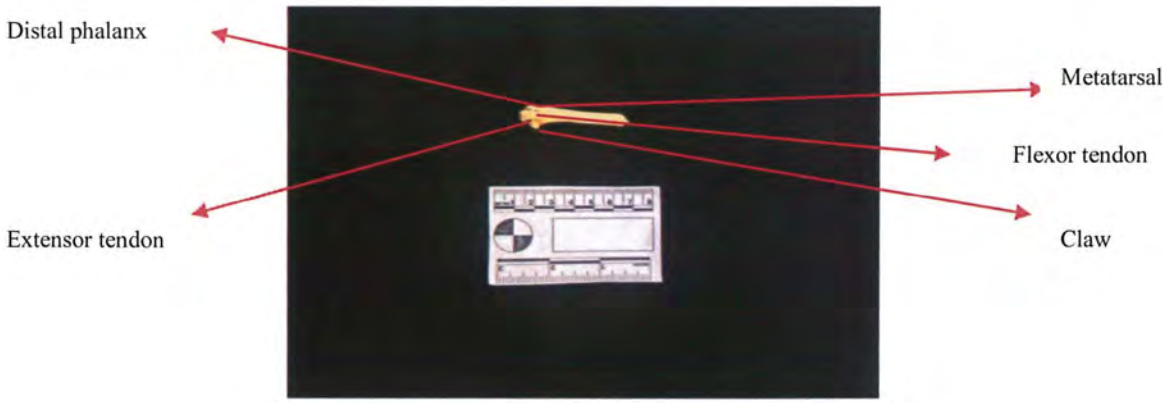

Fig.16, (a), Labeled phallenges of Infant Cat

(Labeling courtesy Michael Broad)

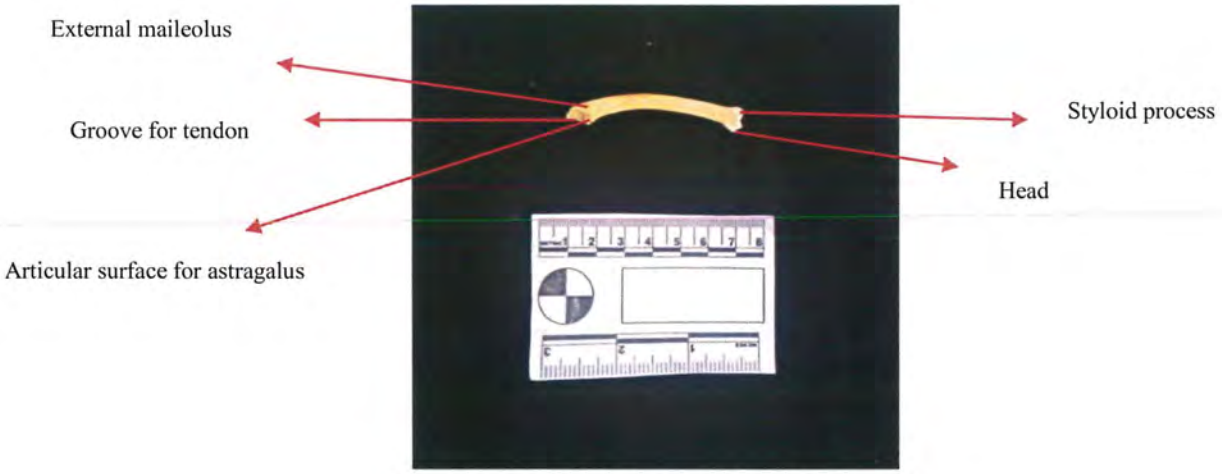

Fig. 17, (b), A labeled fibula of Infant cat

(Labeling courtesy Jonathan Fitzgordon)

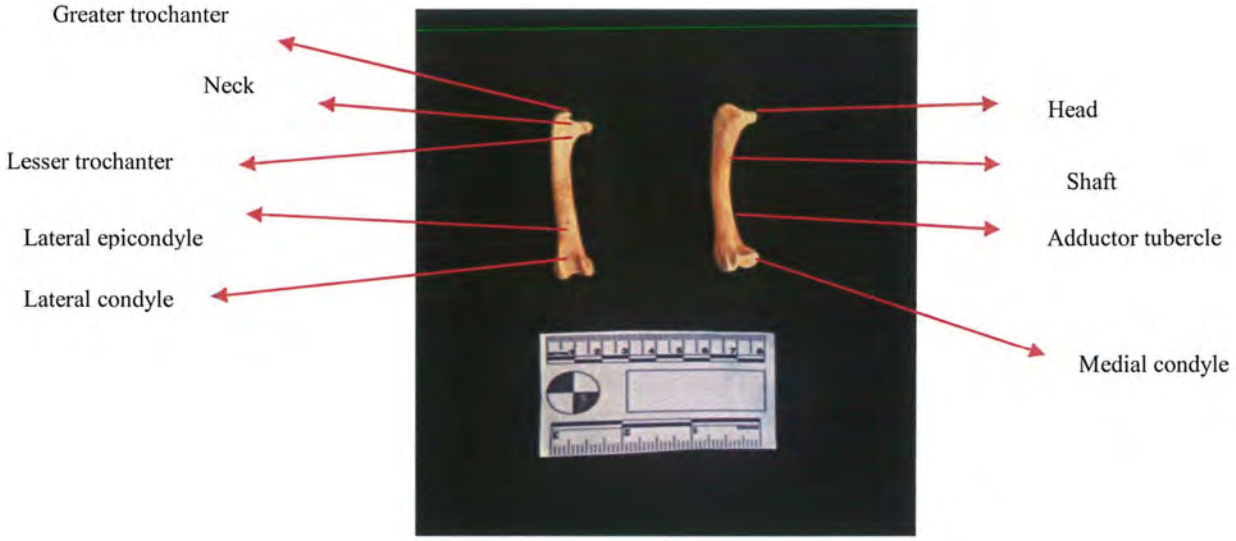

Fig.18, (c), A labeled femur of infant cat

(Labeling courtesy F. Gaillard)

Fig.15, (a) **Phallenges:** These are digital bones of fore and hind limbs of most vertebrates.

Anatomy of every bone is same like it has compact and spongy bone parts as discussed earlier.

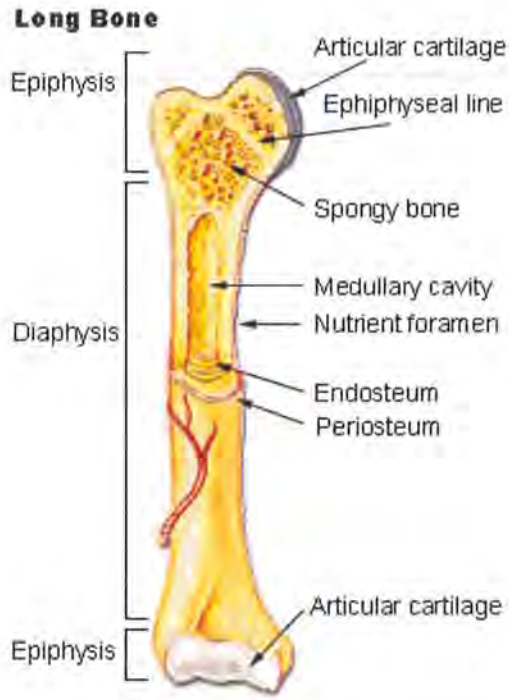

Fig.19, A view of anatomy of a bone, (PetreMcvay Benjamin)

As physiology is concerned then it differs from bone to bone. Like phallenges are present at the end of meta carpels and meta tarsels. In carnivorous animals as cats these are adapted for hunting and quick movement.

(b) **Fibula:** This bone is below femur besides tibia. But it is relatively lean than tibia.

Physiology: Fibula helps in supporting tibia and stabilizing ankle. It is also involved in bearing the muscles.

(a) **Femur:** This is the longest bone of the body of any organism. It is attached on one side with hip and on another side with knee.

Physiology: Femur serves as a sole bone which acts as an attachment point for thigh muscles.

Jackal

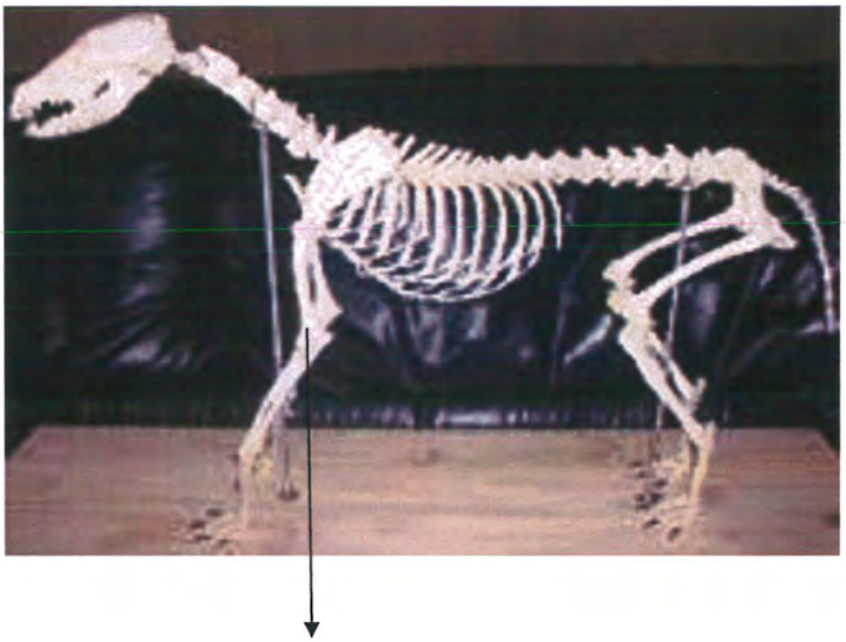

Fig.20, A skeleton of Jackal, (Maree 2016)

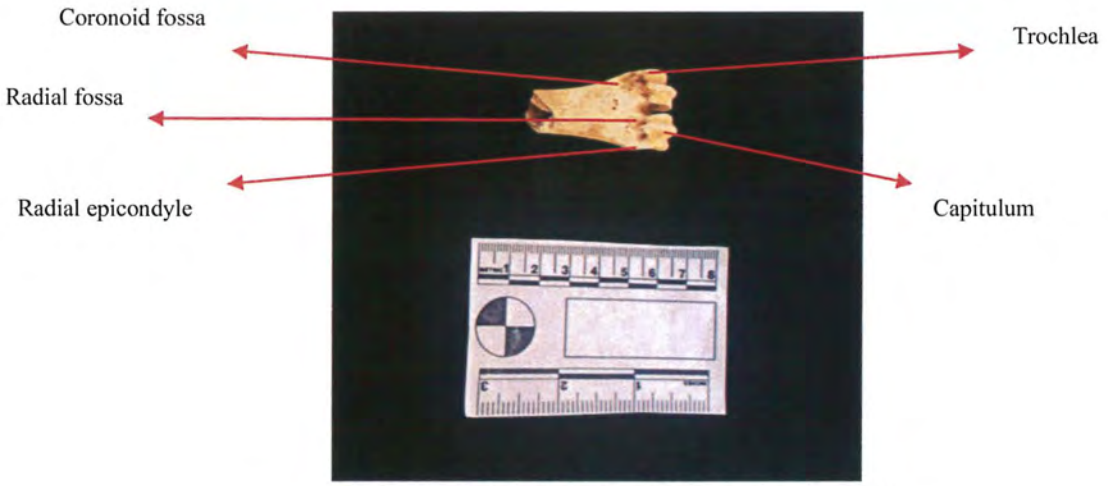

Fig.21, (a), A labeled distal humerus of jackal

(Labeling courtesy Joshya)

Anatomy and Physiology of Jackal

Fig.20, (a) **Distal humerus:** Humerus is the bone of fore limbs. From distal end it is joined with radius and ulna and from proximal end it is coaxed with shoulder bone.

Physiology: As humerus is a bone of fore limbs so inversely speaking it use to assist in better jumping, flexibility in forelimb movement, preying and handling.

Goat

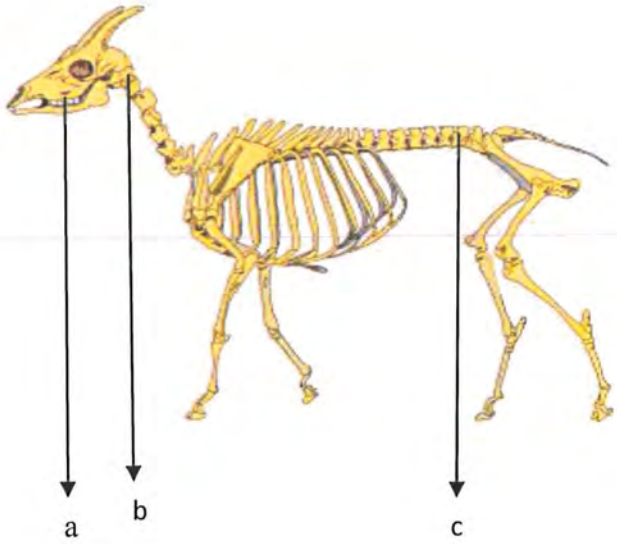

Fig.22, A skeleton of goat, (Hart, S. 2008)

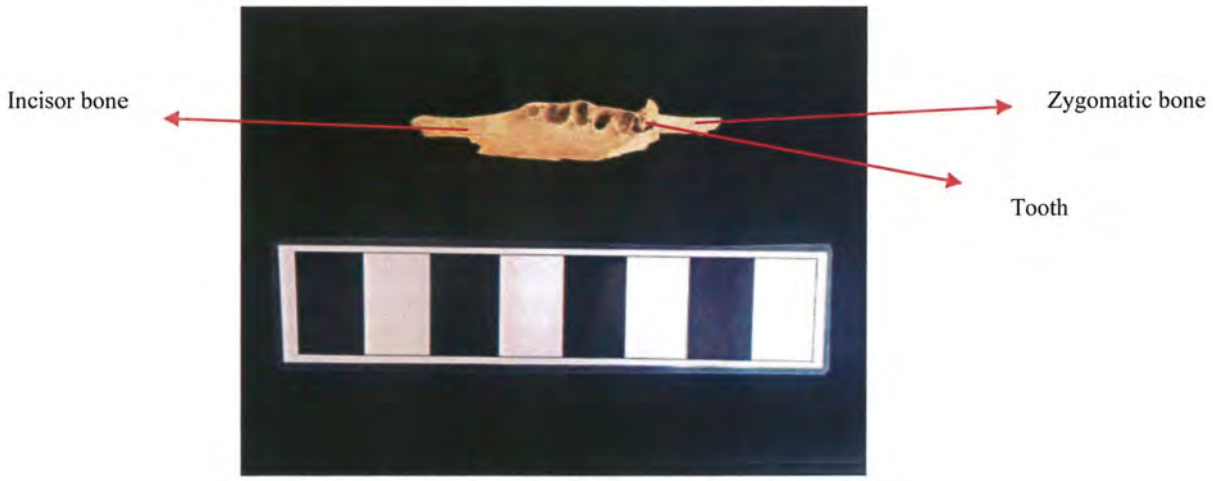

Fig.23, (a), A labeled maxilla of goat

(Labeling courtesy Faisal Shahzad Somroo)

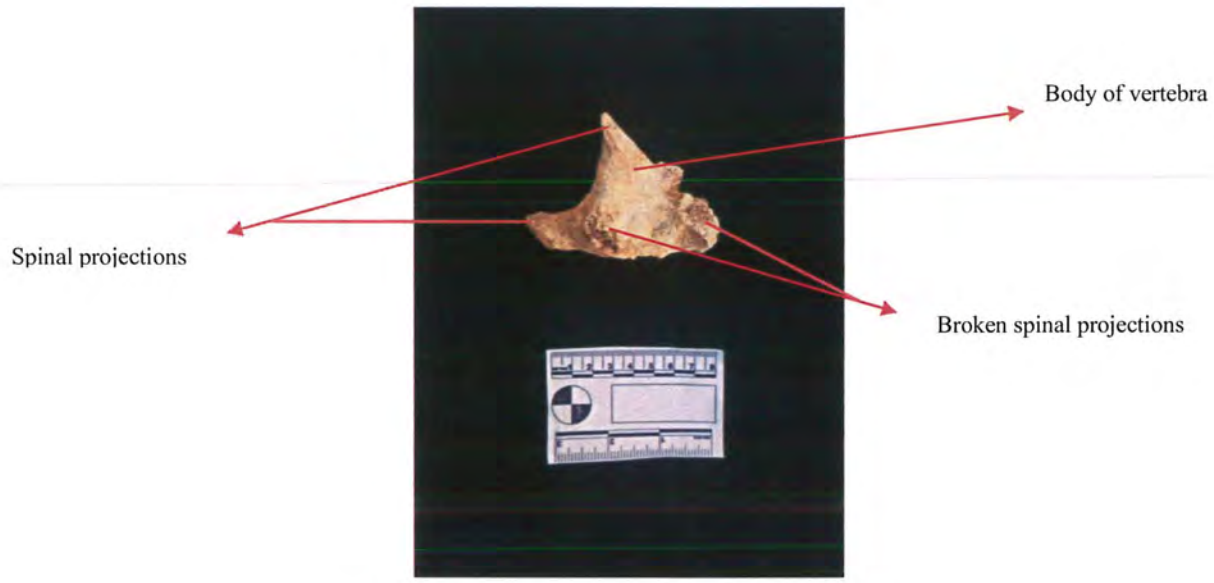

Fig. 24, (b), A labeled spinal cord of goat

(Labeling courtesy Patel et al)

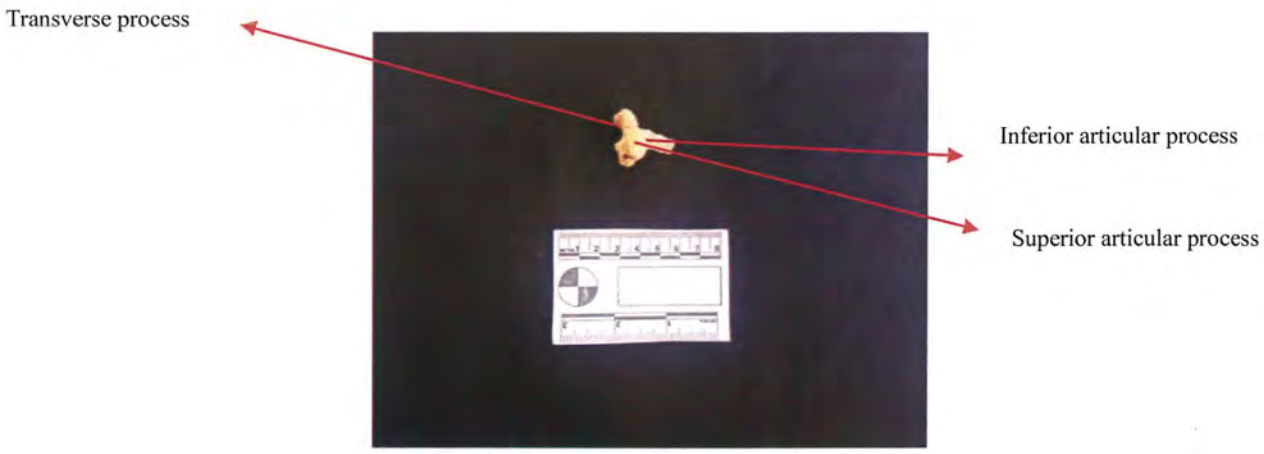

Fig.25, (c), A labeled lumber vertebrae

(Labeling courtesy Stephen Kishner)

Fig.22, (a) **Maxilla:** It is the upper jaw bone which is formed by fusion of two maxillary bones.

Physiology: Maxilla is concerned with cutting, holding the food in oral cavity and grinding.

Note: Visibly in all herbivores the upper teeth are absent but complete upper and lower jaws are present posteriorly.

(b) **Spinal Cord:** It is a long bundle of nervous tissues which starts from the portion of the brain called medulla oblongata to the lumber area.

Physiology: Spinal cord is involved in submission of nerve signals from body to brain and brain to body.

(c) **Lumber Vertebra:** There is set of lumber vertebrae which are present in between thoracic and lumber vertebrae and are five in number.

Physiology: As vertebrae are the functional units of vertebral column. So, these are involved in attachment of pectoral and pelvic girdle, protection of spinal cord and stabilization of body weight. Specifically lumber vertebrae use to protect and support spinal cord and spinal nerves.

Sheep

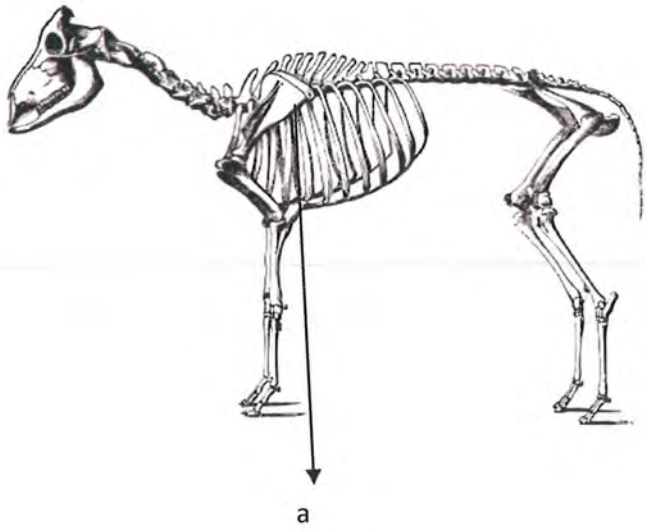

Fig. 26, A skeleton of sheep, (Theobald 1913)

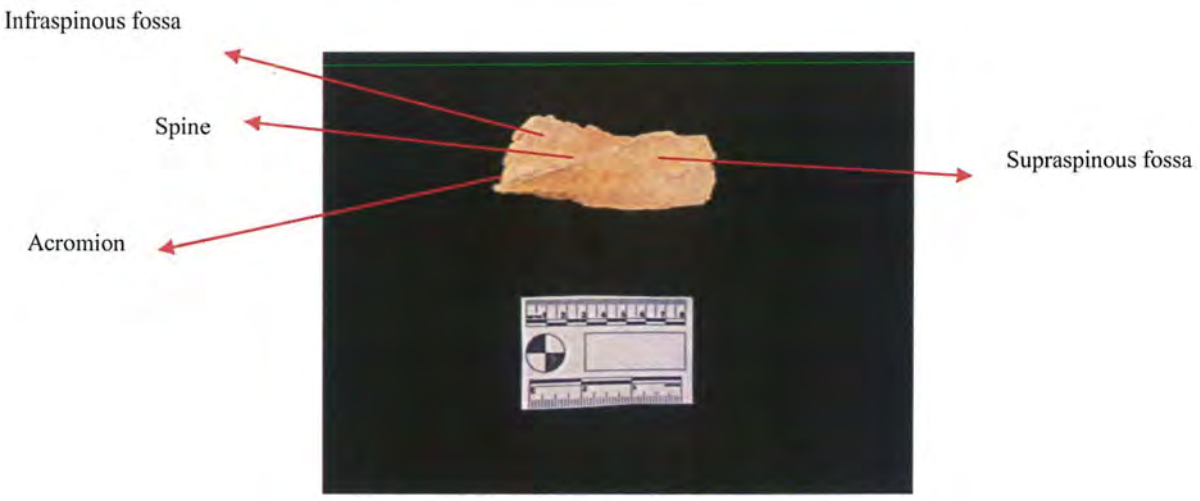

Fig.27, (a), A labeled scapula of sheep

(Labeling courtesy Victoria Aseinall)

Anatomy and Physiology of Sheep

Fig.26, (a) **Scapula:** This is a shoulder blade.

Physiology: Scapula is assists in cushioning the body during an attack of animal on its prey and give flexibility to the movement of an animal.

Cow

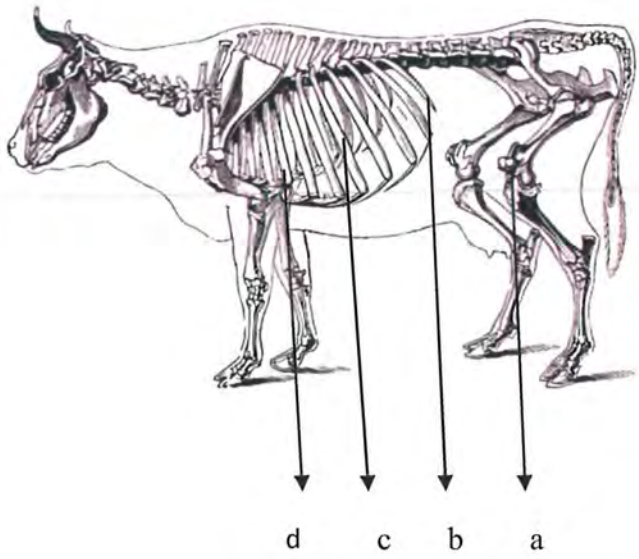

Fig.28, A skeleton of cow, (Theobald 1913)

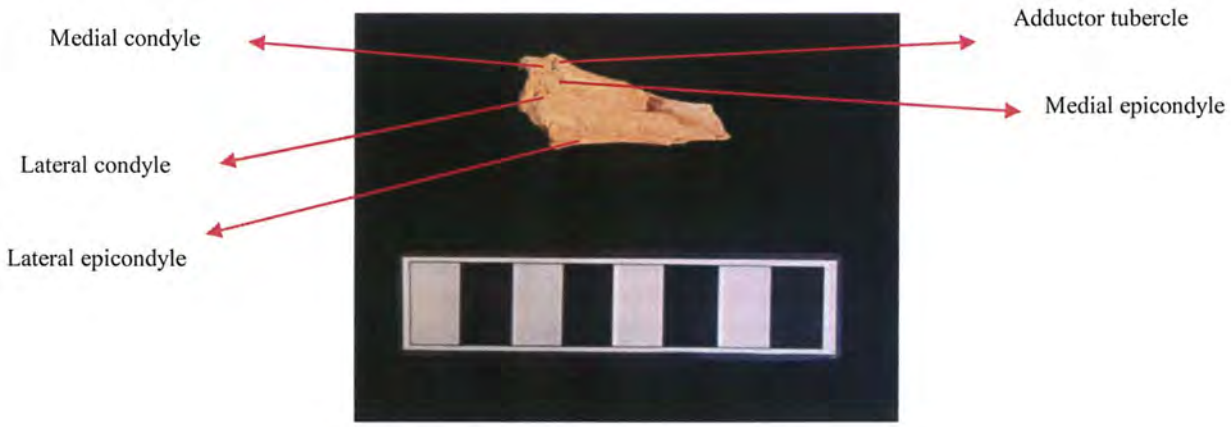

Fig. 29, (a), A labeled anterior distal femur

(Labeling courtesy Oliver Jones)

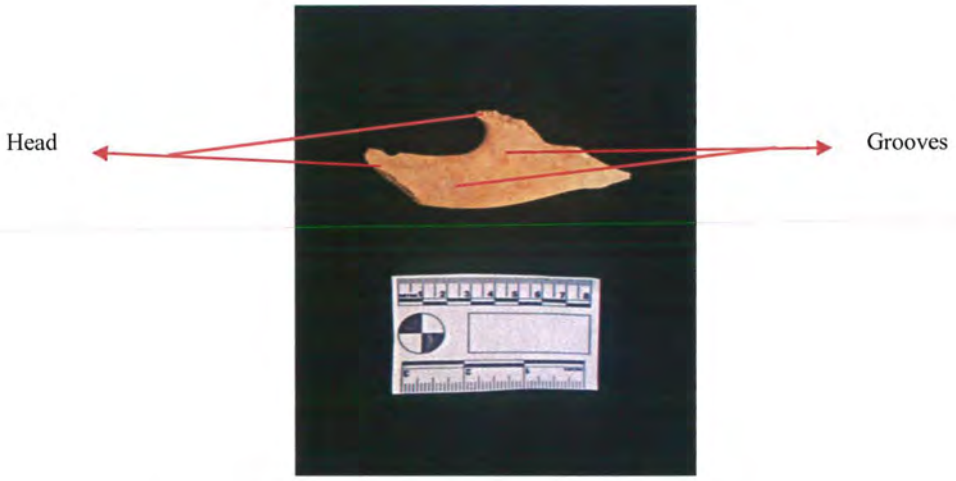

Fig.30, (b), A labeled floating rib of cow, (Labeling courtesy M. Nazim)

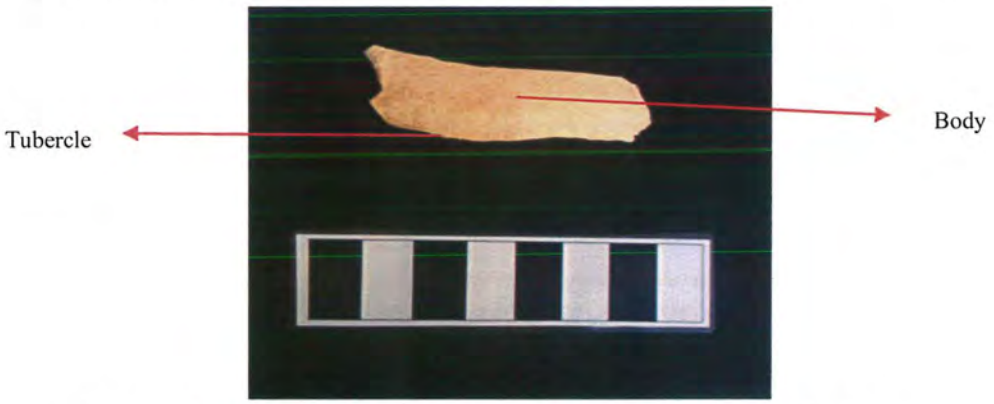

Fig.31, (c), A labeled rib of cow, (Labeling courtesy M. Nazim)

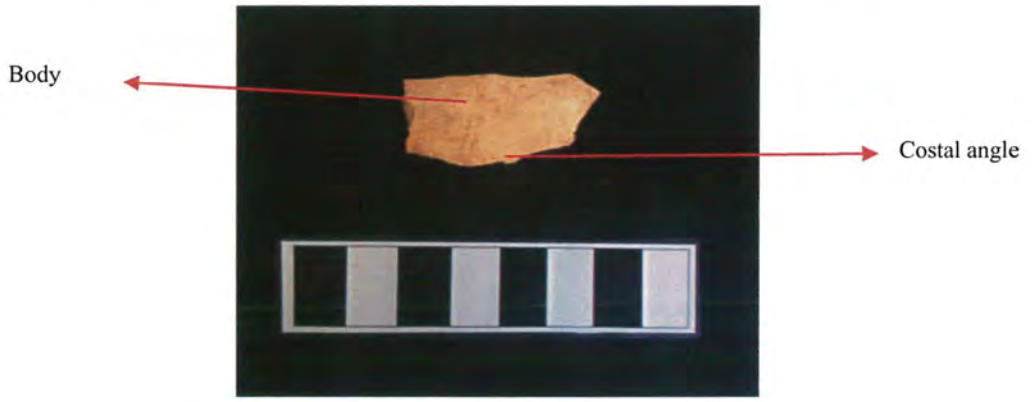

Fig.32, (d), A labeled rib of cow, (Labeling courtesy M. Nazim)

Fig.28, (a) **Distal end of Femur:** Femur is called thigh bone and is present in the upper part of the leg. It is the largest bone of any organism. The upper end of the femur is coaxed with pelvis and the lower end is joined with tibia.

Physiology: Femur of cow is concerned with locomotion and an attachment of thigh muscles.

(b) **Floating rib:** These are the ribs which are free and are not articulated with sternum bone.

Physiology: Floating ribs have protective function and use to cushion kidney and liver.

(d) **Rib:** Ribs are the curved bones which are posteriorly attached with the back bone and anteriorly with sternum.

Physiology: These use to protect organs, assist in breathing and also have supportive function in order to give an erect posture.

Bull

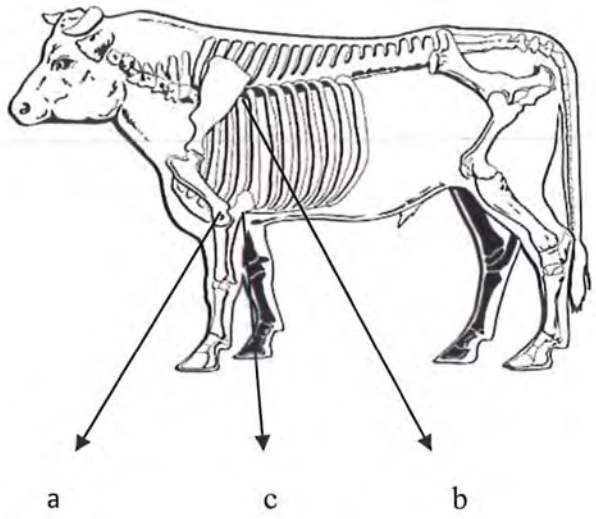

Fig.33, A skeleton of bull, (Norbert Buchholz)

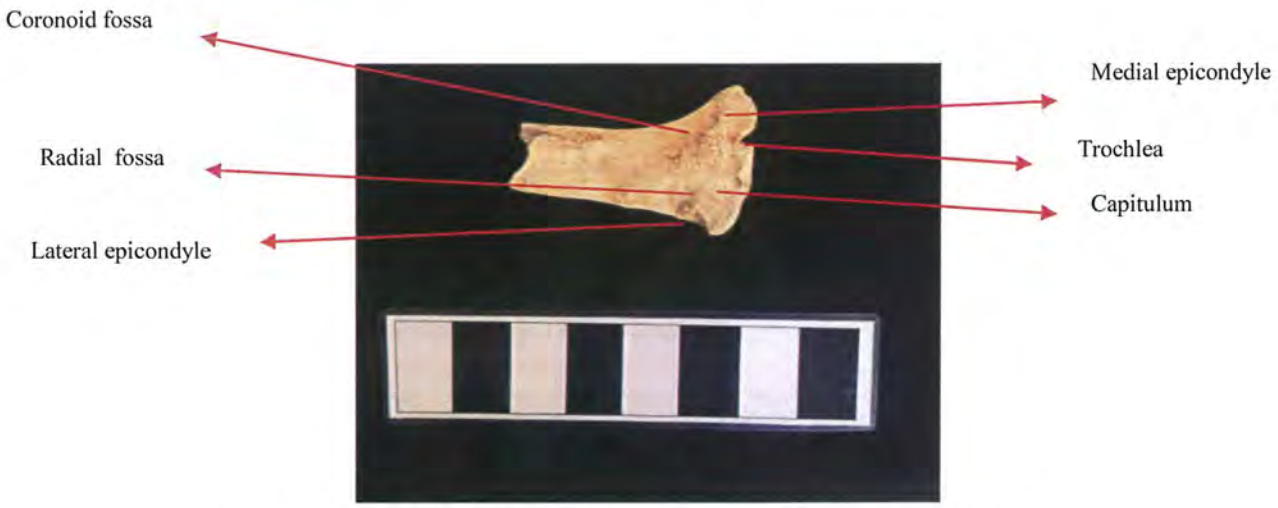

Fig.34, (a), A labeled anterior view of distal humerus of bull

(Labeling courtesy Oliver Jones)

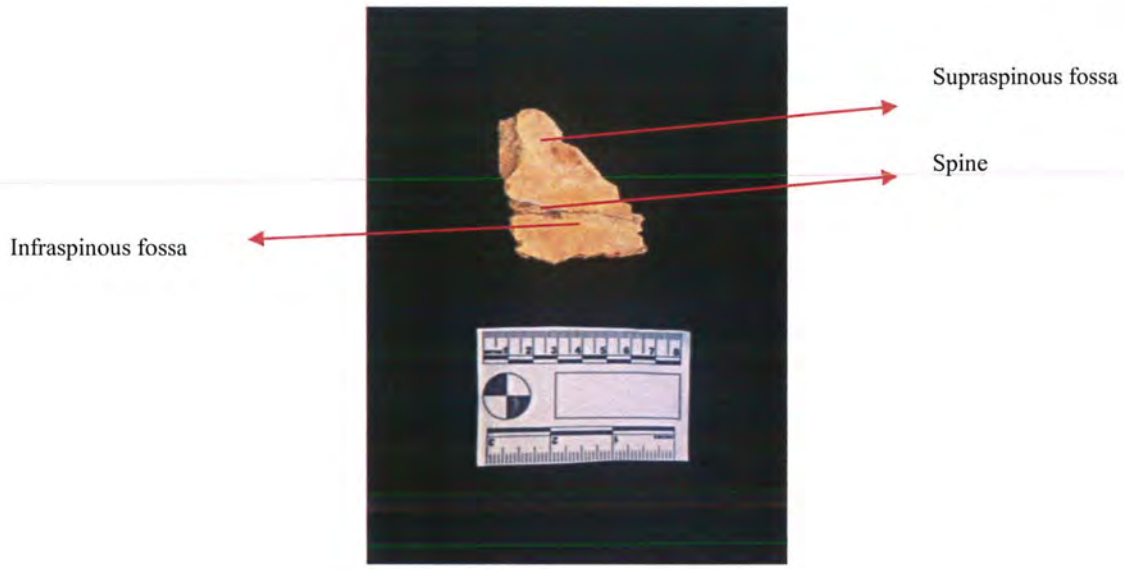

Fig. 35, (b), A labeled scapula of bull

(Labeling courtesy Victoria Aseinall)

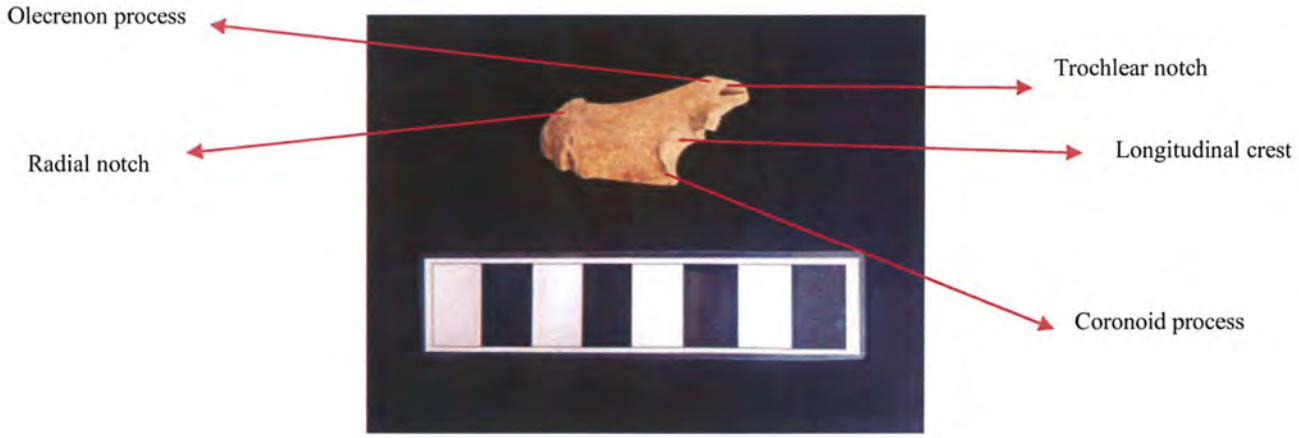

Fig. 36, (c), A labeled ulna of bull

(Labeling courtesy Donald A. Neumann)

Anatomy and Physiology of Bull

Fig.33, (a) **Anterior view of distal humerus:** Humerus comprises of a large rounded head which joined to the body through a narrow portion called the neck and two eminences (knobs/projections), shaft and distal portion which is further attached with radius and ulna.

Physiology: It helps in muscular attachment and as well as movement.

(b) **Scapula:** It is a bone which is distally attached to the upper head of the humerus and proximally to shoulder bone.

Physiology: It serves as a point for the attachment of muscles and will give flexibility when the animal is in dynamic state.

(c) **Ulna:** This is the bone of the fore limb which is present below humerus and on one side of the radius.

Physiology: It is a structural unit of fore limb and helps in movement.

Buffalo

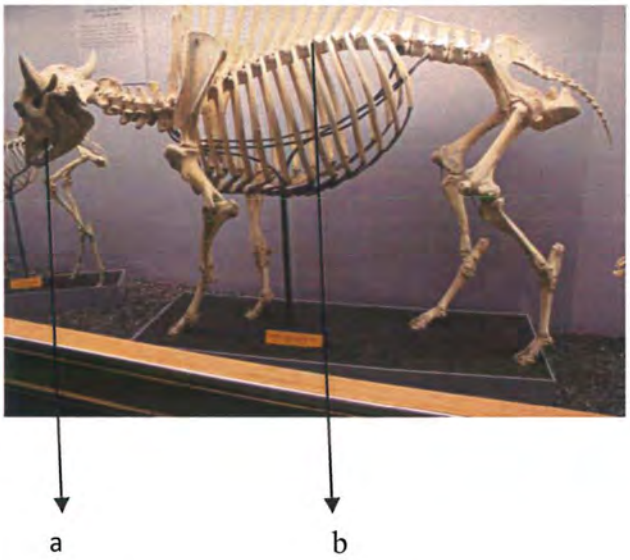

Fig. 37, A skeleton of buffalo (Pugliano 2011)

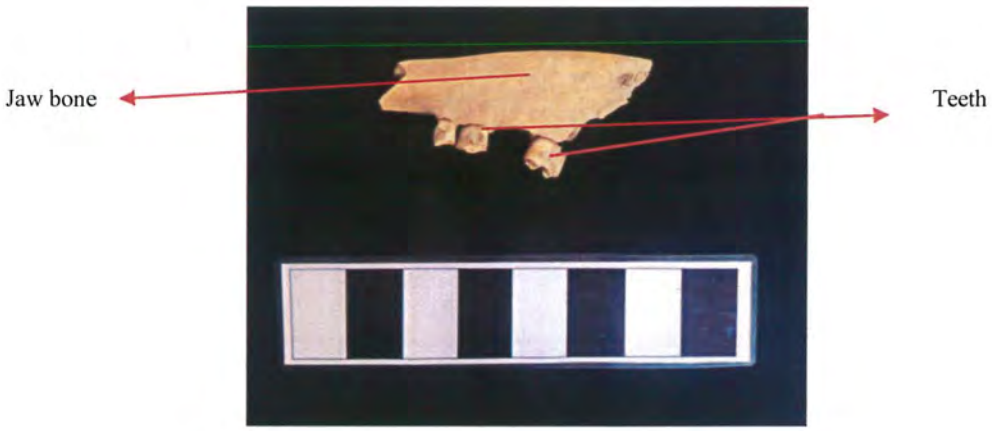

Fig. 38, (a), A labeled maxilla of buffalo

(Labeling courtesy Rahul Chavda)

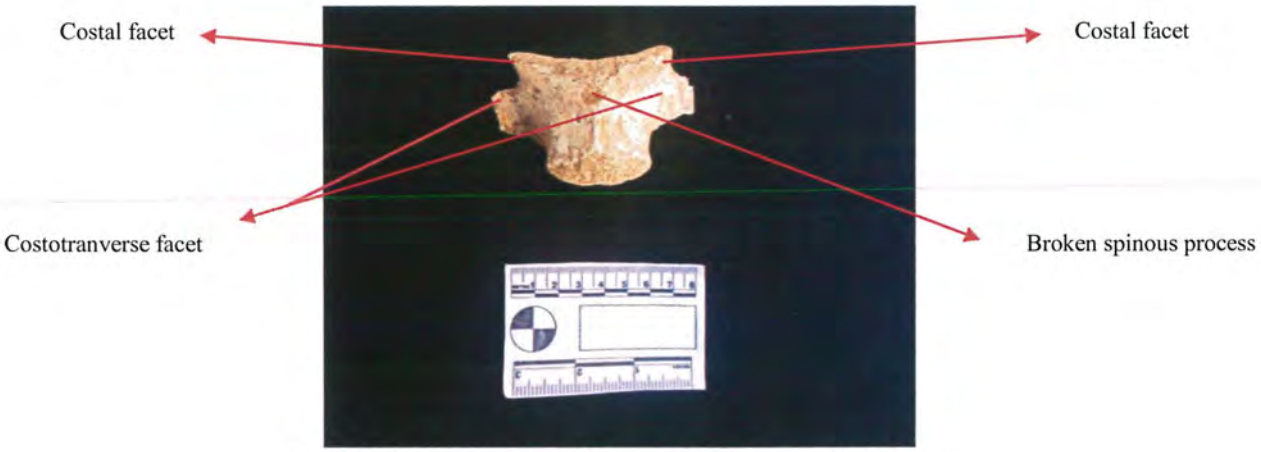

Fig.39, (b), A labeled thoracic vertebrae of buffalo

(Labeling courtesy Jason M. Highsmith)

Anatomy and Physiology of Buffalo

Fig.37, (a) **Maxilla (Left side):** The upper jaw is called maxilla.

Physiology: It is involved in handling, cutting, biting and grinding of food.

(b) **Thoracic Vertebra:** These vertebrae form the middle segment of the back bone or vertebral column. These are sandwiched between cervical and lumber vertebrae.

Physiology: These assist to support the weight of the body and also involved in protecting spinal cord.

Mule

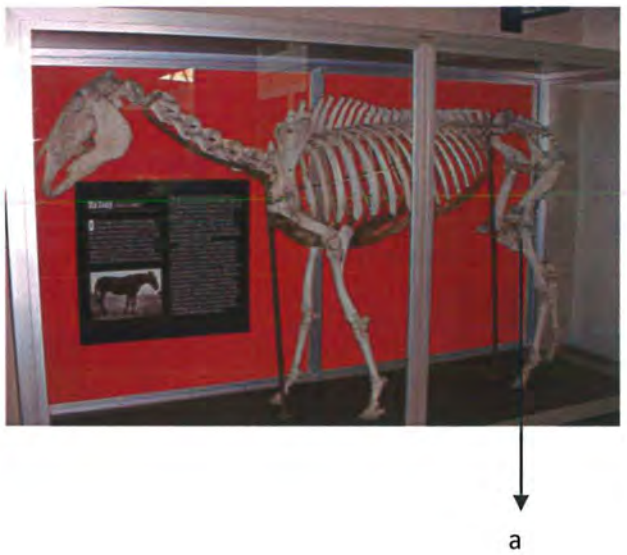

Fig.40, A skeleton of mule, (Chris George 2006)

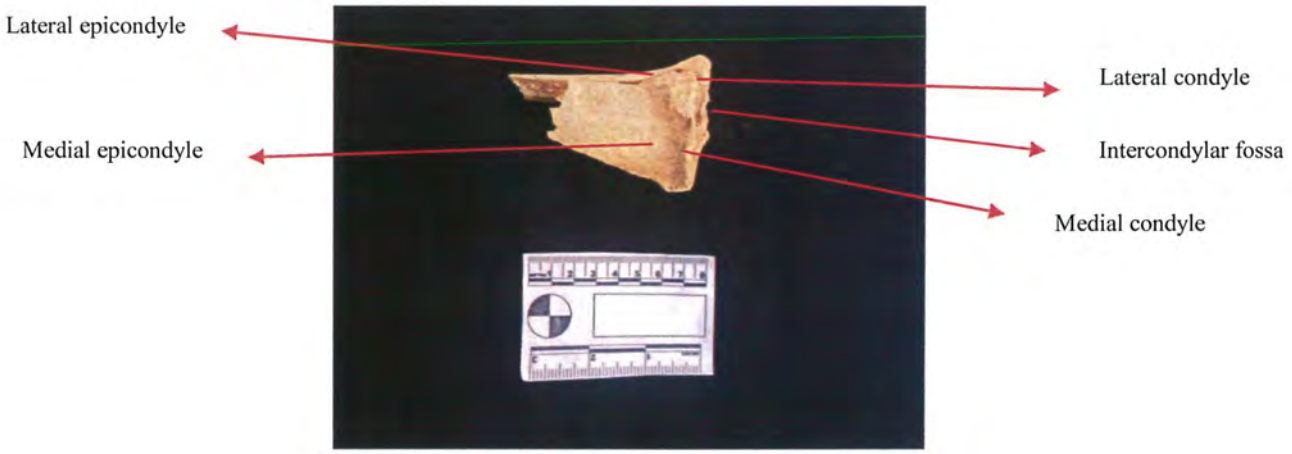

Fig.41, (a), A labeled posterior view of distal femur of mule

(Labeling courtesy Oliver Jones)

Anatomy and Physiology of Mule

Fig. 40, (a) **Posterior view of distal Femur:** Femur is the largest bone of the body which is attached distally with tibia and fibula and proximally with hip bone.

Physiology: Femur is involved in locomotion. It also serves as a site for the attachment of muscles as well as ligaments of knee.

Donkey

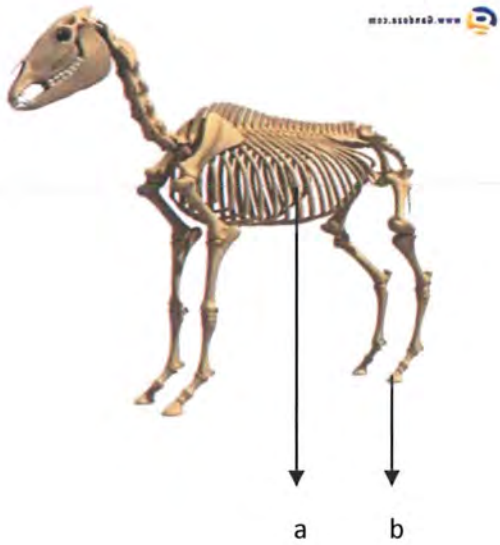

Fig.42, A skeleton of donkey, (R. Anne Pearson & M. Quassat 2000)

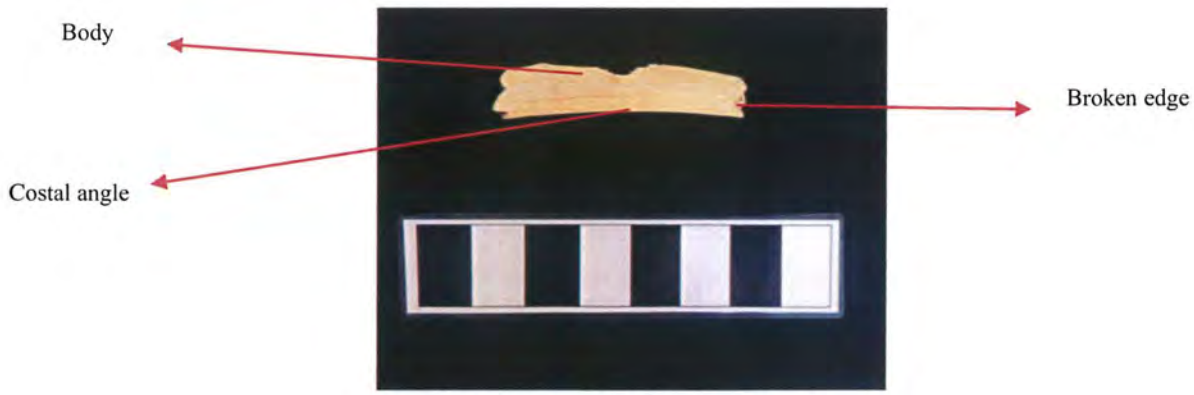

Fig.43, (a) A labeled rib of donkey

(Labeling courtesy M. Nazim)

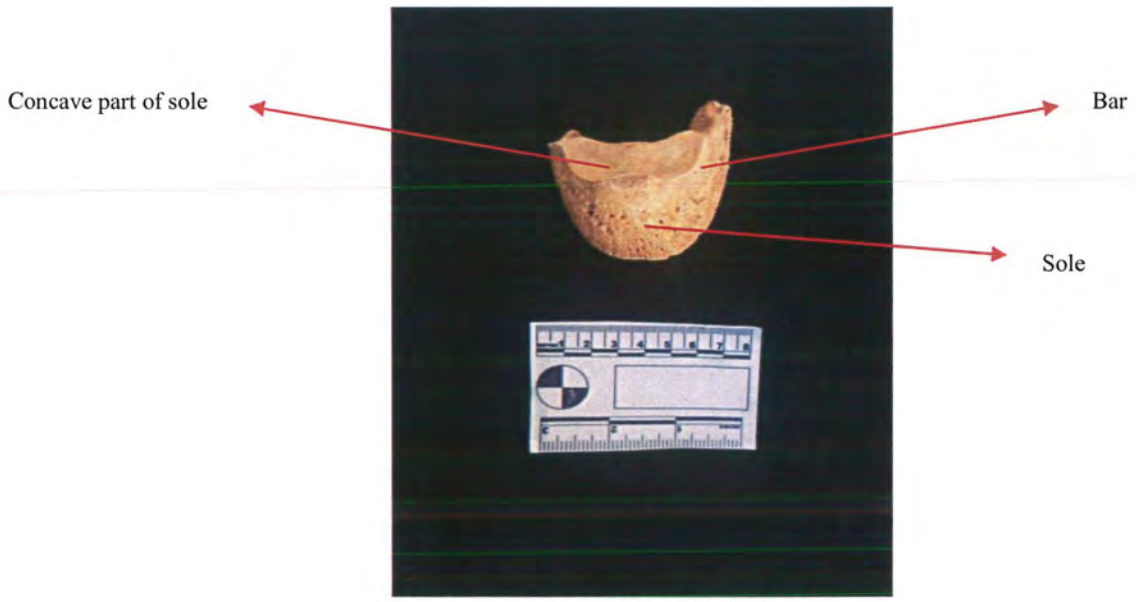

Fig.44, (b), A labeled hoof of donkey

(Labeling courtesy Anya Lavender)

Anatomy and Physiology of Donkey

Fig.42, (a) **Rib:** It is the articulating unit of diaphragm. These bones are curved and form a cage for accommodating soft organs.

Physiology: Formation of rib cage, attachment points of muscles and cushioning of delicate organs like heart, lungs, liver and stomach.

(b) **Hoof:** This is the stiff part, present below the feet of ungulate animals.

Physiology: Hoofs are involved in traction of the animals, protect bones and tissues in hoof capsule, dissipation of energy and support weight of the body.

Horse

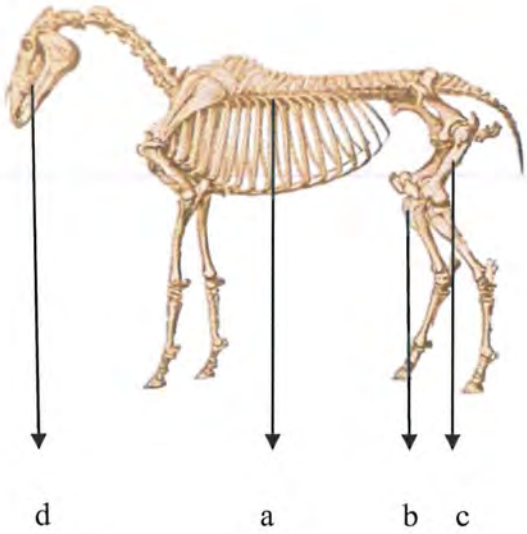

Fig.45, A labeled skeleton of horse (Torrente 2004)

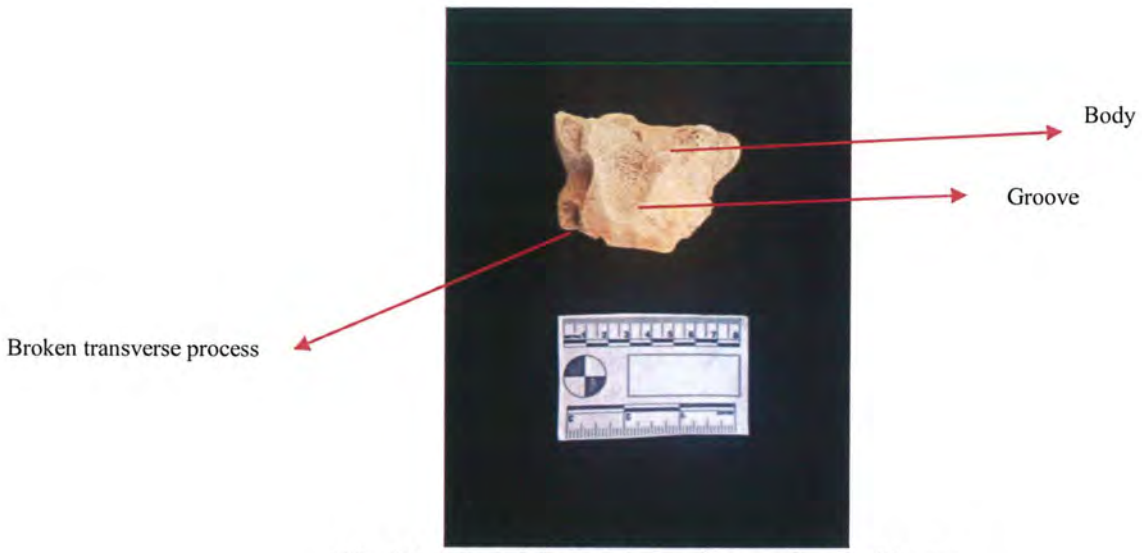

Fig.46, (a), A labeled thoracic vertebrae of horse

(Labeling courtesy Jason M. Highsmith)

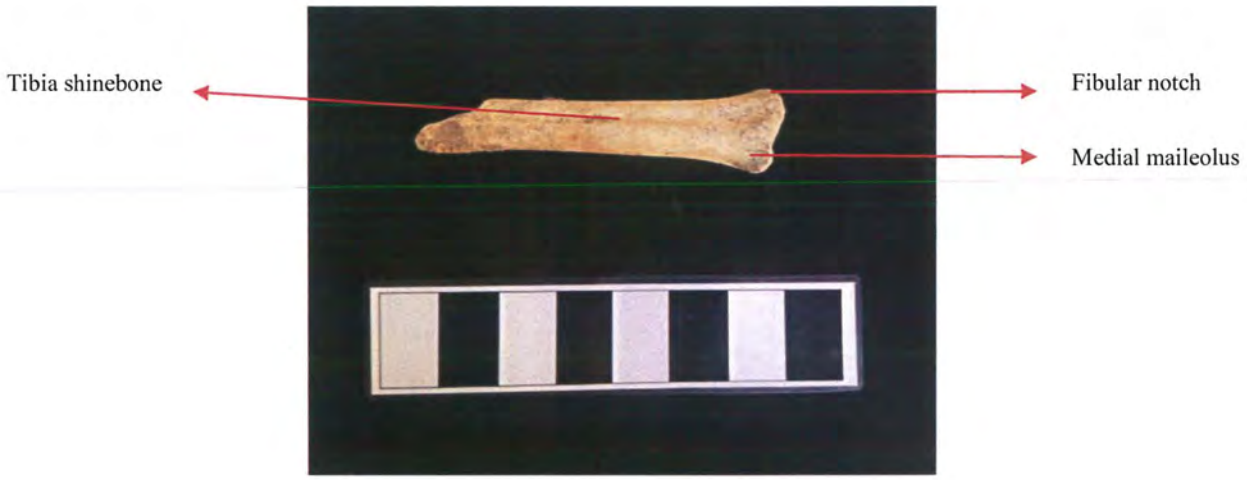

Fig.47, (b), A labeled tibia of horse

(Labeling courtesy Denis Hoa)

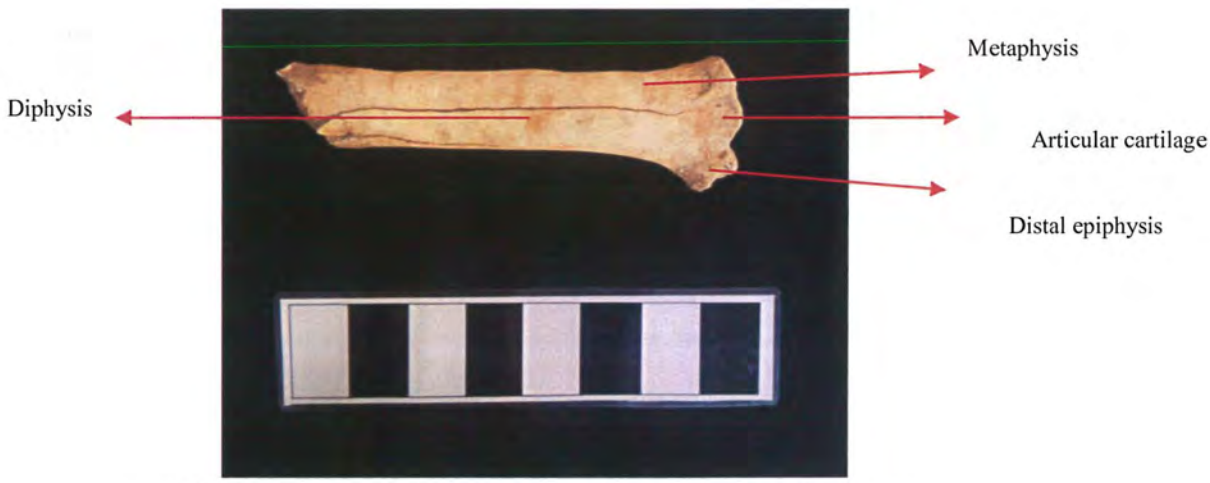

Fig.48, (c), A labeled posterior view of femur of horse

(Labeling courtesy Denis Hoa)

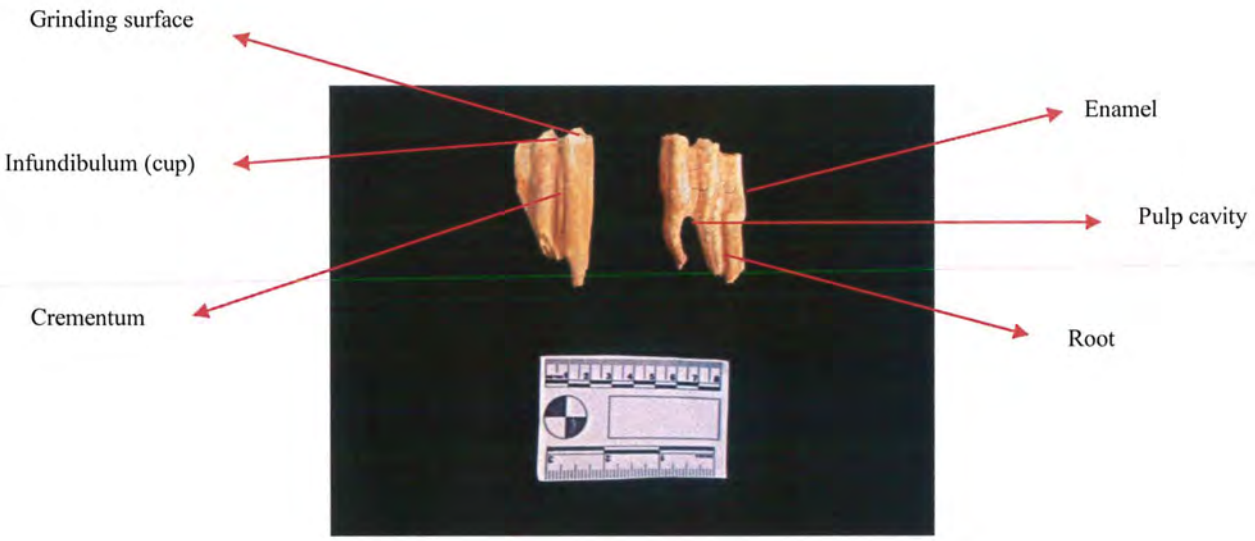

Fig.49, (d), A labeled teeth of horse

(Labeling courtesy GA Lager)

Fig.45, (a) **Thoracic Vertebra:** These are functional units of vertebral column present in between cervical and lumber vertebrae.

Physiology: Supportive (vertebral column) and protective function (spinal cord and nerves).

(b) **Tibia:** This is the bone which is positioned between knee and ankle and is parallel to fibula.

Physiology: Helps to accelerate movement of leg and makes a point where muscles are inserted.

(c) **Posterior view of Femur:** This is the largest bone of the body which is articulated between hip and knee.

Physiology: A sole bone which acts as a central point for the adherence of thigh muscles and the only bone which bears the weight of the body.

(e) **Teeth:** These are the hard, bony and enamel coated structures which use to cut, chew and grind the food.

Physiology: These are involved in cutting, holding food in oral cavity and providing a surface area for grinding.

Chapter # 4

Biological Classification of Animals

Biological Classification is the procedure of categorizing living organism based on their similarities and differences. The sample bones which are identified by the researcher belong to different animals. And according their classification is discussed below:

Classification of Cat

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Cornivora
Family	Felidae
Genus	Felis
Specie	Catus Domesticus
Scientific Name	*Felis catus domesticus*
Size (Average Length)	35cm (14 in)
Average Weight	4-5 kg
Diet	Omnivore
Speed	48km/h
Life Style	Sedentary
Favorite Food	Milk
Habitat	Not specific
Predators	Hawk, Owl, Dogs
Main Prey	Mice, sparrows, spiders, insects and reptiles

Description: Cat has four legs, skin covered with fur and usually found in grey, white, brown black colors.

Classification of Jackal

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Artiodactyla
Family	Conidae
Genus	Canis
Specie	Aureus
Scientific Name	*Capra aegagrus hircus*
Size (Average Length)	90-105 cm
Average Weight	6.8-11 kg
Diet	Carnivore
Speed	32 km/h
Life Style	Herd
Life Span	8-15 Years
Conservation Status	Least Concern
Favorite Food	Grass
Habitat	Dry Woodlands, Grass Plains
Predators	Hyena and Leopard
Main Prey	Antelope, Insects, Reptiles

Description: It has short body covered with fur, large eyes, ears, thick tail and usually found in brown, grey, white and tan color.

Classification of Goat

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Artiodactyla
Family	Bovidae
Genus	Capra
Specie	Aegagrus hircus
Scientific Name	*Capra aegagrus hircus*
Size (Average Length)	40-80 cm
Average Weight	54-77 kg
Diet	Herbivore
Speed	17 km/h
Life Style	Herd
Life Span	10-15 Years
Conservation Status	Least Concern
Favorite Food	Grass
Habitat	Dry Woodlands, Mountains
Predators	Human, Wolves, Coyote
Main Prey	Grass, Fruits, Leaves,Vegetables, Flowers

Description: It has four lean legs, fur of brown, black, white and tan color, long ears and two horns.

Classification of Sheep

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Artiodactyla
Family	Bovidae
Genus	Ovis
Specie	Aries
Scientific Name	*Ovis aries*
Size (Average Length)	90-140 cm
Average Weight	40-130 kg
Diet	Herbivore
Speed	40 km/h
Life Style	Herd
Life Span	5-10 Years
Conservation Status	Least Concern
Favorite Food	Grass
Habitat	Grass Plains, Mountains
Predators	Human, Wolves, Coyote
Main Prey	Grass, Weeds, Vegetables, Flowers

Description: It has thick wooly fur of brown, black, yellow and white color, small tail and long ears.

Classification of Cow

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Artiodactyla
Family	Bovidae
Genus	Bos
Specie	Taurus
Scientific Name	*Bos taurus*
Size (Average Length)	1.5 m-1.8 m
Average Weight	400-800 kg
Diet	Herbivore
Speed	40 km/h
Life Style	Herd
Life Span	12-20 Years
Conservation Status	Threatened
Favorite Food	Grass
Habitat	Forests, Grasslands
Predators	Human, Wolves, Bears
Main Prey	Grass, Seeds, Flowers

Description: It is four legged, leathery skin of white, black and brown color and complicated digestive system.

Classification of Buffalo

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Artiodactyla
Family	Bovidae
Genus	Bubalus
Specie	Bubalis
Scientific Name	*Bubalus bubalis*
Size (Average Length)	1.7 m-1.8 m
Average Weight	600-907 kg
Diet	Herbivore
Speed	35 km/h
Life Style	Herd
Life Span	15-22 Years
Conservation Status	Threatened
Favorite Food	Grass
Habitat	Forests, Grasslands
Predators	Human, Wolves, Bears
Main Prey	Grass, Seeds, Flowers

Description: It is four legged, thick hairy skin of black, grey and brown color and molded horns.

Classification of Mule

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Perissodaetyla
Family	Equidae
Genus	Equus
Specie	Mule
Scientific Name	*Equus mule*
Size (Average Length)	1.2-1.5 m
Average Weight	350-450 kg
Diet	Herbivore
Speed	24 km/h
Life Style	Herd
Life Span	15-20 Years
Conservation Status	Least Concern
Favorite Food	Grass
Habitat	Arid Forests, Deserts
Predators	Fox, Wolves, Lion
Main Prey	Grass, Weeds, Vegetables

Description: Four legs, thick fur of brown, black and grey color along with long snout and long ears.

Classification of Donkey

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Perissodaetyla
Family	Equidae
Genus	Equus
Specie	Asinus
Scientific Name	*Equus asinus*
Size (Average Length)	90-30 cm
Average Weight	200-258 kg
Diet	Herbivore
Speed	24 km/h
Life Style	Herd
Life Span	15-30 Years
Conservation Status	Threatened
Favorite Food	Grass
Habitat	Arid Forests, Deserts
Predators	Fox, Wolves, Lion
Main Prey	Grass, Weeds, Vegetables

Description: It has four thin legs, body covered with fur of brown, black and white color and distinctive sound of Hee-Haw.

Classification of Horse

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Perissodaetyla
Family	Equidae
Genus	Equus
Specie	Caballus
Scientific Name	*Equus caballus*
Size (Average Length)	142-163 cm
Average Weight	380-550 kg
Diet	Herbivore
Speed	64 km/h
Life Style	Herd
Life Span	25-30 Years
Conservation Status	Threatened
Favorite Food	Grass
Habitat	Small Forests, Grasslands
Predators	Human, Wolves, Bears
Main Prey	Grass, Fruits, Leaves
Distinctive Features	Thin legs and long mane

Description: It has thin legs, hairy skin of brown, black, grey and white color and long hairy mane.

Chapter # 5

Conservation/Preservation of Bones and Zooarchaeological Issues

Bones are the structures which are composed of organic and inorganic constituents like collagen and hydroxyapatite respectively. These will give an enough strength as well as flexibility. Bones undergo a lot of changes from different time scales like before burial butchering, boiling, weathering, defleshing and cooking. And after burial, bones continue this process of changes and different chemical reactions take place within them along with outside. Like most of the bacteria and fungi are present in the soil which carry out chemical reactions to alter chemical composition of bones and in this way harm them (Collin 2002, Jans 2005).

But if the deceased animal is exposed then, bacteria living in large intestine will greatly affect the bones in the nearby vicinity. Bones not only suffered from biological damage but also from chemical and hydrological (Huisman et al 2009c).

The long term survival of these faunal remains needs preservation of collagen and hydroxyapatite components of bones. Bones undergo a great damage in acidic soil (collagen lost) and nearby passing out of underground water because it will create more pores on the surface of the bones and in the same way more salts and minerals will be expelled (Hedges and Millard 1995).

Conservation

For the sake of analysis and to propose results researcher should delicately remove the bones from an archaeological site. For removal of bones from an archaeological site, faunal remains should be placed in acid-free tissue paper or polyethylene foam. And the damp bones are firstly exposed to sunlight for drying out. Then the soil present on the surface of the bones is gently removed with soft paint brush. If it is difficult to proceed, then one should use small amount of water in order to remove the soil from bone surface. Otherwise the bones should not be submerged in water. Usually the teeth bones are stronger exteriorly but these are fragile interiorly. And the marks on teeth surface should be retained. That's why there is a great need in order to clean the bones with soft materials. If there is a skull then it will house large amount of soil, which with the passage of time hardens and will break the bone. This soil is to be removed.

To be treated with chemical, the cracked parts of the bones can be joined together by using synthetic polymers. And if the surface of the bones is still overlaid with salts then soluble salts can be cleaned out by applying water with a cotton bud and insoluble salts can be removed by applying acryloid B-72-water solution. The dried clean bones should be stored in polyethylene bags along with the documentation slips on which complete details of the bones have been written (Wills and Ward 2014).

Preservation

For preservation purpose; gelatin animal glue, paraffin wax, polyvinyl acetate, emulsions, shellac, acrylic resins in solvents and acrylic emulsions are used (Shelton and Johnson 1995). These applied materials were usually shiny and when coated then a researcher would not be able to see the surface details. These materials also use to shrink when are applied and were difficult to remove. Recently the tests have been applied in order to remove the old resins and a new procedure has been devised; the laser treatment. But prior to this, various solvents were applied in order to remove the resins from the upper surface (Korenberg et al 2012).

For the sake of restoration of bones, principally skull bones plasticine, cocktail sticks and nails were used. The formed bone will be in between the porous surfaces that's why it was more susceptible to be apart. If the same break is repeatedly re-adhered then there will be series of bone and glue, and the resultant bond will be inaccurate and unstable (Cook and Ward 2008).

There are various factors which influence the preservation status of bone. These factors include extrinsic and intrinsic. Extrinsic factors are temperature, air, soil type, ground water, nature of fauna and flora, human activities and methods of burials (Handerson 1987). The intrinsic factor is the bone chemical composition and density (Garland and Janaway 1989).

Issues in Zooarchaeology

Zooarchaeology is the discipline which is useful in the field of archaeology. It is helpful in proposing past environment, subsistence practices of the past, species of animals available in a specific territory and their diet.

A lot of faunal remains have been collected from archaeological sites of Pakistan as few are discussed above. Unfortunately, no zooarchaeologist is available in Pakistan. In this way the field of zooarchaeology is greatly suffering. But there are various issues which are creating obstacles in this field. Like, Pakistan is lacking experts of zooarchaeology that's why the samples under examination will not be rightly identified. And the researchers also don't like to choose zooarchaeology for research because there is no one to guide them properly. Actually there will be several reasons behind this. Zooarchaeology is a pain staking discipline of archaeology. Sometimes the bones of related animals will be same like in the case of sheep and goat. And it is difficult to distinguish between such bones. A researcher should be very much conscious while identifying faunal remains. Even a minor error can change entire results and the derived aspects in order to reconstruct history will be proved wrong.

Like, the researcher also has to suffer from the same problem. For the purpose of identification of samples, Natural History Museum had been visited. But the identification of bones was not reliable. According to them, some bones were of hippopotamus, giraffe and rhinoceros. As Badalpur (Taxila Valley) is my case study and these animals are not found in the whole region even past times as well.

But for the sake of corrected identification, the researcher has consulted district gazetteer and compared the bones with the standard ones.

The most authentic method applied in zooarchaeology is; Genetic testing/DNA testing. But this technique is expensive. And this process is seldom used in Pakistan. That's why another procedure of identifying faunal remains is usually used in which the sample bones are compared with standard bones.

Catalogues (Excavation Season 2014-15)

Phallenges of Infant Cat (Pl. 4, Fig.57)

Object: Bone

Site: Badalpur

Inv. No: BP-1

Locus. No: Cell # 2

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 5.4 cm, Width: 0.8 cm

Condition: Irregularly broken from posterior end.

Description: These are the bones present below meta carpels and meta tarsals. Posterior half of this set of bone is broken. Small grooves on the surface of the fused bones are visible. Small knob like structures can be seen at anterior end of the bones.

Fibula of Infant Cat (Pl. 5, Fig. 59)

Object: Bone

Site: Badalpur

Inv. No: BP-2

Locus. No: Cell # 2

Layer 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 6.1 cm, Width: 0.6 cm

Condition: Intact

Description: It is a bone present at the lower half of the hind limb aligned with tibia. It is in good condition and there are grooves on the upper and lower ends. Fade steins which are visible on its surface.

Femur of Infant Cat (Pl. 5, Fig.61)

Object: Bone

Site: Badalpur

Inv. No: BP-3

Locus. No: Cell # 2

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 7 cm, Width: 0.7 cm

Condition: Intact

Description: There are two left and right femurs present side by side. Their size shows that these are of same animal. These bones are also having grooves on proximal and distal ends. A projection on their sides shows their amalgamation to another bone.

Humerus distal end of Jackal (Pl. 6, Fig.63)

Object: Bone

Site: Badalpur

Inv. No: BP-4

Locus. No: Cell # 1

Layer: Trench # Y 15

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 4.7 cm, Width: 2.5 cm

Condition: Fragile

Description: This is the bone of the fore limb and there are deep grooves at the swollen head of this bone which show the point of attachment of other bones to form a joint. But shaft of the bone is broken.

Upper Jaw of Goat (Pl.6, Fig. 65)

Object: Bone

Site: Badalpur

Inv. No: BP-5

Locus. No: BP-213

Layer: 3

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 13.8 cm, Width: 3.2 cm

Condition: Broken

Description: This goat jaw has been broken. There are five depressions for holding teeth and the last one has a slightly broken tooth. Two elongated projections on its both sides serve as a support.

Spinal Cord of Goat (Pl.7, Fig.67)

Object: Bone

Site: Badalpur

Inv. No: BP-6

Locus. No: Cell # 2

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 8.7 cm, Width: 5.3 cm

Condition: Broken

Description: It is spinal cord of a goat. Its surface is cracked and porous. Two projections of spinal cord are badly broken. Green steins are visible on its surface.

Lumbar Vertebrae of Goat (Pl. 8, Fig.69)

Object: Bone

Site: Badalpur

Inv. No: BP-7

Locus. No: Cell # 2

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 2.8 cm, Width: 2 cm

Condition: Damaged

Description: It is lumbar vertebra of goat which comprises of two projections. One long projection is on left side and a smaller one is on the top. A small hole has been seen in the lower body of the vertebrae.

Scapula of Sheep (Pl.8, Fig.71)

Object: Bone

Site: Badalpur

Inv. No: BP-8

Locus. No: Cell # 2

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 11 cm, Width: 4.5 cm

Condition: Broken

Description: Scapula of the sheep is irregularly broken from all sides. The spine of the scapula is also amorphous in appearance.

Distal end of femur of Calf (Cow) (Pl. 9, Fig.73)

Object: Bone

Site: Badalpur

Inv. No: BP-9

Locus. No: Z-15

Layer: 3

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 12 cm, Width: 5 cm

Condition: Slightly broken

Description: This bone has a broader head and narrower posterior end. The posterior of the bone is broken on which few crevices are also visible. Head of the bone is specialized for forming a joint.

Floating rib of Cow (Pl. 10, Fig. 75)

Object: Bone

Site: Badalpur

Inv. No: BP-13

Locus. No: Entrance

Layer: 1

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 10.5 cm, Width: 4.2 cm

Condition: Broken

Description: Floating ribs are present at the end of the rib cage. These ribs are not articulated with sternum. For this reason these are called floating ribs. This floating rib has upper hook like structure which is broken from its tip. The larger curve of the bone is intact.

Rib of Cow (Pl. 11, Fig. 77)

Object: Bone

Site: Badalpur

Inv. No: BP-14

Locus. No: BP-Y16, Cell # 9

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 12.5 cm, Width: 5.4 cm

Condition: Broken

Description: Ribs are units of rib cage. These combine to form a structure called diaphragm which is specialized to cushion delicate organs. This rib is broader in width and is shorter in length. But both left and right sides are broken. Left end is somewhat sharp at the edge.

Rib of Cow (Pl. 11, Fig. 79)

Object: Bone

Site: Badalpur

Inv. No: BP-15

Locus. No: BP-Y16, Cell # 9

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 17.7 cm, Width: 5 cm

Condition: Broken

Description: This is a splited piece of rib which has also both ends sharpen. It is deeply curved from inner side.

Distal humerus of Ox (Pl. 12, Fig. 81)

Object: Bone

Site: Badalpur

Inv. No: BP-10

Locus. No: BP-Y 16, Cell # 9

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 12.3 cm, Width: 7.2 cm

Condition: Cracked

Description: This is a bone of forelimb. On one end it is attached with shoulder bone and from lower end it is attached to radius and ulna. This bone has pigmented surface and is broken from posterior side. Small holes are scattered on the surface of upper end.

Scapula of Bull (Pl. 12, Fig. 83)

Object: Bone

Site: Badalpur

Inv. No: BP-11

Locus. No: Cell # 2

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 6 cm, Width: 6 cm

Condition: Damaged

Description: Scapula is the shoulder bone and is three dimensional. It is badly broken and only a middle portion of the whole bone is visible in the picture. There are various porous patches on its surface. A large brown stein is present on broader upper side.

Ulna (Left Forelimb)of Bull (Pl. 13, Fig. 85)

Object: Bone

Site: Badalpur

Inv. No: BP-12

Locus. No: Courtyard

Layer: 3

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 12.2 cm, Width: 5.5 cm

Condition: Slightly broken

Description: This bone is the broken upper edge of the ulna. The lower half of the bone is badly broken. There are number of steins which are visible on its surface.

Left Maxilla of Buffalo Calf (Pl. 13, Fig. 87)

Object: Bone

Site: Badalpur

Inv. No: BP-16

Locus. No: BP-Y16, Cell # 9

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 17.7 cm, Width: 5 cm

Condition: Broken

Description: The upper jaw of calf buffalo is weight in weight. This is the supporting bone to which teeth are attached. Its tip is broken from right side and the posterior part of the bone is broader wedged shape. Three teeth are attached to its lower end but a depression is empty in between teeth. The posterior tooth is molar and a depression before it shows that there will be another molar at this place. Two teeth on anterior side are pre-molars.

Thoracic Vertebrae of Buffalo (Pl. 14, Fig. 89)

Object: Bone

Site: Badalpur

Inv. No: BP-17

Locus. No: Courtyard

Layer: 3

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 8 cm, Width: 5.2 cm

Condition: Broken

Description: Vertebrae are functional units of vertebral column. This vertebra is lighter in weight and is covered with pores from upper and lower sides. Its upper side has a deep curve. There is a small depression in between these two sides. Two small projections are present on both sides. Green pigmentation is seen on its surface.

Distal end of femur of Mule (Pl. 14, Fig. 91)

Object: Bone

Site: Badalpur

Inv. No: BP-18

Locus. No: Z-15

Layer: 3

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 8.5 cm, Width: 5 cm

Condition: Slightly broken

Description: Femur is the longest bone of the body. This is distal end of femur to which tibia and fibula are attached. Its anterior end is broader in shape and posterior end is elongated and broken.

Rib of Donkey (Pl. 15, Fig. 93)

Object: Bone

Site: Badalpur

Inv. No: BP-19

Locus. No: Cell # 1

Layer: 1

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 14.2 cm, Width: 3 cm

Condition: Cracked

Description: Ribs of the donkey are heavy in weight. This rib is broken from upper side and from left and right sides. There is a slight curve on lower side of the rib. Few cracks are seen on its surface.

Hoof of Donkey (Pl. 15, Fig. 95)

Object: Bone

Site: Badalpur

Inv. No: BP-20

Locus. No: BP-Y 16, Cell # 9

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 5.7 cm, Width: 6.5 cm

Condition: Intact

Description: Hoof is lighter in weight. It is semicircular in shape. And there is a deep depression on its surface which shows a place for the attachment of other bones. Its surface is porous and has long slightly deep crevices.

Thoracic Vertebrae of Horse (Pl. 16, Fig. 97)

Object: Bone

Site: Badalpur

Inv. No: BP-21

Locus. No: Cell # 2

Layer: 2

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 5 cm, Width: 7.5 cm

Condition: Broken

Description: It is lighter in weight and broader in volume. Several curves and depressions are seen on its surface which shows small holes.

Tibia of Horse (Pl. 17, Fig. 99)

Object: Bone

Site: Badalpur

Inv. No: BP-22

Locus. No: Courtyard

Layer: 3

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 18 cm, Width: 4 cm

Condition: Slightly broken

Description: This bone is below femur. Tibia has a long groove in the middle. Its anterior end is broader and the posterior one is elongated and broken. It has greenish steins on its surface.

Femur of Horse (Pl. 18, Fig. 101)

Object: Bone

Site: Badalpur

Inv. No: BP-23

Locus. No: Courtyard

Layer: 3

Material: Calcium Carbonate ($CaPO_4$)

Size: Length: 22.2 cm, Width: 6 cm

Condition: Damaged

Description: It is the longest bone. It has undulating anterior end and posteriorly broken. It consists of remarkable width having deep cracks.

Teeth of Horse (Pl. 19, Fig. 103)

Object: Bone

Site: Badalpur

Inv. No: BP-24

Locus. No: Courtyard

Layer: 3

Material: Calcium Phosphate ($CaPO_4$)

Size (1): Length: 6.7 cm, Width: 3.9 cm

Size (2): Length: 7 cm, Width: 3.5 cm

Condition (1): Intact

Condition (2): Intact

Description (1): Teeth of the horse are wavy from upper side. Two roots of it are jointed with each other while another one is free and curved. Its surface is covered with plaque.

Description (2): This set of teeth is also wavy and pointed from upper side. Its roots are broken. Roots of teeth of right side are missing only the left root is minorly projecting.

Bone Artifact (Knitting tool/Needle) (Pl. 19, Fig. 105)

Object: Bone

Site: Badalpur

Inv. No: BP-25

Locus. No: X-15

Layer: 3

Material: Calcium Phosphate ($CaPO_4$)

Size: Length: 8 cm, Width: 1 cm

Condition: Broken

Description: This is a needle which is made from interior spongy bone. Its anterior side is pointed. It might be used to make holes in hides or other stuffs etc. Its exterior is uniformly refined.

Appendix

Plate # 1

Fig. 50, A general view of Saraikhola, Taxila Valley (Halim, Pakistan Archaeology 1972)

Fig.51, A general view of Hathial, Taxila Valley (Khan. G. M 1983)

Plate # 2

Fig.52, A general view of Bhir Mound, Taxila Valley (Photograph taken by researcher)

Fig.53, A general view of Sirkap, Taxila Valley (Photo taken by researcher)

Plate # 3

Fig.54, A general view of Dharmarajika monastery, Taxila Valley (Photo of Japanese Archaeological Mission: 1988)

Fig.55, A general view of Jinan Wali Dheri, Taxila Valley (Photograph taken by researcher)

Plate # 4

Fig.56, A general view of Badalpur, Taxila Valley (Photograph taken by researcher)

Fig.57, Phallenges of Infant cat

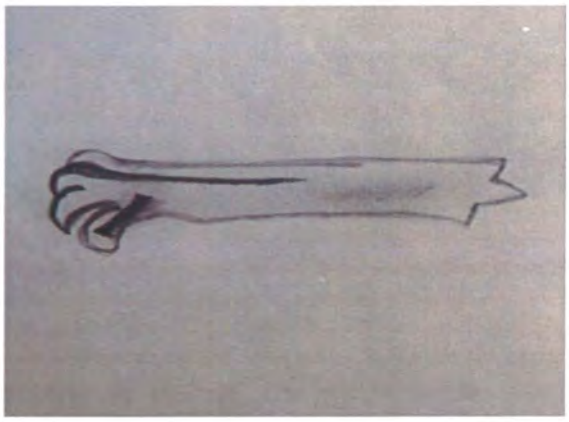

Fig.58, Sketch of Phallenges of Infant cat

(Photographed and Sketched by researcher)

Plate # 5

Fig.59, Fibula of Infant cat

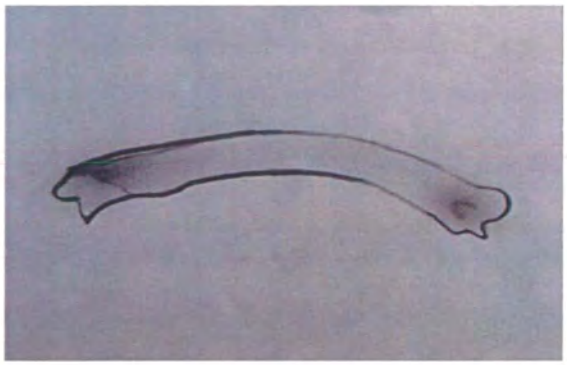

Fig.60, Sketch of fibula of Infant cat

(Photographed and Sketched by researcher)

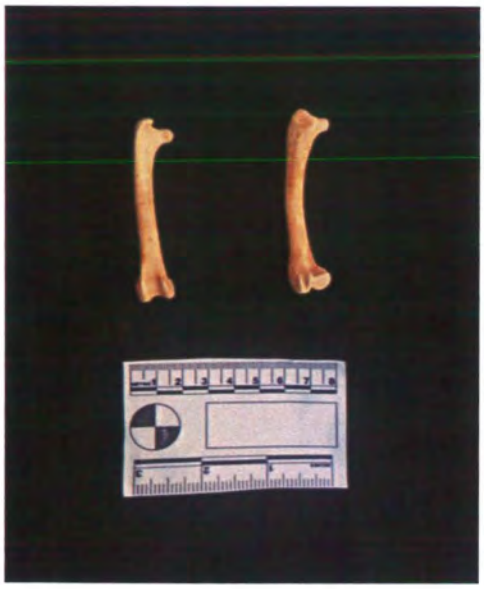

Fig.61, Femur of Infant cat

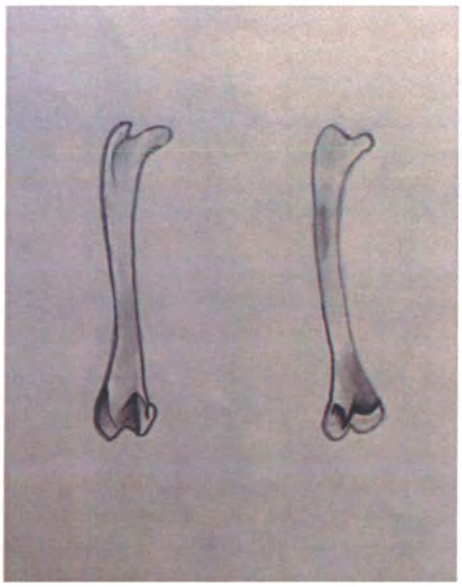

Fig.62, Sketch of femur of Infant cat

(Photographed and Sketched by researcher)

Plate # 6

Fig.63, Distal humerus of jackal

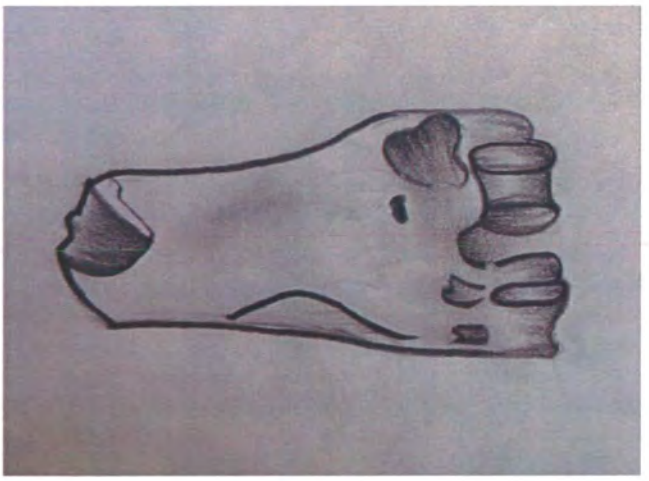

Fig.64, Sketch of distal humerus of jackal

(Photographed and Sketched by researcher)

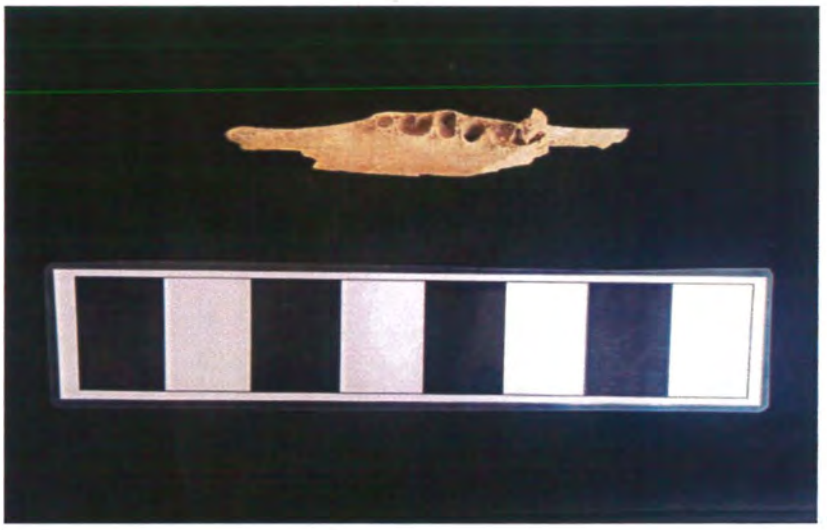

Fig.65, Maxilla of goat

(Photographed by researcher)

Plate # 7

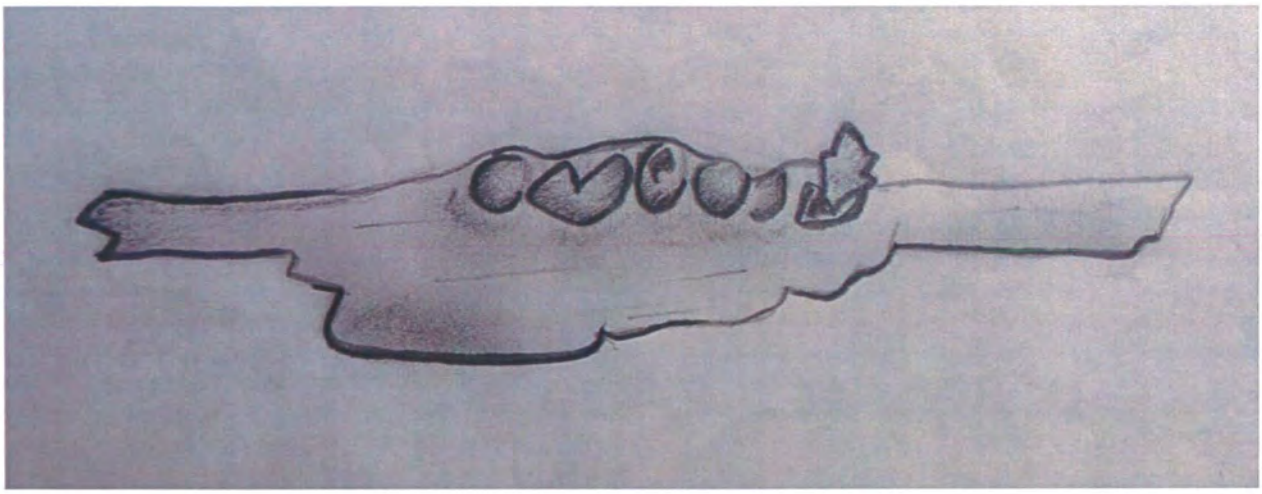

Fig.66, Sketch of Maxilla of goat

(Sketched by researcher)

Fig.67, Spinal cord of goat

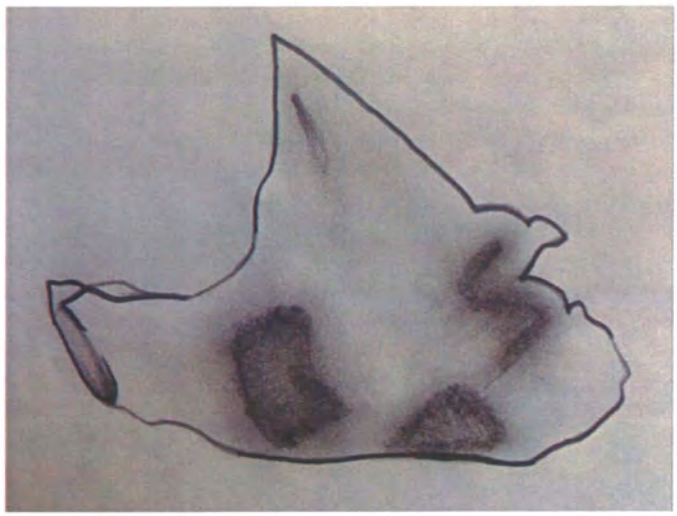

Fig.68, Sketch of spinal cord of goat

(Photographed and Sketched by researcher)

Plate # 8

Fig.69, Lumber vertebrae of goat

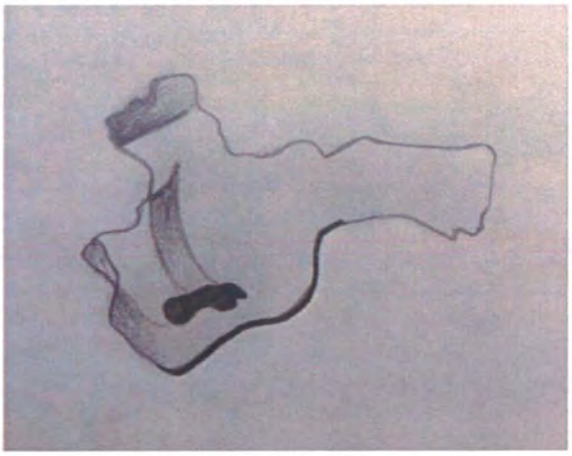

Fig.70, Sketch of lumber vertebrae of goat

(Photographed and Sketched by researcher)

Fig.71, Scapula of sheep

(Photographed by researcher)

Plate # 9

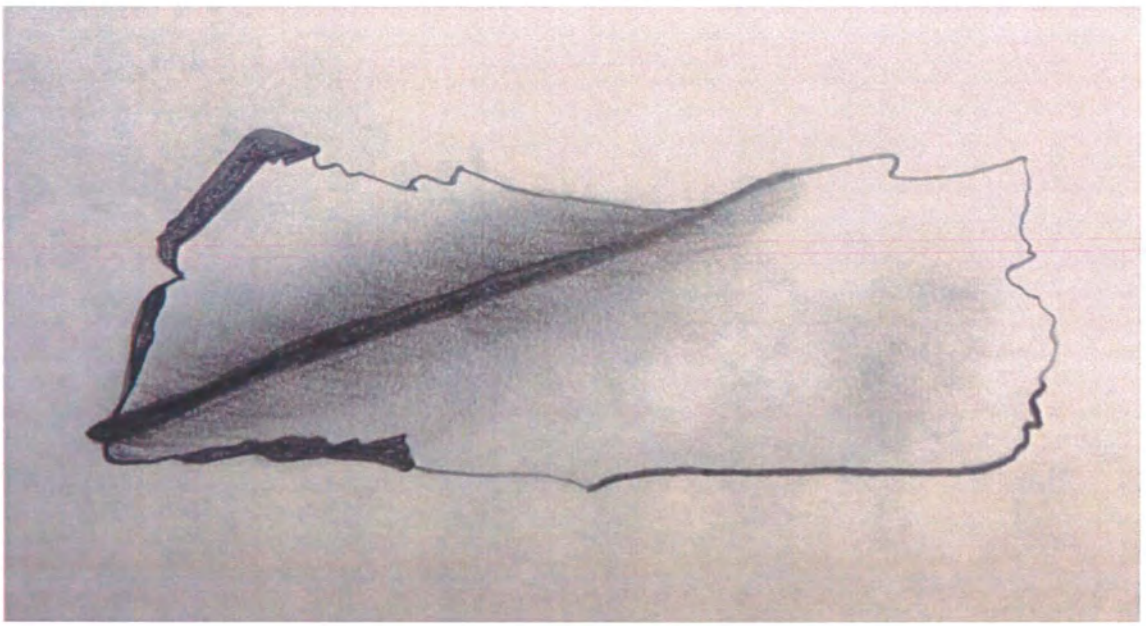

Fig.72, Sketch of Scapula of Sheep

(Sketched by researcher)

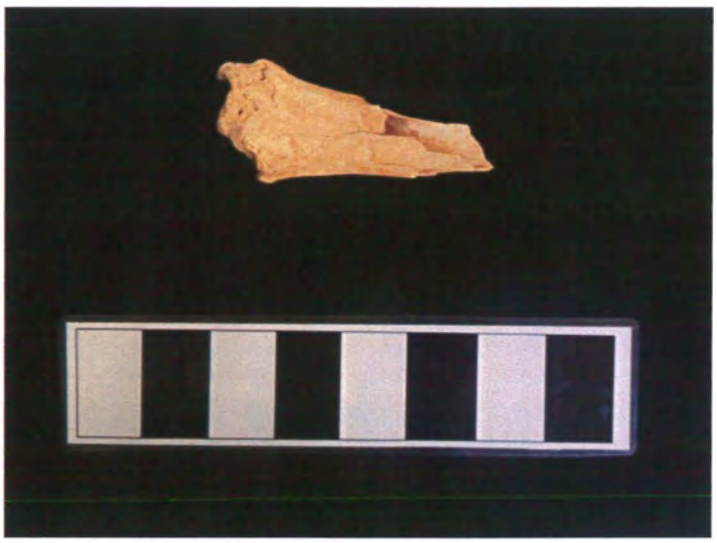

Fig.73, Distal femur of calf

(Photographed by researcher)

Plate # 10

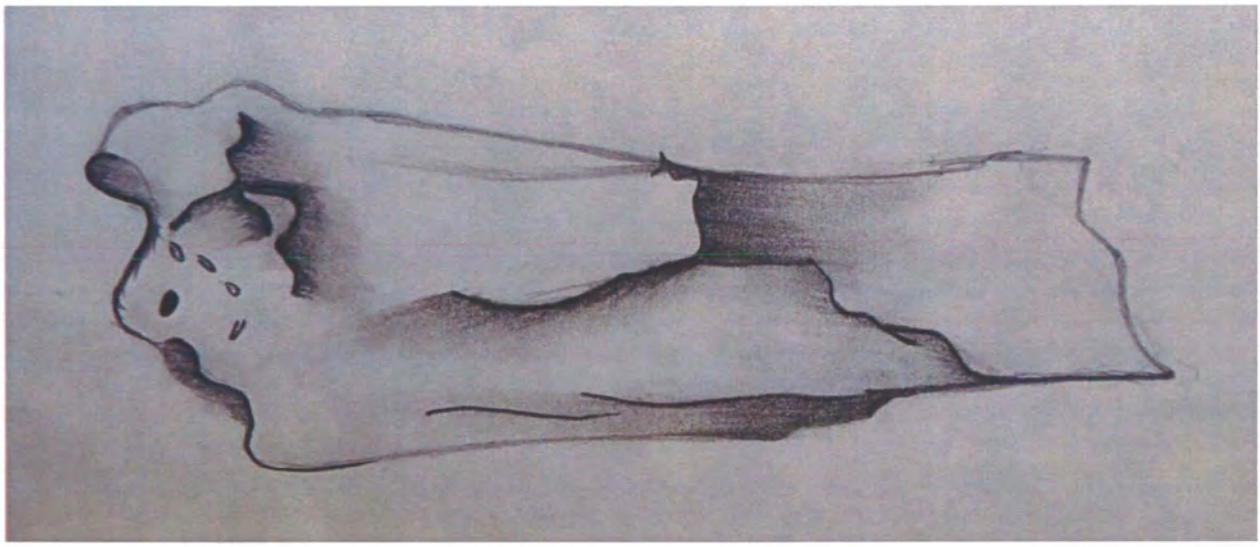

Fig.74, Sketch of Distal femur of calf

(Sketched by researcher)

Fig.75, Floating rib of cow

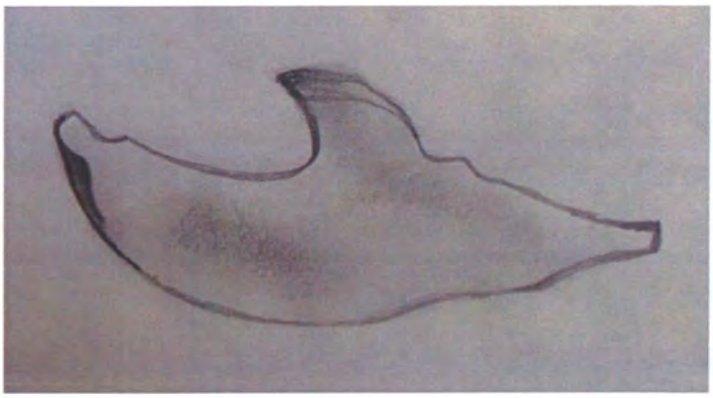

Fig.76, Sketch of floating rib of cow

(Photographed and Sketched by researcher)

Plate # 11

Fig.77, Rib of cow

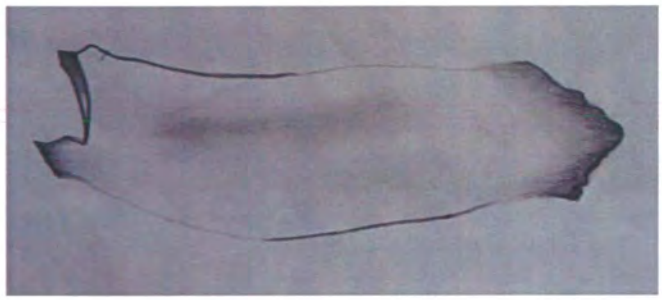

Fig.78, Rib of cow

(Photographed and Sketched by researcher)

Fig.79, Rib of cow

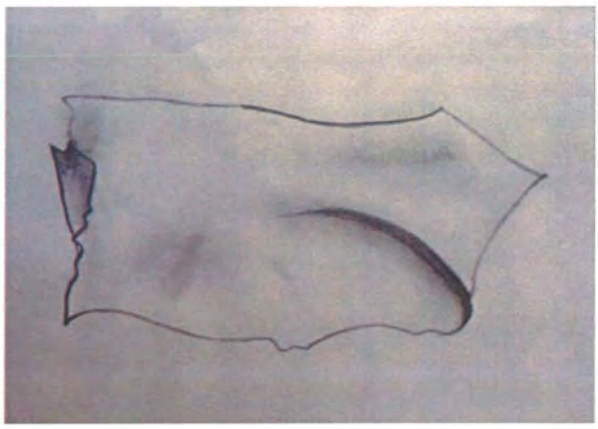

Fig.80, Sketch of rib of cow

(Photographed and Sketched by researcher)

Plate # 12

Fig.81, Distal humerus of Ox

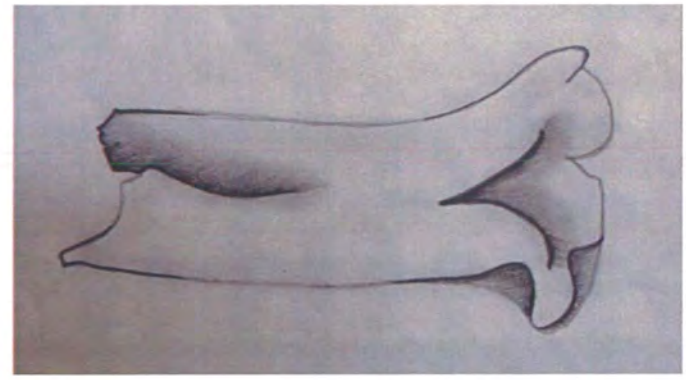

Fig.82, Sketch of distal humerus of Ox

(Photographed and Sketched by researcher)

Fig.83, Scapula of Bull

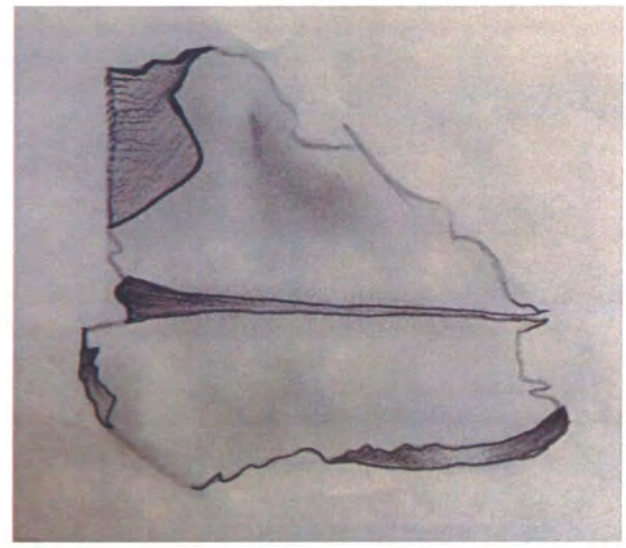

Fig.84, Sketch of scapula of bull

(Photographed and Sketched by researcher)

Plate # 13

Fig.85, Ulna of Bull

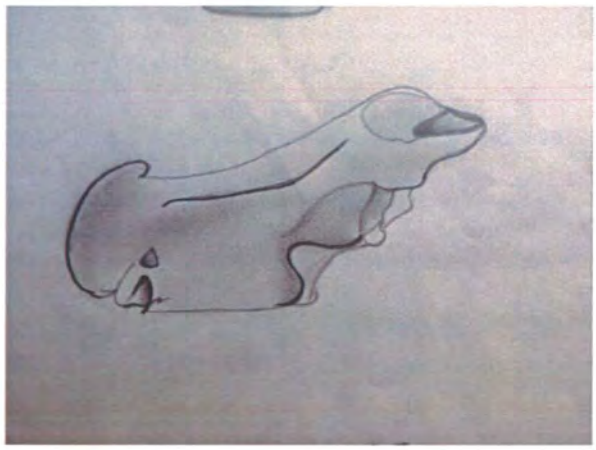

Fig.86, Sketch of Ulna of bull

(Photographed and Sketched by researcher)

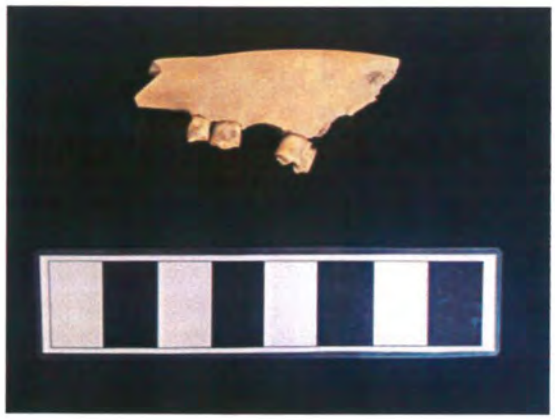

Fig.87, Maxilla of Buffalo

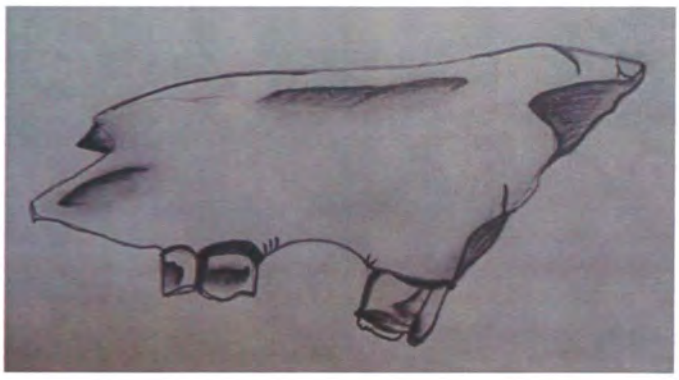

Fig.88, Sketch of Maxilla of Buffalo

(Photographed and Sketched by researcher)

Plate # 14

Fig.89, Thoracic Vertebrae of Buffalo

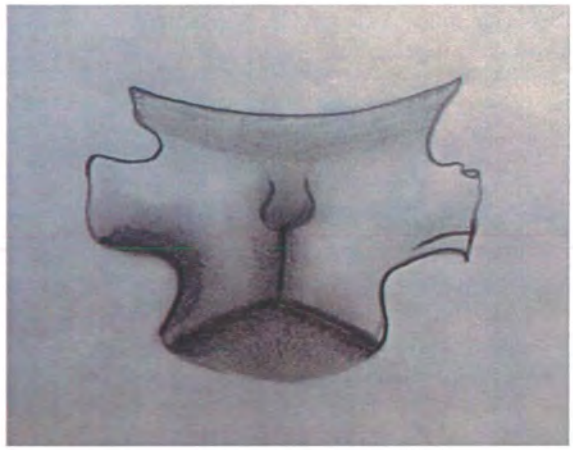

Fig.90, Sketch of thoracic vertebrae of buffalo

(Photographed and Sketched by researcher)

Fig.91, Distal Femur of Mule

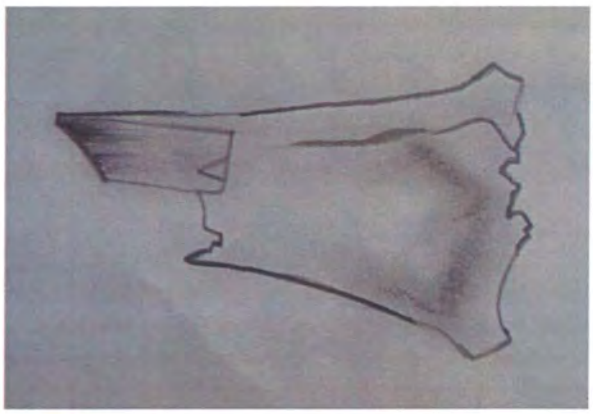

Fig.92, Sketch of distal femur of Mule

(Photographed and Sketched by researcher)

Plate # 15

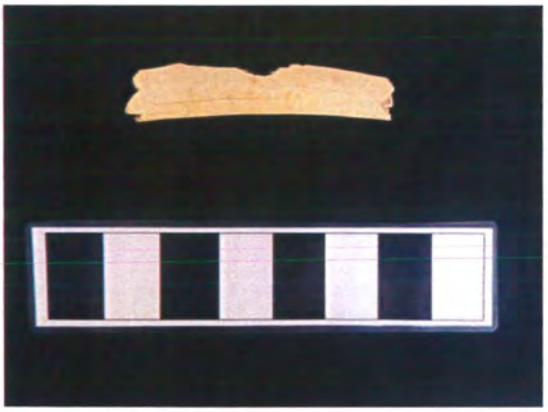

Fig.93, Rib of Donkey

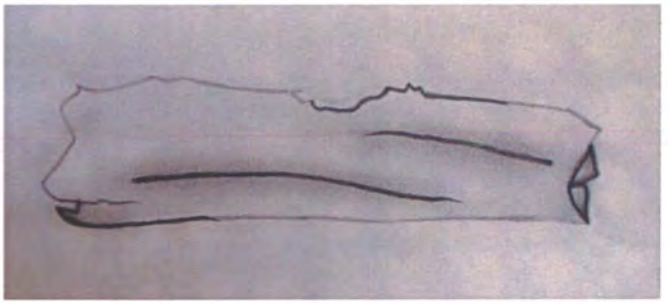

Fig.94, Sketch of rib of donkey

(Photographed and Sketched by researcher)

Fig.95, Hoof of Donkey

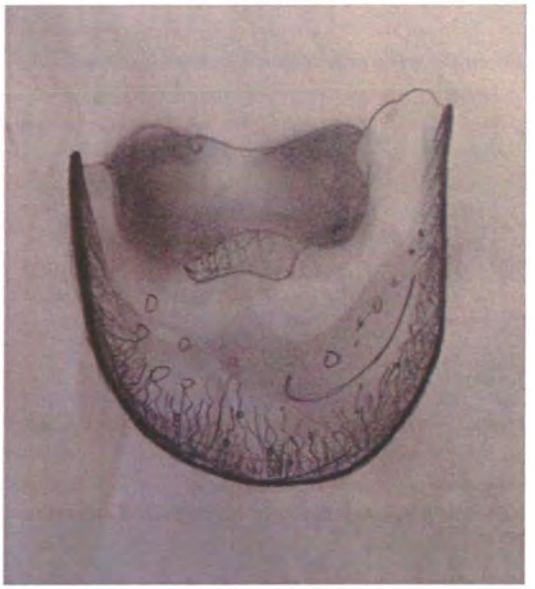

Fig.96, Sketch of hoof of donkey

(Photographed and Sketched by researcher)

Plate # 16

Fig.97, Thoracic vertebrae of Horse

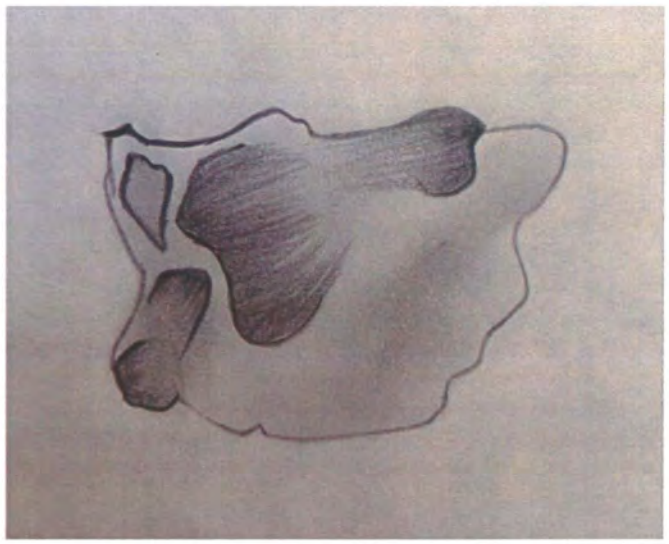

Fig.98, Sketch of thoracic vertebrae of horse

(Photographed and Sketched by researcher)

Plate # 17

Fig.99, Tibia of Horse

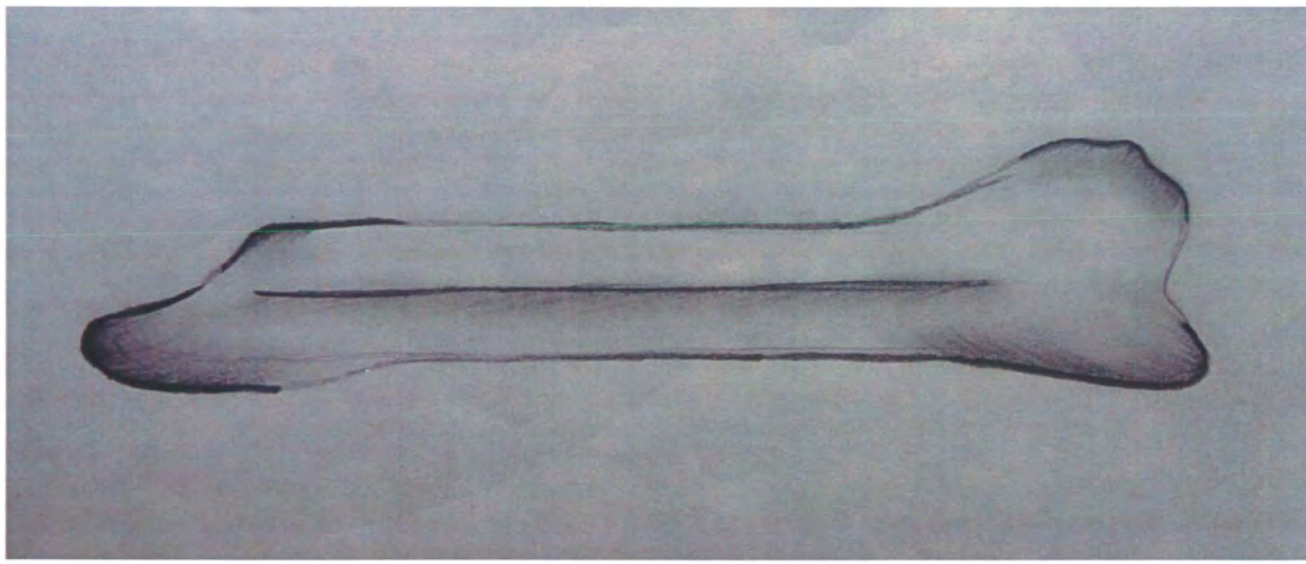

Fig.100, Sketch of tibia of horse

(Photographed and Sketched by researcher)