

**KHIRBAT AL-MUDAYNA: A
PRELIMINARY FAUNAL REPORT**

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Abstract

Khirbat al-Mudayna on the Wadi ath-Thamad is an Iron Age II site in central Jordan located on the northern border of ancient Moab. Excavation of Mudayna by field school students from Wilfrid Laurier University and the University of Saskatchewan has been ongoing since 1996 and will continue in 2001. This study presents a preliminary analysis of over 8000 animal bones that have been recovered from Mudayna since excavation began.

The analysis of the faunal remains is based around theories of sheep and goat herd management strategies, developed by Redding, and meat distribution strategies developed by Zeder. It also considers the food systems theories that LaBianca has proposed in his work with the faunal remains at Tell Hesban. The types and amounts of faunal material recovered from Mudayna are compared with the fauna excavated at Hesban, located 30 kms northwest of Mudayna, as they are the only extensive collection of fauna reported on from the Iron Age Transjordan.

Analysis of the Mudayna faunal material shows that herd security was the primary goal of the Iron Age herders and a system of direct to consumer distribution was in place at Mudayna. The Mudayna fauna confirms LaBianca's theories about the nature of the Transjordanian Iron Age tribal kingdoms. The fauna demonstrate the importance of tribal connections within the society as well as emphasize the lack of distinction between the "urban elite" and the "rural tribesman". The Mudayna fauna also show that the Iron Age environment was more lush than today, supporting richer pasture, shrubs and trees. This faunal analysis will be useful as a comparative tool for future work in Transjordan.

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For my parents, who taught me
about unconditional love

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Chapter 1

Introduction

1.1 General Introduction

The Wadi ath-Thamad project began in 1995 under the guidance of project director P.M.M. Daviau (Wilfrid Laurier University). It is focused around the site of Khirbat al-Mudayna on the Wadi ath-Thamad located some 20 km southeast of Madaba, Jordan (Figure 1.1). Khirbat al-Mudayna is a small, fortified Moabite site on the northern Moabite plateau. It sits on the ancient border between Iron Age Moab and Ammon. For clarity it must be noted that Khirbat al-Mudayna on the Wadi ath-Thamad is the northernmost of six sites in Jordan that share the name Khirbat al-Mudayna (Daviau *et al.* 2000:1). Khirbat al-Mudayna on the Wadi ath-Thamad is located on the Palestinian Grid at 236.220 east/ 110.920 north and is site number 2311.014 in JADIS (Palumbo 1994:2.133).

The project has three major components: 1) the excavation of the Iron Age occupation of Khirbat al-Mudayna, 2) the excavation of the Roman/Nabataean occupation of Khirbat al-Mudayna, and 3) a 10 km² regional site survey centered on Khirbat al-Mudayna. Taken together it is hoped that these three components will provide information about the Iron Age settlement of the area as well as offer evidence of Mudayna's religious, cultural and political associations (Daviau 1997: 222). In 1995, a four-day surface survey of Mudayna took place to collect basic information about the ceramics found at the Iron Age site. From 1996 to 1999, students from Wilfrid Laurier University excavated both the Iron Age and the Roman/Nabataean occupations of Mudayna. In 1998 and 1999, students from the University of Saskatchewan also participated in the Mudayna field school. No excavation took place at Mudayna during the summer of 2000, but work will continue at the site in 2001. The regional survey around Mudayna, directed by A. Dearman (Austin Presbyterian Seminary) from 1996-1997 and C. M. Foley (University of Saskatchewan) from 1998-1999, will continue in 2001.

This thesis is a preliminary analysis of the faunal remains excavated from the Iron Age occupation of Mudayna during the 1996 - 1999 seasons. The faunal remains from the Roman/Nabataean occupation at Mudayna have not been analyzed and will not be discussed

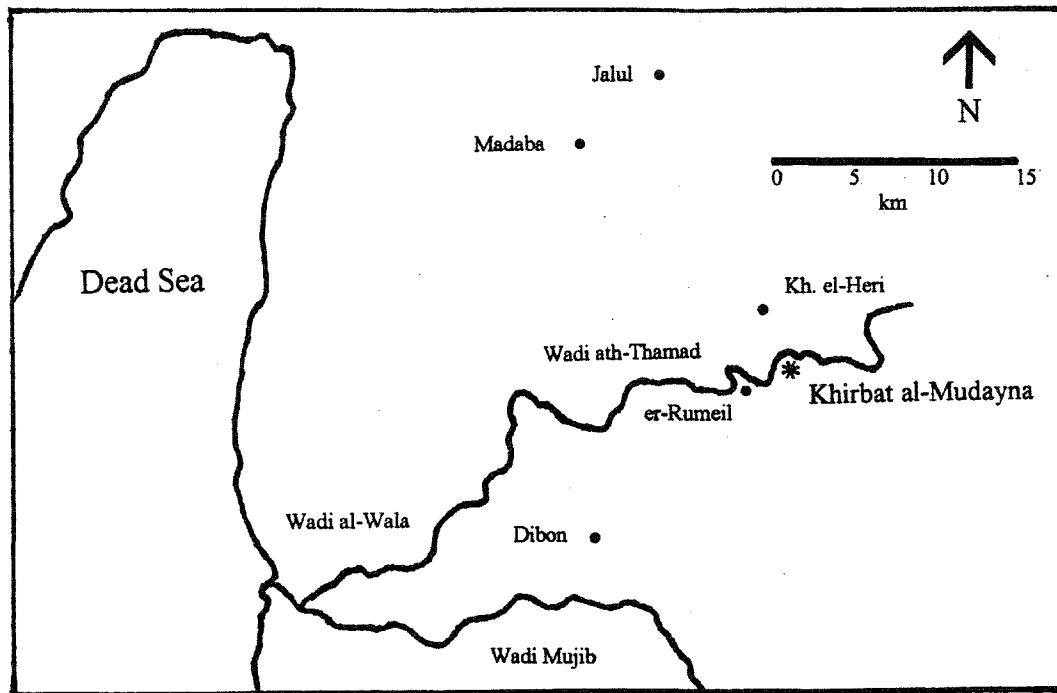


Figure 1.1 Map of central Jordan including Khirbat al-Mudayna, Dibon, Madaba and Jalul (Adapted from Daviau and Steiner 2000: Figure 1)

within this thesis. A total of approximately 500m² or 5% of the Iron Age occupation has been exposed, all of which is located at the northern end of the site. Excavation began at the northern end of the site because the initial survey correctly indicated the likelihood of a large gate complex located there. Besides the gate complex, excavation has revealed a small shrine and an adjacent courtyard both located just interior (south) to the gate (Figure 1.2).

The analysis of the Iron Age faunal remains presented in this thesis is preliminary for several reasons. First and most obviously, the excavation of Mudayna is not yet complete and probably will not be so for another five seasons. New data may yet arise necessitating a reinterpretation of the present data. As more material is excavated from a site, the chances of finding identifiable pieces of rare taxa at that site increase (Driesch and Boessneck 1995:90). The rarest and most interesting animals identified from a site are often those species represented by a single bone find. Secondly, no domestic structure or refuse deposit has been excavated. The faunal assemblage from the public areas excavated (gate, courtyard, and shrine) may differ from an assemblage excavated from a domestic structure or a refuse deposit (Zeder 1988:21).

Despite some possible shortcomings, the preliminary nature of this assemblage does not diminish the value of the analysis. Over 8000 bone fragments were studied for this project, a

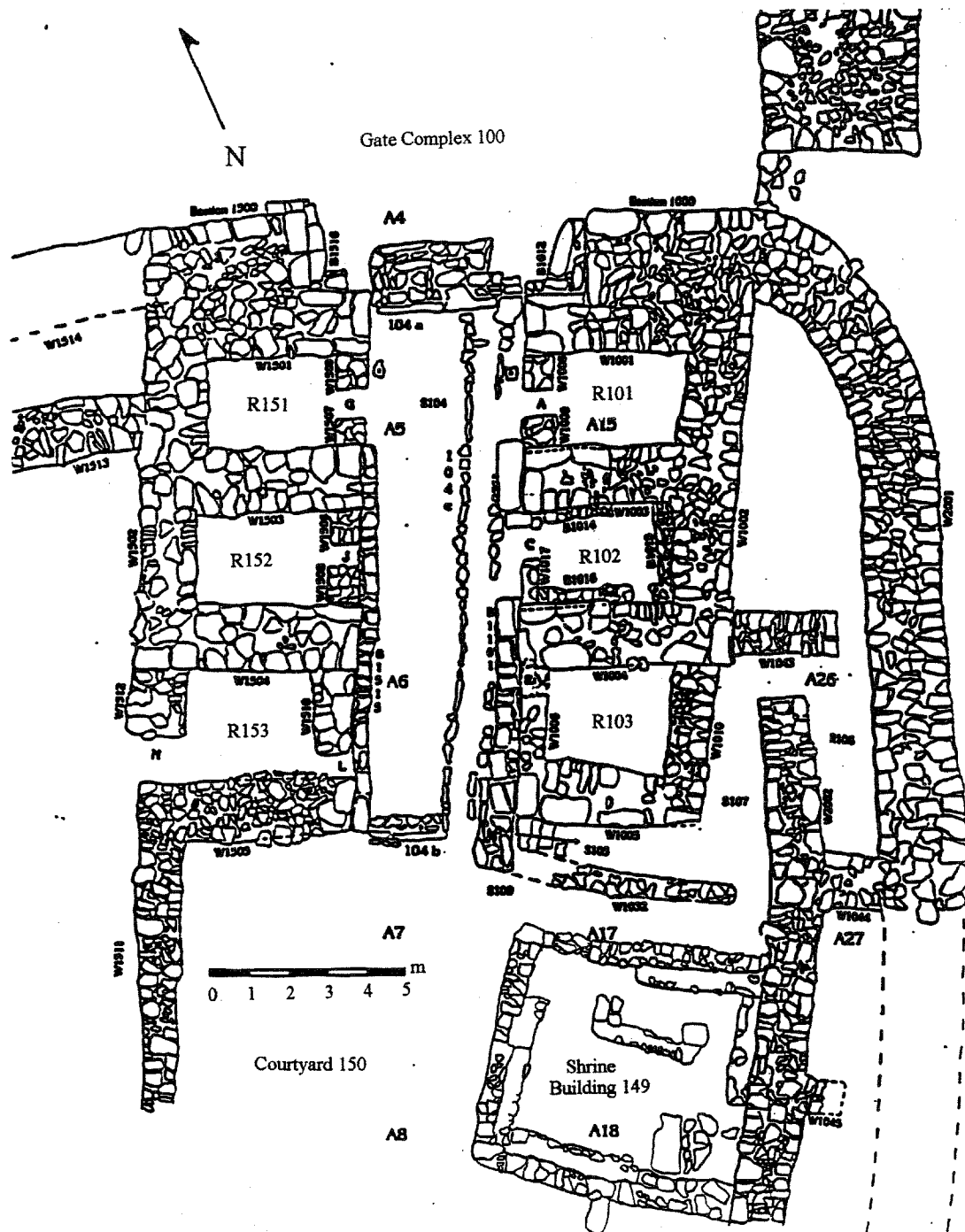


Figure 1.2 Plan of Khirbat al-Mudayna including Gate Complex 100, Courtyard 150, Building 149 and the northeastern casemate wall
(Adapted from Daviau et al. 2000: Figure 2)

significant figure when one considers that they all originate from a single period, namely Iron II (1000-586 B.C.E.). Preliminary reports are both necessary and common from many of the major excavations in the Near East (Hohlfender 1988; Rollefson and Simmons 1988; Seger *et al.* 1990; Richard 1990; Geraty *et al.* 1990; Daviau 1993, 1994, 1996). If large excavations did not publish preliminary reports, nothing would be written about the site for years or decades (a nasty habit many archaeologists are attempting to break). So while the analysis of the Mudayna faunal remains will be open to reinterpretation in light of new data, a preliminary interpretation is warranted.

1.2 History and Politics of Iron Age II Moab

Considered in isolation, the faunal remains from Khirbat al-Mudayna are interesting, but provide limited information about Iron Age life in Moab. It is only by considering the faunal remains within an historical and political context that they may offer evidence in support of (or refuting) current ideas about Iron Age Moabite lifestyles. To that end, a brief recounting of Moabite history and particularly the Moabite political situation within the Iron Age is presented.

During the Iron Age II, Moab was a small state, or tribal kingdom, whose political fortunes were largely dictated by the activities of its larger neighbours, particularly Israel, Syria and Assyria, but also to a lesser extent Judah, Ammon and Edom. Egyptian influence within Moab during the Iron Age is present but quite limited (Worschech 1997: 232). The ancient literary sources discussing Moab are few and, save for the Mesha stele (Moabite stone), all are written by non-Moabites. The two largest sources mentioning Moab are the Old Testament and various Assyrian texts recounting military actions and tribute lists. The historical accuracy of all of these documents, including the Mesha stele, is debatable, but when combined, a reasonably accurate general chronology of rulers and major military actions may be pieced together.

Early in the Iron II, the Israelite king David claimed the northern portion of Moab for Israel. It is thought that, besides annual tributes paid to Israel, the political organization within Moab was not affected by David's expansion because the King of Moab maintained his throne as an Israelite vassal (Bernhardt 1982: 164). Moab remained in vassalage under Solomon's rule and possibly until some time after Ahab's death (852 B.C.E.) (Bernhardt 1982: 164). Other scholars have suggested, however, that Moab won its independence after Solomon's death (ca. 930 B.C.E.) and remained free until Omri reasserted Israelite control around 880 B.C.E. (Dearman 1989: 156), at which point Moab was again subjugated until after Ahab's death. Omri was an Israelite army commander who became king of Israel and began a powerful but short-lived dynasty that ended with the assassination of the fourth Omride king Jehoram by another

Israelite army commander Jehu in 842 or 841 B.C.E. (Dearman 1989: 157). Omri was succeeded by his son Ahab, who was in turn succeeded by his son Ahaziah. Ahaziah passed the kingship to his brother Jehoram, the last of the Omrides.

The Mesha stele, the only lengthy text recovered from Moab to date, refers to events that are thought to have occurred sometime between the final years of Ahab's reign (855-852 B.C.E.) and the earliest years of Jehu's succession (842-830 B.C.E.) (Dearman 1989: 163). The Mesha stele is a memorial inscription (Drinkard 1989: 154) that proclaims the victory of Mesha, king of Moab, over the Israelite house of Omri that had oppressed Moab for "many days" (read 'years') because Kemosh (Moab's principle deity) was angry with his people. Because the exact date of the Moabite revolt is unknown, several reconstructions of the politics behind the revolt have been proposed depending on whether it took place before or after Ahab's death. If Ahab was still alive, and if the Aramaean wars mentioned in 1Kings 20 and 22 may be dated to his reign, then Moab may have revolted from Israelite control when the Israelites were distracted by the Aramaeans. Dearman (1989: 164) suggests that Moab may have been encouraged to revolt by the Aramaeans who hoped to divide the Israelite troops. If the Aramaean wars are not linked with Ahab's reign, another possible scenario for Moab's revolt exists, based around the anti-Assyrian coalition formed in the Levant at the time in preparation for an Assyrian invasion. Ahab may have ceded Moab's territory back to Mesha in return for their unlimited support in the coalition (Dearman 1989: 167). Once all of the Israelite troops had been removed from Moab, and the Assyrians were the focus of Israelite attention, Mesha took the opportunity (perhaps with the Assyrians' blessing), after Ahab's death, to revolt.

Beginning in the mid-ninth century B.C.E., the Assyrians were the major influence on the political realities of Transjordan. The Assyrian king Shalmaneser III staged half a dozen campaigns into southern Syria beginning in 853 B.C.E. with the battle at Qarqar (Eph'al 1982: 75). In 805 B.C.E., Adad-nirari III defeated the king of Damascus (Syria) and imposed tribute on territories as far south as Edom (Eph'al 1982: 76). While Moab was not mentioned in the inscriptions detailing the tribute payments, it is inconceivable that Assyria would not have demanded some type of tithe from Moab. The Assyrian army did not penetrate into Transjordan until Tiglath-Pileser III's campaigns in 734-732 B.C.E. (Bennett 1982: 181). Tiglath-Pileser III kept detailed enough records that the kings of all of the small Transjordanian states (Sanipu of Ammon, Salamanu of Moab and Kaush-Malaku of Edom) are recorded on his tribute lists (Bennett 1982: 181). Assyria remained the strongest power in Transjordan until the end of the seventh century B.C.E. when the Babylonians came to power. By 599/8 B.C.E., Moabite troops were fighting under Babylonian command against Judah, who had rebelled against

Nebuchadnezzar in 600 B.C.E. (Eph'al 1982: 172). The Babylonians remained a major power, fighting with Egypt for control of the region, until well after the Iron Age II period is considered to have ended (586 B.C.E.).

1.3 Previous Work

Khirbat al-Mudayna on the Wadi ath-Thamad has been known to archaeologists since the late 19th century (Daviau 1997:222). At the beginning of the 20th century Brünnow and Domszewski (1904 figs. 14, 15) published sketches and descriptions of Mudayna and a few years later Musil (1907: figs. 136, 137) published photographs and a plan view of the site. In the 1930s Nelson Glueck (1934:13-32) visited Mudayna and performed a surface survey collecting sherds and figurines. After the 1930s, no archaeological work occurred at Mudayna until the beginning of the Wadi ath-Thamad project in 1995. Generally, little archaeological work took place in Moab between Glueck's excursions and the 1960s. Since the 1960's a small number of significant archaeological sites have been excavated in Moab and Ammon (Moab's northern neighbour) including Hisban (ancient Heshbon), Tall al-Umayri, Tall Jalul, Lehun, Tall Jawa and Khirbat al-Mudayna on the Wadi ath-Thamad (Miller 1997:200). Most of these excavations and their accompanying surveys were organized under the umbrella of the Madaba Plains Project. The Madaba Plains Project is unique because its central theoretical focus is on the use of various food systems employed by Transjordanian tribal groups during the Iron Age (Herr *et al.* 1997:145). A short examination of food systems theories as a potential framework for the interpretation of the faunal material excavated at Mudayna is presented below.

Just as the number of sites which have been excavated in Moab is limited, the amount of effort which has gone into systematically studying and publishing the faunal remains from these sites, and Near Eastern sites in general, also is limited. Near Eastern faunal reports that do appear in the literature often derive from work done at sites dating to the Neolithic period or older. One reason for the prehistoric focus of these zooarchaeological reports is the importance of animal domestication as an indicator of a major prehistoric economic shift. Although archaeologists know the general location and time that domestication occurred for most animals in the Near East, the quest to refine these dates and locations is a major occupation for many zooarchaeologists.

Another reason zooarchaeological analysis has not featured prominently in Near Eastern archaeological reports has to do with the emphasis traditionally placed on ceramic, architectural, and when possible textual studies. Ceramics, architecture and texts were (and often still are) the primary foci of study because they could best answer the questions biblically oriented Near

Eastern scholars were asking. Questions of Israelite settlement patterns, the Exodus route and a general confirmation of the Bible as a historical document were all on the table, and it did not appear that wasting time with some dusty old goat bones would facilitate solutions. Even during the “New Archaeology” phase of the 1960s and 1970s, the few Near Eastern processualists focused their scientific study of animal remains on the less popular prehistoric sites (Trigger 1989:385). In his Harvard Ph.D. dissertation, Lipovitch (1999:14) presents a wonderful quote by Charles Reed describing a typical archaeologist of the 1960s as someone who

does not usually understand bones, and considers them to be unpleasant biological matters, a second-class category of objects, to be treated with less care, to be chopped across in cleaning a vertical excavation face, to be saved perhaps if they are hard but to be destroyed if pressing or if they are soft, or perhaps to be tossed on the dump-heap willy-nilly whether salvageable or not (Reed 1963:204).

Perhaps it is fortunate the intensive archaeological study of Moab blossomed recently and so avoided the excavation (destruction) of many important sites in a method we would consider today as unscientific. Excavations associated with the Madaba Plains Project operating in the region, particularly the Hesban project, have invested a great deal of effort into the study of the faunal material. They have used the faunal assemblage as part of their five parameters of food systems conditions (environmental, settlement, landuse, operational and dietary) (LaBianca 1990:12) to explain the intensification and abatement of the Transjordanian population through time. If all of the excavations of Moabite sites continue with this tradition, eventually a database of sufficient proportions will be developed enabling archaeologists to see a much clearer picture of both ancient faunal distribution and lifeways and ancient human distribution and lifeways.

1.4 The Nature of the Moabite State/Kingdom

Recently scholars such as LaBianca (1990: 39-40, 1999: 20-23) and Younker (1997: 246) have argued that while Moab displayed a number of material traits consistent with state society, it may best be thought of as a tribal kingdom. LaBianca (1999: 20-23) offers ten characteristics that he believes encapsulate the important features of a tribal kingdom, several of which are presented here as they apply particularly well to Khirbat al-Mudayna and this study. LaBianca’s first hypothesis is that the “tribal social structure was intimately linked to their way of obtaining food” (LaBianca 1999: 20). It is LaBianca’s belief that by analyzing the food system in use at a site, statements about the type of society that site belonged to may be made. LaBianca defines a food system as a “complex unity consisting of all of the purposive, patterned (institutionalized), and interconnected activities carried out by a group of individuals in order to

procure, process, distribute, prepare or consume food, and dispose of food remains” (LaBianca 1990: 9). The food system concept is particularly useful for archaeologists as it focuses on the daily activities of people and infers larger organizational patterns rather than the other way around. LaBianca suggests the patterns of increased and decreased sedentarization seen in Transjordan through time may be explained as the reaction of tribal groups to climactic, landscape and political changes, encouraging shifts towards either land-tied (agricultural) or range-tied (pastoral) food procurement strategies (LaBianca 1999: 20). Settlement patterns in Iron II Moab show that it was a period of sedentarization (LaBianca 1990: 141) indicating that both climatic and political conditions favored site-based activities like agriculture and large-scale building projects.

The second feature of a tribal kingdom important to this study is that the emergence of kings did not extinguish the existing tribal social structure (LaBianca 1999: 21). A “supra-tribal layer of bureaucratic organization” (LaBianca 1999: 21) is thought to have evolved but importantly, a strong division between rural tribesmen and “urban elite” did not form the way it did in larger state societies such as Egypt and Mesopotamia (LaBianca 1999: 21).

A third hypothesis about Transjordanian tribal kingdoms is that fortified towns acted as administrative centers for rural hinterlands (LaBianca 1999: 21). The ‘fortified towns’ LaBianca mentions have alternately been called ‘border fortresses’ by Glueck and ‘outposts’ by Dearman (Dearman 1997: 205). A fourth hypothesis is that most people did not live within these ‘fortified towns’ but rather in houses, tents or caves adjacent to agricultural or pasture land (LaBianca 1999: 22). Because the ‘fortified towns’ mentioned by LaBianca were not really towns at all, Dearman’s term of ‘outpost’ best represents the function of these sites. Fortified outposts were not constructed with large-scale habitation in mind, as larger fortified cities were. An outpost may have served a multitude of purposes such as administrative/trade center, sanctuary, stronghold, caravanserai, and border/road station, but was never intended to be a ‘town’. The difference is, of course, semantic but nonetheless it is important for the archaeological interpretation of a site’s function. Khirbat al-Mudayna is a classic example of a Moabite fortified outpost. In fact the description LaBianca gives of a typical fortified town “a cluster of administrative buildings located on the top of a hill of some sort and surrounded by ramparts and/or walls and protected by a moat and entered by gates” (LaBianca 1999: 21) seems to be made with Mudayna in mind.

The hypotheses LaBianca proposes for the nature of Transjordanian tribal kingdoms are applicable even when the kingdoms were under Israelite or Assyrian hegemony. As previously mentioned, the structure of Moabite society likely did not change significantly under either

Davidic or Omride vassalage. The same is thought to be true under Assyrian hegemony, as the lives of ordinary people were likely unaffected by the switch in elite political powers (Bennett 1982: 181).

This thesis tests LaBianca's theories about the nature of the Moabite kingdom through the analysis of the faunal remains from Khirbat al-Mudayna. It uses models developed by Redding (1981) that allow archaeologists to understand the strategies employed by ancient herders as well as models developed by Zeder (1986) that allow archaeologists to understand the type of meat distribution system in place at an archaeological site. Used together, these two models allow an understanding of how Mudayna functioned on a daily basis to be reached. They also allow LaBianca's theories about how the Iron Age Moabite kingdom generally functioned to be tested.

1.5 Chapter Summary

The majority of this thesis is taken up by the actual analysis of Mudayna's faunal remains. Chapter two provides background information about the physical nature of Mudayna's environment. Chapter three discusses exactly how the faunal remains were analyzed, both qualitatively and quantitatively. Chapter four details how each individual element was identified. At a historical Near Eastern archaeological site such as Mudayna, most of the bones recovered are from sheep and goats, two animals whose bones are famously difficult to tell apart. It becomes very important, therefore, if any credibility is to be assigned to the faunal report, that the method used to distinguish between these species is stated explicitly. Chapter five presents an analysis of the sheep and goat remains. Specifically it discusses the ratio of sheep to goats, the ages at death of the sheep and goats, the sheep and goat female/male ratio, the distribution of 'meat-rich' and 'meat-poor' sheep and goat bones, a volume bone density analysis of the sheep and goat bones and an outline of the butchery marks found on the sheep and goat bones. Chapter six presents the identifications of the other less common species found at the site. Brief discussions about the significance of these finds are presented. Chapter seven offers a summary of the findings of the Mudayna faunal analysis in relation to Mudayna's function as a site and the nature of the Moabite tribal kingdom in general.

Chapter 2

Mudayna and its Environment

2.1 Khirbat al-Mudayna

The Iron Age occupation of Khirbat al-Mudayna has been dated by both absolute (radiocarbon) and relative (ceramic typology, palaeography) techniques to the middle of the Iron II period (900 - 700 B.C.E.). Two radiocarbon dates have been taken from the site. The first date, taken from a sample of charred ceiling beam discovered in Gate Room 103 came back as 810 B.C.E. A second date of 790 B.C.E. was received from a charred sample of a woven floor mat found within Gate Room 152 (Daviau *et al.* 2000: 5). The 790 B.C.E. date has a 95% confidence interval of 810-755 B.C.E. (Beukens 1998). Relative dating techniques agree with the radiocarbon dates. Almost all of the ceramics excavated at Mudayna are typical of Iron Age or Iron Age II. A short inscription on a small limestone altar, excavated from Building 149, can be dated, palaeographically, to the first half of the 8th century (Dion and Daviau 2000:5). Generally, the architecture exposed at Mudayna appears to be 'typically' Iron Age as well.

Khirbat al-Mudayna sits on the southern bank of the Wadi ath-Thamad approximately 500m from the wadi itself. The top of the site measures 140m x 80m but those measurements increase substantially if one considers the size of the outer earthen embankment surrounding the site. The earthen embankment ringing the site has not yet been excavated but judging from its present appearance it may have functioned as a dry moat for the site or perhaps as a short defensive roadway leading from a primary southern gate to the secondary northern gate.

A northern six-chambered gate measuring 15.50m x 15.00m has been fully excavated (figure 1.2). The gate is smaller in size than similar gates found at Gezer, Lachish, Megiddo and Hazor likely because there simply was no more room to build it larger at that end of the site (Daviau 1997:224). The six-chambered gate exhibits two construction sub-phases of a single construction event (Daviau *et al.* 2000:15). The first sub-phase includes the four northern, massive and well-built, gate rooms and the second sub-phase includes the two southern, slightly smaller and poorly constructed, gate rooms. A conflagration destroyed this gate turning some of the limestone wall stones into lime powder and charring many of the construction beams and

two woven reed floor mats (undoubtedly enhancing their preservation!). A substantial casemate wall, constructed concurrently with the four northern gate chambers, circumvallates the site. Excavation of a single casemate room (Room 106) took place in 1999 to understand the construction of both the inner and outer casemate walls. The inner wall (Wall 2002) was preserved to a height of 3.12m. A southern extension of this wall acts as the eastern wall of a small shrine (Building 149) located just south of the gate complex.

Building 149 is a small shrine (5.50m x 5.50m) 2.50m south of the eastern half of the gate complex (figure 1.2). We know building 149 is a shrine because of its architecture (benches line the interior walls of the room) but more importantly because three limestone altars, lamps and specialized artifacts were found *in situ* within the room (Daviau and Steiner 2000:1). Moabite religious practices are not very well known, and most of what we do know about them comes from external (non-Moabite) literary sources (Mattingly G. 1989:213) like the Hebrew Bible. While details may not be known, it can safely be assumed the Moabites did regularly offer sacrifices to their gods, Kemosh (Moab's principle deity) in particular. It is likely that the sacrifices offered took the forms of liquid libations, grain, incense and meat among others. The meat sacrifices are of particular interest for this thesis. It is possible that many, even the majority of the animal bones found in the courtyard outside of the shrine are directly attributable to the ritual sacrifice of animals in the shrine.

The courtyard (Courtyard 150) (figure 1.2), located south of the gate complex and west of the shrine, held a higher density of animal bones per square meter than any other area of the site. Approximately 40 percent of the total number of animal bones recovered from the site came from the courtyard. The surface of the courtyard was comprised of beaten earth and cobbles. A small probe beneath the surface revealed what may have been an earlier surface but further excavation must occur to clarify this.

The remainder of Mudayna is unexcavated but surface examination across the center and near the southern end of the site revealed exposed wall lines suggesting that there are substantial architectural structures remaining to be explored.

2.2 Environs

The Wadi ath-Thamad is an eastern branch of a wadi system that runs generally southwest, changing names several times, eventually flowing into the Dead Sea via the Wadi Mujib (Biblical Arnon). Khirbat al-Mudayna sits atop a small limestone outcrop near the southern bank of the wadi. The highest elevation of Khirbat al-Mudayna is 629 meters above sea level, well below the height of the surrounding hillsides. The lack of visibility from Mudayna

would have caused a serious defensive problem, especially considering it may have served as an outpost on the Moabite-Ammonite border, were it not for the four strategically placed watch towers on the hill tops around the site. These watchtowers allowed for visual communication between Mudayna and her closest neighbours. The effect of this communication was the creation of a sort of early detection system for the people at Mudayna.

At the northeastern foot of Mudayna, between the site and the wadi, lies an alluvial fan used today by the local population for small-scale agriculture. Small alluvial fans of this type are common along the Wadi ath-Thamad because local geological faults have combined to form a graben that reduces the stream gradient sufficiently to allow deposition of finer soils to take place (Cordova 1999:7). The same alluvial fans were present during the Iron Age and were certainly used for agriculture and pasture then as well.

2.3 Precipitation

The average annual rainfall around Khirbat al-Mudayna is between 200 - 300 mm. Rainfall in Jordan generally increases as one travels north and west although it rapidly decreases near the shores of the Dead Sea (Cordova 1999: 2). Madaba, located 20km northwest of Mudayna, received an annual average of 351.7mm of rainfall from 1937 to 1975 (Abujaber 1989: 248-249). Research done by the excavation team at Hesban, approximately 30km northwest of Mudayna, found that environmental “conditions which existed during the Iron Age appear to have been basically the same as those existing today” (LaBianca 1990: 141). In an average year, the limited amount of rainfall at Mudayna provides enough moisture for dry farming and pasture growth. There are always, of course, years that receive less than average precipitation (the standard deviation of the Madaba rainfall data was 133.2mm). If the area around Mudayna received less than 200mm of rainfall for a number of consecutive years both agricultural production and animal husbandry would suffer, inflicting great hardship on the local population. Almost all of the annual precipitation for Mudayna, and Jordan in general, occurs between October and March (Figure 2.1). The lack of rainfall during the summer months and the ephemeral nature of the water flow within Wadi ath-Thamad meant that the local population had to construct water storage facilities to provide for the dry season. At Mudayna a large depression, approximately 4.00m in diameter and of unknown depth, is located southeast of Courtyard 150. It is possible that this depression served as a large water storage system for Mudayna, although excavation has yet to confirm this possibility. The Mudayna survey team has also located cisterns in the surrounding countryside. Another problem caused by the concentration of rainfall into a short period of time is the heavy erosion that it causes through

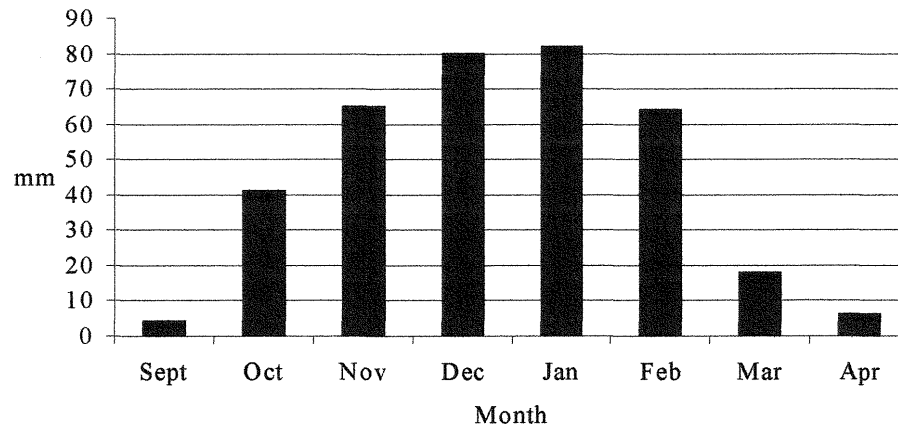


Figure 2.1 Mean monthly rainfall amount for the period 1923-65 at Madaba, Jordan (Adapted from Abujaber 1989: Figure 1.2)

flooding. The sparse ground cover and steep slopes of the region aggravate this erosion (Cordova 1999: 5).

2.4 Soils and Vegetation

Soils in the region around Mudayna have been described using varied nomenclature over the past century (Cordova 1999: 11-12; Reifenberg 1947: Figure 2; Lacelle 1986: 45-48; Zohary 1962: 10-19). In order to avoid confusion this thesis will use the terminology used recently by Cordova (1999: 11-12) and Lacelle (1986: 45-48). Under this system of classification, the soils of the region are divided into three principle types: red Mediterranean soils, yellow Mediterranean soils and yellow soils.

Red Mediterranean soils, which should not be confused with the similar but more fertile Terra Rosa soils, are found on the highlands of the Transjordanian plateau (Lacelle 1986: 45). They have a high clay content, which allows them to retain water, and high levels of calcium and potassium, both of which are important to encourage plant growth. Red Mediterranean soils exist approximately 10km north and west of Khirbat al-Mudayna.

Yellow Mediterranean soils are quite similar to red Mediterranean soils but are commonly slightly thinner and occur on areas of higher slope (Cordova 1999: 11). Because they developed in slightly drier areas, the iron staining which provides the red colour to both red Mediterranean soils and Terra Rosa is limited (Lacelle 1986: 48). Khirbat al-Mudayna is located in a region dominated by yellow Mediterranean soils.

Yellow soils are thin, weakly developed soils found near the floor of the Jordan River valley (Lacelle 1986: 48). Their low topographic position makes them the victims of downslope seepage resulting in a higher lime and salt content than the Mediterranean soils. Two other soil types occur in the region; Alluvial soils and Regosolic soils (Lacelle 1986: 53). Alluvial soils

develop on the fans and floodplains of wadis. Regosolic soils generate on areas of exposed bedrock and nari. Regosolic soils are very recent, undeveloped soils.

Khirbat al-Mudayna lies in a transitional zone between two vegetational type regions: the Mediterranean non-forest region and the drier Steppe region (Cordova 1999: 2). The red Mediterranean soils found in the area likely supported a much richer floral regime than is seen today; possibly even oak forests (Cordova 1999: 2). Most of the land in Jordan has been cleared of trees to create prime agricultural land and to provide fuel and building supplies for both domestic and industrial uses. The clearing of the land began in the Neolithic and has occurred in waves, coinciding with periods of large-scale settlement, throughout history (LaBianca, Ø. and Lacelle, L. 1986: 146). Once the initial clearing of a parcel of land takes place, that area becomes susceptible to erosion. As erosion occurs, the soil becomes thinner and less fertile, unable to support the vegetation it once did. This cycle eventually leads to different, more desert like, floral regime occupying the area. Zohary (1962: 53) notes that a number of species of Irano-Turanian (equivalent to the Steppe vegetation) trees and shrubs have penetrated into Mediterranean zones where the primary forests have been cleared.

A study of the ancient floral remains found during the excavation of Khirbat al-Mudayna has not yet been undertaken. The only plant species that have been identified from the site are Olive (*Olea* sp.) (in the form of charred pits and ceiling beams) carob (*Ceratonia siliqua*) and mulberry (*Ficus* sp.) (in the form of charred ceiling beams) (Daviau 1997: 224).

As previously mentioned, Khirbat al-Mudayna is located in a transitional zone between two vegetational regimes; Mediterranean non-forest and Steppe. Some common plants presently found within each region are listed here, but because no floral survey has been undertaken around Mudayna the plants listed merely intended to represent the broad vegetational regions. Common trees and shrubs of the Mediterranean area include deciduous trees (*Styrax officinalis*, *Rhamnus palaestina*, *Quercus ithaburensis*), a spiny dwarf shrub (*Sarcopoterium spinosum*), and a common shrub (*Salvia triloba*) (Zohary 1973: 86). The Irano-Turanian (Steppe) region is home primarily to short shrubs (*Artemisia herba-alba*) thorny shrubs (*Rhus tripartita*) and grasses (*Stipa* spp.) (Zohary 1973: 90). Oleander (*Nerium oleander*) and tamarisk (*Tamarix* spp.) often inhabit the wadi systems.

2.5 Fauna

Many of the faunal species that live around Khirbat al-Mudayna today also lived in the region during the Iron Age. The largest shift in the types of fauna found around the site has occurred within the last 100 years with the introduction of motorized vehicles and high-powered

rifles (Uerpmann 1987: 9; Kingdon 1991: 10; Harrison 1964:13). Human hunting has taken a terrible toll on the native fauna, particularly the large mammals. Many of the large ungulate and carnivore species that could be seen in packs or herds, as little as fifty years ago are very rare if not entirely missing from the area. The Mesopotamian fallow deer (*Dama mesopotamica*), a species found at Mudayna, may no longer exist in the wild. The small roe deer (*Capreolus, capreolus*) has recently become rare. The white Arabian oryx (*Oryx leucoryx*), recorded within Iron Age phases at both Hesban and Jericho, is now nearing extinction. Another animal recorded from Iron Age Hesban is the Nubian ibex (*Capra nubiana*). Today, wild ibex are rarely encountered (but conservation efforts at En Gedi, Israel, are helping to keep the species alive). Two large carnivores that are approaching regional extinction within Arabia are the cheetah (*Acinonyx jubatus*) and the Syrian bear (*Ursus arctos syriacus*) (Harrison 1964: 13). The lion (*Panthera leo*), the ostrich (*Struthio camelus syriacus*) and the wild ass (*Equus africanus*) have already been regionally extirpated (Mountfort 1964: 230).

The distribution of smaller mammals, birds and herpetofauna in the region has remained much more constant since the Iron Age. Very few small animal remains were recovered at Khirbat al-Mudayna but this is likely the result of excavation technique rather than a real absence of these animals at the site. Small animals of note that were recovered include a mongoose (*Herpestes ichneumon*), a member of the gerbil family (*Psammomys obesus*) a hedgehog (*Erinaceus europaeus*), an eagle (*Accipitridae*), a rock dove (pigeon) (*Columba livia*), and two fish bones identified as sea breams (*Sparidae*).

A complete list of both the wild and domestic mammalian species presently found in the area around Khirbat al-Mudayna appears in Appendix A.

Chapter 3

Methodology

3.1 Introduction

The methodology used for the analysis of the faunal material from Khirbat al-Mudayna on the Wadi ath-Thamad is presented within this chapter. It is important that the methodology be apparent for the reader to understand any biases that may have occurred during data collection and analysis. In this way, the reader may make an informed judgement about the validity of any conclusions reached through the analysis of the data. Recently, the blind acceptance of the accuracy of faunal identifications has been called into question (Klein *et al.* 1999: 1228; Gobalet 2001: 377), particularly when distinctions between two morphologically similar species are being made (Gobalet 2001: 378). Because so much of the analysis of the Mudayna collection depends on the differentiation of sheep and goat (a difficult task) explicit detail is provided on how the identifications were made. Details about the criteria used and a summary of measurements taken on identified bones are presented in Chapter four. The remainder of this chapter discusses excavation procedure and introduces the methods of qualitative and quantitative analysis performed on the Mudayna faunal material.

3.2 Excavation Techniques

Excavation of Khirbat al-Mudayna took place over four six-week seasons during the summers of 1996 to 1999. Excavation concentrated on the northern end of the site. Having a narrow spatial focus during excavation is not ideal when one considers the project from a zooarchaeological sampling point of view (Meadow 1978: 19), although Courtyard 150 (Figure 1.2) did provide a good sample size of bones. Analysis of the faunal material would be more balanced if a portion of the southern end of the site had been excavated or even tested through a few well-placed *sondages*. As this was not the case, extrapolation must be made tentatively for the entire site from the remains found within the public structures, namely the gate (Gate Complex 100), the shrine (Building 149) and Courtyard 150.

The grid laid out over Mudayna (by Robert Force, Ontario Land Surveyor) runs through the long axis of the site, approximately 35° east of north and west of south. The grid is comprised of six-meter squares that were excavated in 5m x 5m units, leaving one meter wide baulks at the north and east sides of the square. The baulk placements were variable, however, depending on the logistics of the area (occasionally two baulks were placed side by side to create a two-meter wide walkway) and the presence of architecture (the gate rooms were excavated using the walls as borders). Lettered fields (A, B, C, etc.) divide the site into groups of 100 squares each. The majority of the squares excavated were located within Field A; the four exceptions were located in Field C.

The tools used during excavation were the typical arsenal found at Near Eastern sites including: large picks, hoes, sledge-hammers, pry bars, hand picks, trowels, brushes, dustpans, guffahs (rubber baskets), much sweat, some blood and tears. Whenever possible, to keep excavation proceeding at a brisk pace, the larger tools were employed. The project hired untrained locals (though many had worked at the site for consecutive seasons and were familiar with the job) to carry, and when necessary, sift the earth from excavation.

Full screening of the site did not occur. Loci that appeared to be associated with living surfaces or those that contained unusual artifacts received full screening, but others received either no screening (topsoil) or random screening (approximately one in ten guffahs). The screens employed sported a coarse wire mesh with a minimal hole size of 5mm. In a recent report, James (1997) noted that 75% of faunal remains from animals the size of cottontails or smaller are lost when using ¼ inch (6.4mm) screen. Very few microfauna were recovered from Mudayna; a situation likely directly attributable to the lack of consistent fine-screening techniques employed at the site. In order to test this hypothesis, and correct biases resulting from it, a sample area should be excavated using 3.2 mm or 1.6 mm screens in future seasons.

3.3 Qualitative Faunal Analysis

All of the faunal material found during excavation was kept and recorded using the same proveniencing system used for the pottery. Field, Square, Locus and Pottery Pail number, with Pottery Pail number being the most specific unit, separated groups of bones into provenience clusters. When excavation revealed rodent or similarly small and fragile bones they were packaged separately within a small container, often a film canister, to insure against damage or loss during transport. Before the bones were packaged, however, a small 2mm wire-mesh screen was used to sift the matrix in the area immediately surrounding the find to search for any associated remains. When particularly fragile bones including mandibles/maxillas with loose

teeth were recovered they were wrapped in tinfoil or any material that was handy to prevent against damage during transport. At the end of each day all of the faunal material was driven to Amman where it was dry-brushed and counted before being repackaged in paper bags for transport to Canada.

The faunal remains were shipped to the University of Saskatchewan where further cleaning, with water when necessary, took place. A calcareous incrustation present on some of the bones, almost exclusively those from squares A7 and A8, within Courtyard 150, required more intensive treatment. Incrustations of this type are common on bones excavated from warm, arid environments (Stahl and Brinker 1991: 138). Immersion of the faunal material requiring treatment into a solution of 15% dilute acetic acid for several hours at a time, depending on the thickness and stubbornness of the coating, was utilized. It was not possible to remove one hundred percent of the incrustation, but most taxonomic landmarks were cleared for visibility and measurements. Dental picks were helpful during the final stage of cleaning. Two primary implications arise from the encrustation that remains on the bone. First, the weight of the incrustated bones is greater than it should be. Because there was no accurate and reliable way to estimate the weight of the coating remaining on the bone, reduced weights could not safely be assigned to each specimen. The weight recorded for the material from squares A7 and A8 is that of the bone plus any remaining incrustation. The potential bias created by the increased weight of the incrustated specimens is tempered somewhat because *all* of the bones recovered from squares A7 and A8 weigh more. Every taxonomic category represented by the bones from squares A7 and A8 shows a weight increase relative to the amount of bone recovered belonging to that category. The distribution of the extra weight should have occurred in such a fashion that the relative weight of each taxonomic category remains the same. The second implication involves the overall visibility of the bone surface. Because areas of the bone remain hidden from view, it was not possible to record any modification that may have occurred on the surface of the bone in that location.

After all of the bones were cleaned they were catalogued using a program based in Microsoft Access developed by Michael Magee. I chose this program because it enabled the recording of specific bone elements. For example, when cataloguing a humerus the program allows you to record which of the following elements of the humerus are present: head, neck, major tubercle, minor tubercle, proximal shaft, deltoid tuberosity, teres major insertion, teres minor insertion, postero-lateral foramen, mid-shaft, distal shaft, radial fossa, lateral epicondyle, medial epicondyle, trochlea, capitulum, olecranon fossa, or complete. The detail allowed with this program aids in accurately calculating statistics such as MNI, MNE and MAU (discussed below). Any modifications of the bone, cultural or natural, were also recorded. Specific types of

modifications noted include cutmarks, weathering, burning, teethmarks and pathologies. Measurements of the bones were taken whenever sufficient preservation allowed. Most of the measurements taken were those documented by Angela von den Driesch (1976) to ensure a standard, comparable selection, but occasionally additional measurements were also taken. The location and purpose of these additional measurements are described when the measurements are presented. Before measurements of bones become meaningful, the type of bone you are measuring must be known.

Specific identification of the bones recovered from Mudayna was the largest challenge presented by the collection. The University of Saskatchewan is home to an excellent faunal comparative collection, but its focus is on North American, rather than Near Eastern, fauna. Because the U of S comparative collection does not include a number of important large Near Eastern species, such as gazelles, Persian fallow deer, camels or ibex, other methods had to be employed for their identification. The smaller fauna recovered from Mudayna, particularly the rodents and birds, also proved to be a problem and could often only be identified to the family level. In some cases, when appropriate photographs and/or measurements of reference specimens were available, a more specific identification is given. The two fish specimens recovered are identified at the family level. Sheep (*Ovis aries*) and goat (*Capra hircus*) specimens were collected from farms around Saskatoon, processed and cleaned for use as comparative material. The goat carcasses collected were from both Spanish and Boer goats.

In the absence of a complete comparative collection, identification of some specimens relied upon measurement tables, diagrams and photographs, and distribution maps culled from the literature. Particularly useful sources included: von den Driesch and Wodtke (1997), von den Driesch and Boessneck (1995), Boessneck and von den Driesch (1978, 1995), Boessneck (1995), Lepiksaar (1995), Lipovitch (1999), Tchernov (1992, 1994), Tchernov *et al.* (1987), Ducos (1968), Walker (1985), Bökönyi (1977), Zeder (1986), Harrison (1964, 1968, 1972), Uerpmann (1982, 1987), Compagnoni (1978a, 1978b), Compagnoni and Tosi (1978), Brown and Gustafson (1957), Clutton-Brock (1979), Greenfield (1992), Quintero and Köhler-Rollefson (1997), and Davis (1980a).

While indirect identification of specimens should be avoided whenever possible, it was unfortunately unavoidable in some instances. When an indirect identification is presented all of the reasons for the identification as well as any arguments against it are also presented. Because most of the identified specimens from this collection are either *Ovis aries* or *Capra hircus* (two species notoriously difficult to tell apart) detailed lists are provided of what criteria were used to differentiate between the two. A number of useful guides (Boessneck 1969; Boessneck *et al.*

1964; Clutton-Brock *et al.* 1990; Lawrence 1980; Prummel and Frisch 1986; Payne 1985) detailing the most reliable methods to distinguish between *Ovis* and *Capra* skeletal and dental remains were used, in addition to the comparative material collected, for the assignment of species to the Mudayna sheep and goat remains.

Whenever specimens could not be identified to the genus or species level, they were assigned to the next most specific taxonomic category possible. Examples of these categories are Artiodactyla size class five (ASC5), Ungulate size class six (UngulSC6) and when necessary Mammal size class 1-6 (MSC1-6). The size classes used in this thesis are adapted from size classes presented by Dyck and Morlan (1995:140) for use with North American mammals (Table 3.1). The weight categories have been maintained, but the examples presented for each category has been changed to a more suitable animal. The only difficulty Dyck and Morlan's weight categories present is with the classification of various gazelles. Adult male mountain gazelles (*Gazella gazella*) fit into size class five while the females belong in size class four (Baharav 1974: 42). The smaller dorcas gazelle (*Gazella dorcas*) also belong in size class four. Within this thesis all gazelle are considered to be the lower limit of size class five so that the designation of Artiodactyla size class five includes gazelle along with sheep, goat and small deer. A complete list and summarized tables of all the measurements taken on the Mudayna faunal material are provided for comparison with other collections. Whenever possible the sex and age at death of specimens were also recorded.

Table 3.1 Mammalian size classes used within this thesis (modified from Dyck and Morlan 1995: 140)

Size Class	Weight	Verbal Description	Examples
SC6	200-700 kg	Very Large Mammal	Cattle, Horse
SC5	25-200 kg	Large Mammal	Sheep, Goat, Gazelle*, Deer
SC4	5-25 kg	Medium Mammal	Badger,
SC3	700 g - 5 kg	Small-Medium Mammal	Hare
SC2	100-700 g	Small Mammal	Gerbil
SC1	<100 g	Micro-Mammal	Mouse, Vole

* Note: Gazelles are treated as SC5 but in reality most of them should be in SC4

Calculating the age at death of specimens is done by recording mandibular tooth-wear and epiphyseal fusion of all identifiable specimens. Mandibular tooth wear of *Ovis* and *Capra* specimens was recorded following the method described by Payne (1973: 281-303). Tooth eruption ages for the horse (Silver 1969: 291; Levine 1982), gazelle (Davis 1980b: 130), cattle (Grigson 1982: 14-15), and pig (Bull and Payne 1982) are also available in the literature. *Ovis* and *Capra* epiphyseal fusion data has been published by a number of authors (Silver 1969, Bullock and Rackham 1982), but this thesis combines a summary of eight sources compiled by Moran and O'Connor (1994) and the groupings given by LaBianca (1995: 56). Horse, cattle and

pig epiphyseal fusion dates are given by Silver (1969: 285-286), Grigson (1982: 22), and Bull and Payne (1982). Data for gazelle epiphyseal fusion is found in two articles by Davis (1980b, 1983). Equally important as identifying a specimen's age at death is determining the sex of a specimen.

Sexing of specimens was done by examining the measurements and morphology of those specimens. Certain bones, when preserved well enough, allow a morphological distinction of sex to be made. The pelvis and horncore (Figures D-1, D-4) are particularly useful for determining the sex of the specimen. Distinction between male and female *Ovis* and *Capra* pelvises was made by following criteria presented in Boessneck (1969: 344-348) and Boessneck *et al.* (1964: 78-95). Grigson (1982) presents some morphological differences between male and female cattle bones and horncores. Because most bones do not allow for sex differentiation by morphological traits, measurements of sexually dimorphic areas of bones often are relied upon. Measurements are not the best indicator of sex, however, because often there is a large amount of overlap in the size of male and female bones. Within this thesis sex distinction via measurement data is only made when a specimen is clearly at the extreme range of the measurement continuum. Exceptions to this rule are possible when research has shown that a crisp distinction, with little or no overlap, between male and female measurements occurs. An example of measurements that clearly distinguish between male and female bones is found with recent *Gazella gazella* atlas vertebrae (Horwitz *et al.*: Figure 2).

3.4 Quantitative Faunal Analysis

Without some type of quantitative analysis, the study of faunal remains from any site is reduced to a sort of 'laundry list' of species present at the site. Through quantitative analysis the faunal analyst attempts to provide some meaningful information about the site and its ancient inhabitants using the bits of broken bone left scattered around the site prior to its abandonment. Before specific analytical units are discussed, it will be helpful to define how the terms 'element', 'specimen' and 'fragment' are used within this thesis.

Both 'element' and 'specimen', for the purposes of this thesis, are defined as "a bone or tooth, or fragment thereof" (Grayson 1989: 16). Grayson used this definition strictly for the term 'specimen' in his work, while he defined 'element' as "a single complete bone or tooth in the skeleton of an animal." (Grayson 1989: 16). In this thesis, the head of the femur is considered both an 'element' and a 'specimen' where Grayson considered it only a 'specimen'. The interchangeable use of these two terms should not cause undue confusion because the context of the reference will always be made clear. Within this thesis, the term 'fragment' refers to any individual piece of bone or tooth that is not an anatomically complete bone or tooth. Therefore,

the head of a femur is actually considered an element, a specimen and a fragment, while a whole femur is only an element or a specimen.

The definitions, and the abbreviations of those definitions, of the analytical units employed by zooarchaeologists are often not exact and have led to confusion in the past. In order to avoid any such confusion, the method used to derive the analytical units is explicitly stated below. The five basic units used in this thesis are NISP, MNI, MNE, MAU and %MAU.

NISP is an observational unit that Lyman (1994: 100) defines as “the number of identified specimens per taxon”. Keeping in mind that ‘taxon’ is defined as “a subspecies, species, genus, family, or higher taxonomic category” (Lyman 1994: 100), Lyman’s definition of NISP is suitable for this thesis. Both the power and the weakness of NISP lie in the fact that it is an unmodified observational unit. Because NISP is a direct count of bone fragments, Near Eastern zooarchaeologists often use it to determine the ratios of animals found at the site (i.e. *Ovis:Capra:Gazella*). These ratios provide information about the herding strategies or hunting patterns used at the site. The largest problem with using NISP as a representative of the quantity of various taxa found at a site is that it does not take into consideration differential fragmentation and variable preservation. For NISP to be meaningful as an indicator of abundance, fragmentation and preservation must be consistent for all taxa found at a site; an unlikely scenario. Despite NISP’s shortcomings it will be used within this thesis to represent ratios of taxa for two reasons. First, other Near Eastern sites have been examined using NISP so the use of it here allows for comparison with those sites. Second, MNI is used in conjunction with NISP values, helping to assuage some of the preservation and fragmentation distortions NISP produces.

MNI (Minimum Number of Individuals) is a derived unit defined by Lyman (1994: 100) as “the minimum number of individual animals necessary to account for some analytically specified set of identified faunal specimens”. MNI is a calculation that had been used by paleontology for a number of decades before White began to use it in zooarchaeological studies in the early 1950s (Klein and Cruz-Urbe 1984: 26). The use of MNI helps to mitigate against fragmentation biases by ensuring that even if a particular skeleton was smashed into thousands of pieces, producing a large NISP, the MNI would still be ‘one’, reflecting a more accurate count of animals from the site. Preservation of less dense skeletal elements typically occurs less frequently than preservation of dense elements (Lyman 1982: 115). MNI is insensitive to this preservation bias, counting the same number of animals regardless of reduced preservation, providing the more dense elements survive. Because MNIs have been calculated differently by different zooarchaeologists (Klein and Cruz-Urbe 1984: 26), rendering comparison of data impossible, it is important that the method used to calculate MNI values is explicit.

MNI values for this thesis were calculated considering both the side and the maturity of the bone element. As the Mudayna remains were catalogued it was noted exactly what elements (typically anatomical landmarks) of the bone were represented on each specimen. For example, if a distal humerus was recovered, I recorded that the distal shaft, radial fossa, lateral epicondyle, medial epicondyle, trochlea, capitulum and olecranon fossa were all present. The occurrence of each element was then divided by side (left or right) and maturity (mature or immature). The four groups produced (left mature, left immature, right mature and right immature) were then combined into four possible, non-overlapping, paired combinations (left mature + left immature, left mature + right immature, right mature + right immature, right mature + left immature) and whichever combination had the greatest number of elements became the MNI for that bone type. 'Non-overlapping' simply means that no bones within any paired combination could have come from the same individual as would be the case if the combinations of left mature + right mature or left immature + right immature were used. Once the MNI for every bone type had been calculated the bone type with the largest MNI became the indicator of MNI for the species it represented. After MNI had been calculated it was a simple matter to determine MNE, MAU and %MAU.

MNE (Minimum Number of skeletal Elements) is a derived unit that tells the zooarchaeologist how many elements or skeletal portions (group of elements) must have been present to account for the collection's NISP. MNE values are not necessarily analogous to MNI, but may represent some portion of a skeletal element (for example the proximal humerus may be represented by a different MNE than the distal humerus) or a group of skeletal elements (a fore limb or hind limb) (Lyman 1994: 102). MNE may be calculated in a variety of ways so, like MNI, it is imperative that the zooarchaeologist define how his MNE values are derived. For this thesis, MNE values were calculated by simply summing the number of times a particular skeletal element (typically a landmark such as the deltoid tuberosity) occurred for a particular taxon within the collection. The side and maturity of the element was not considered. MNE values are used to derive both MAU and %MAU.

MAU (Minimum number of Animal Units) values are calculated by simply taking the MNE value of a particular skeletal element and dividing it by the number of times that element occurs within the skeleton. For example, the MNE for the deltoid tuberosity will be divided by two (left and right side) but the MNE of the cervical vertebrae spine will be divided by five (seven minus the axis and atlas). MAU values are often not a whole number because of the division by anatomical occurrence. MAU values are typically normalized to %MAU values by dividing all of the MAU values of a particular taxon by the greatest MAU value for that taxon (Lyman 1994: 106) and then multiplying by 100. MAU values are useful when zooarchaeologists

wish to study differential transport, survivorship, and frequency of skeletal parts. As Lyman (1994: 110) points out, when zooarchaeologists are asking questions about the transport, survivorship and frequency of skeletal parts “the number of individual animals is irrelevant; whether more humeri or more tibiae are represented is paramount.” Such questions must be asked at a small, fortified site like Mudayna because they may provide information about the food distribution system utilized at the site. The organization of the food distribution system, in turn, tells the zooarchaeologist about the basic economy of the site (Zeder 1991: 33-42).

Chapter 4

Identification of Individual Elements

4.1 Introduction

After all of the faunal remains from Khirbat al-Mudayna had been identified preliminarily, they were analyzed by groups of individual elements (i.e. femorae, humeri etc.). Analysis within element groupings allowed measurement compilations to be created. It also ensured accurate assignment of the elements to a particular species by providing a large number of comparative specimens. A description of the analytical methods used for the identification of each element is presented below. Special attention is paid to the identification of any unusual specimens such as *Gazella*, *Dama mesopotamica* and *Camelidae*. A summary of measurements taken on each element is also given as these are often the key to the identification. The presentation of the individual elements is modeled on the style used by David Lipovitch (1999) in his Ph.D. dissertation from Harvard University.

4.1.1 Femorae

A total of 152 femorae from large and very large mammals were studied within this collection. Of those, 16 were identified as *Ovis aries*, 10 as *Capra hircus* and a further 71 as *Ovis/Capra*. The most useful criteria for distinguishing between sheep and goat femorae are found at the proximal end of the bone. Boessneck (1969: 348) notes that the shape of the head of the femur is more ball-like in *Capra* and more “roller-like” in *Ovis*. The region between the head and the neck also differs. *Ovis* shows a smooth transition from head to neck where *Capra* has a slight shelf at the transition. Another consistent distinguishing feature used in this study was the shape of the greater trochanter. *Ovis* has a trochanter with a square proximal edge, but in *Capra* the upper proximal corner is scooped out. Clutton-Brock (1990: 30) states that distinction between the greater trochanters of the two species is “nearly foolproof”. The distal end of the femur presents more difficulty for specific identification. The only criterion noted by Clutton-Brock (1990: 30) regarding the distal end of the femur is the absence of a synovial pit within the

Table 4.1 Distinguishing Criteria of *Ovis* and *Capra* Femorae

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Ball-shaped caput (<i>Capra</i>)	827, 987, 1125, 3218	
Roller-shaped caput (<i>Ovis</i>)		1, 352, 504, 635, 639, 918, 1044, 1757, 1810, 1910, 2573, 3710
Shelf-like drop at lateral edge of caput (<i>Capra</i>)	827, 987, 1125, 3218	
Lateral extension of caput (<i>Ovis</i>)		1, 352, 504, 635, 639, 918, 1044, 1757, 1810, 1910, 2573, 3710
Edge of greater trochanter squared (<i>Ovis</i>)		504, 1044, 1070, 1810, 2573, 3710
Edge of greater trochanter scooped (<i>Capra</i>)	987, 1125, 3218	
Steep trochlea patellaris (<i>Capra</i>)	1237, 1574, 1942, 3351, 3691	
Shallow trochlea patellaris (<i>Ovis</i>)		1233, 1904, 2404
Synovial pit present in trochlea patellaris (<i>Capra</i>)	505, 1237, 1942, 3351, 3691	

distal trochlea. Boessneck (1969: 350) states that the presence of a synovial pit is characteristic of *Capra* while it is absent in *Ovis*.

For this study, I found that the morphology of the proximal end of the femur, specifically the shape of the head and the greater trochanter, was the most reliable indicator of species. The distal criterion (the presence or absence of a synovial pit) seemed less reliable because, as Clutton-Brock (1990: 30) points out, “the frequency of absence of the pit in the goat has not been assessed”. For this reason, if a clear synovial pit was present the specimen was identified as *Capra*, but if the specimen lacked a synovial pit it was not automatically labeled as *Ovis*. Only three distal femorae were labeled as *Ovis*. These three femorae had distal trochleae that conformed in shape to the figure presented by Boessneck *et al.* (1964: Figure 54) as well as having no synovial pits. As may be seen in Table 4.1, no femur identified as either *Ovis* or *Capra* exhibit overlapping characteristics. Because none of the femoral distinguishing criteria used in this study takes precedence over any other, all femorae examined that exhibited overlapping characteristics were labeled as *Ovis/Capra* in the name of prudence.

One mountain gazelle (*Gazelle gazelle*) proximal femur was identified from Khirbat al-Mudayna (Figure D-2). The identification of this specimen as *Gazella* sp. was initially made by

reference to a photograph of a *Gazella subgutturosa* proximal femur published by Compagnoni (1978: 122) in a report on gazelle remains from Shahr-I Sokhta, Iran. Morphologically the Mudayna specimen was a perfect match. The size of the Mudayna specimen fit nicely within the range of measurements published for *G. subgutturosa* proximal femorae within the same report (see Table 4.2). Reference to the literature, however, revealed that the Mudayna specimen was almost certainly from a *G. gazella* rather than a *G. subgutturosa* based on the typical geographical occurrences of the species. In his comprehensive report of ancient ungulate distribution, Uerpmann (1987: 90-103) lists ten archaeological sites within Israel and Jordan that have confirmed *G. gazella* remains. The presence of *G. subgutturosa* is not confirmed at any archaeological site in Israel and only in the early Neolithic stratum at Ain Ghazal, Jordan, has it been questionably reported. Harrison (1968: 362) notes that occasionally members of the smaller sub-species *Gazella subgutturosa marica* are found in the eastern deserts of Jordan, but the Mudayna specimen is too large to be identified as this sub-species. Other authors (Davis 1980a: 135; Tchernov *et al.* 1987: 55; Driesch and Wodtke 1997: 519) have confirmed the general validity of the non-overlapping distributions of *G. gazella* (in the Levant) and *G. subgutturosa* (east of the Euphrates).

Gazelle remains have been reported from Hesban, 30km northwest of Mudayna. In their analysis of the gazelle remains, Driesch and Boessneck (1995: 88-89) did not assign any of the post-cranial remains to a particular species. Instead, they suggested that the three basic size categories found represent three groupings of gazelle bones. The smallest group contains bones from the female dorcas gazelle (*G. dorcas*), the second group is derived from the male dorcas gazelle and the female mountain gazelle (*G. gazella*), and the third group is made up of male mountain gazelle bones, perhaps with the inclusion of some male Persian gazelle (*G. subgutturosa*) bones. Horncores, the most reliable indicator of gazelle species, were reported for both *G. dorcas* and *G. gazella*, but not for *G. subgutturosa*.

The morphology of the gazelle proximal femur found at Mudayna is practically identical to the previously mentioned published specimen of a *Gazella subgutturosa* proximal femur from Shahr-I Sokhta. Because of the morphological similarities between different gazelle species

Table 4.2 Comparison of seven *G. subgutturosa* femorae with a Mudayna Gazelle specimen
(Adapted from Compagnoni 1978: 127)

Femur	1	2	3	4	5	6	7	Mudayna
maximum prox. width	48.5	50.0	43.0	49.0	50.0		46.5	46.9
width articular head	26.4	26.5	23.0	26.0	24.0		25.0	24.3
diameter of head (a.-p.)	19.9	19.4	18.2			20.0	18.8	20.2

Table 4.3 Summary Statistics of Femur Measurements (mm)

DC	<i>Ovis aries</i>	<i>Capra hircus</i>	<i>Ovis/Capra</i>	<i>Gazella</i>	<i>Bos taurus</i>
Mean	21.99	22.09	20.83	20.21	45.17
Median	21.90	22.22	21.02	20.21	45.17
Standard Deviation	1.86	0.76	0.41		
Minimum	19.53	21.16	20.36	20.21	45.17
Maximum	24.55	22.77	21.12	20.21	45.17
Count	10	4	3	1	1
Bp	<i>Ovis aries</i>	<i>Capra hircus</i>	<i>Ovis/Capra</i>	<i>Gazella</i>	<i>Bos taurus</i>
Mean	46.66	44.22		45.90	
Median	46.51	44.40		45.90	
Standard Deviation	3.15	2.71			
Minimum	42.97	41.43		45.90	
Maximum	50.65	46.84		45.90	
Count	4	3		1	
Bd	<i>Ovis aries</i>	<i>Capra hircus</i>	<i>Ovis/Capra</i>	<i>Gazella</i>	<i>Bos taurus</i>
Mean	36.19	39.24	40.54		
Median	36.19	39.24	40.54		
Standard Deviation		1.53	1.21		
Minimum	36.19	38.15	39.68		
Maximum	36.19	40.32	41.39		
Count	1	2	2		
SD	<i>Ovis aries</i>	<i>Capra hircus</i>	<i>Ovis/Capra</i>	<i>Gazella</i>	<i>Bos taurus</i>
Mean	16.3				
Median	16.3				
Standard Deviation					
Minimum	16.3				
Maximum	16.3				
Count	1				

(Uerpmann 1987: 90), the similarity between the Mudayna specimen and the Shahr-I Sokhta specimen only indicates that the Mudayna specimen is from a relatively large gazelle. *G. gazella* and *G. subgutturosa* overlap in their size distribution and so a specific identification can not be assigned based on size alone. I have relied on the known geographical distribution of *G. subgutturosa* and *G. gazella* to assign the specific designation of *G. gazella* to the Mudayna specimen. While this designation is almost certainly accurate, the possibility remains that hunters or travelers/traders arriving from Mesopotamia imported this specimen to the site.

The *Gazella gazella* proximal femur found at Khirbat al-Mudayna shows complete fusion of the head, the greater trochanter and the lesser trochanter. Published data (Davis 1980b: 133) regarding *G. gazella* limb bone epiphyseal fusion timing states that the proximal femur is fully fused at 10-16 months. With this information in mind the specimen from Mudayna may be aged as *at least* one year old, but possibly much older. The well-developed muscle attachments present on the specimen are suggestive of a stronger, older individual. The Mudayna specimen

has a number of cutmarks located on the posterior face of the greater trochanter as well as on the medial face of the neck. The evidence of butchering on this gazelle femur shows that when possible the residents of Khirbat al-Mudayna supplemented their diet with meat from the local wild fauna.

Table 4.3 above shows a summary of measurements taken on the femorae identified to species. A full listing of the individual measurements taken is found in Appendix C.

4.1.2 Patellae

Patellae from Mudayna are represented by eight *Ovis aries*, three *Capra hircus*, and three *Ovis/Capra* specimens. When patellae are fairly well preserved it is not difficult to differentiate between *Ovis* and *Capra*. The presence of a large indentation on the lateral-proximal anterior face of the patella indicates the specimen is a sheep. The absence of an indentation occurs if the specimen is a goat. None of the *Capra* specimens were completely preserved so no measurements could be taken from them. Measurements for the *Ovis* patellae are presented in Table 4.5 below.

Table 4.4 Distinguishing Criteria of *Ovis* and *Capra* Patellae

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Indentation on lateral proximal face (<i>Ovis</i>)		1683, 1774, 2149, 2285, 2756, 3755, 3862, 3863
No indentation on face (<i>Capra</i>)	1969, 3839, 3856	

Table 4.5 Summary Statistics of *Ovis* Patellae Measurements (mm)

GB	<i>Ovis</i>
Mean	23.96
Median	23.65
Standard Deviation	1.29
Minimum	22.74
Maximum	25.65
Count	5
GL	<i>Ovis</i>
Mean	31.61
Median	31.18
Standard Deviation	2.69
Minimum	29.16
Maximum	34.49
Count	3

4.1.3 Tibiae

132 medium and large mammal tibiae were identified from the Mudayna collection. Of these tibiae, 59 were identified as *Ovis/Capra*, nine were clearly *Ovis aries* and ten were clearly *Capra hircus*. Identification of bone fragments as *Ovis/Capra* tibiae is not difficult because of the distinct shape of the bone, noticeable even when only small fragments of the bone remain. Specific identification to either *Ovis* or *Capra* is quite difficult, however, and may only be undertaken when a large portion of either the proximal or the distal end of the bone is preserved. At the proximal end of the tibia a single feature distinguishes between *Ovis* and *Capra*. Near the anterior end of the proximal face of the tibia, above the tibial tuberosity, a small circular pit with several nutrient foramina at its bottom occurs on *Capra hircus* specimens (Boessneck 1969:350). *Ovis aries* tibiae have the nutrient foramina in the same location but lack the pit. Unfortunately, the anterior section of the proximal end of the tibia was only preserved on four specimens, limiting the usefulness of this otherwise unmistakable characteristic. The distal end of the tibia is more dense and so was preserved more often.

Boessneck (1969: 350) states that no consistent criteria for identifying between *Ovis* and *Capra* appear on the distal end of the tibia, but Prummel and Frisch (1986: 572-574) list four such criteria for the distal end. Only two of the criteria suggested by Prummel and Frisch were used in the analysis of the Mudayna faunal remains. The first criterion used was the shape of a small protuberance on the anterior face of the distal tibial shaft. Both *Ovis aries* and *Capra hircus* have this small protuberance, but in *Ovis* the protuberance remains on the lateral edge of the shaft while in *Capra* the protuberance curves medially towards the center of the shaft. The other criterion used is located on the medial malleolus. Prummel and Frisch (1986: 574) note that in *Capra hircus* the sulcus malleolaris is well pronounced while in *Ovis aries* the sulcus

Table 4.6 Distinguishing Criteria of *Ovis* and *Capra* Tibiae

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Circular pit with nutrient foramina at proximal end (<i>Capra</i>)	3234, 3662	
No circular pit (<i>Ovis</i>)		226, 1045, 1247, 3032
Lateral anterior-distal ridge (<i>Ovis</i>)		503, 1328, 2206, 2414
Medial anterior-distal ridge (<i>Capra</i>)	346, 502, 953, 1656, 2344, 2700, 2818, 3458	
Well pronounced groove on medial malleolus (<i>Capra</i>)	346, 502, 953, 1656, 2344, 2700, 2818, 3458	
Faint groove on the medial malleolus (<i>Ovis</i>)		503, 1328, 2206, 2414

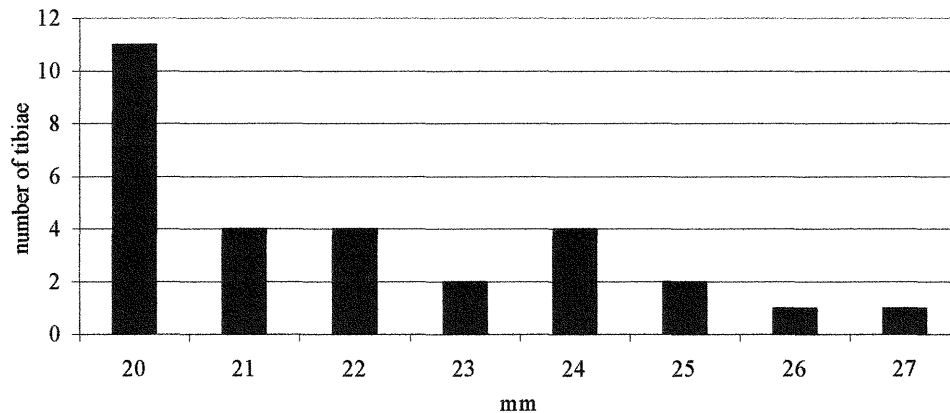


Figure 4.1 Hesban gazelle tibiae, greatest breadth of the distal end (Bd)
(Adapted from Driesch and Boessneck 1995 Figure 5.17)

malleolaris is a shallow, faint ridge. Because I have not been able to locate a study that confirms these criteria as consistent, they were only used for specification when they occurred together and both of them appeared either goat-like or sheep-like. The two other criteria given by Prummel and Frisch (1986: 573) were not utilized in the study of the Mudayna fauna because they are too dependant upon the general shape of the distal tibia which is rather inconsistent (Clutton-Brock *et al.* 1990: 30).

One Dorcas gazelle (*Gazella dorcas*) distal tibia was identified from the Mudayna faunal remains. Identification of this specimen, like the identification of all of the post-cranial gazelle specimens, is based on size and geography rather than specific morphology. Two measurements taken on the Mudayna specimen (see Table 4.4) were compared with published gazelle tibia measurements from Hesban (Driesch and Boessneck 1995: 90) and Shams Ed-Din Tannira, Syria (Uerpmann 1982: 28-29). The greatest breadth of the distal end (Bd) of the Mudayna gazelle tibia is 20.06mm; the same size as the smallest distal tibiae found at Hesban (Figure 4.1). Driesch and Boessneck (1995: 89) have suggested that the smallest of the gazelle remains present at Hesban represent female Dorcas gazelles. If their suggestion is valid then the Mudayna distal tibia likely also represents a female Dorcas gazelle. However, because of the uncertainty in assigning even species to gazelle bones using size alone, the assignment of sex for this specimen has been reserved.

The smallest distal tibia Bd recorded at Shams Ed-Din Tannira was 21.0mm and the smallest Dd (greatest depth of the distal tibia) was 17.5mm. Both of these measurements are slightly larger than the measurements recorded for the Mudayna specimen. Uerpmann (1982: 30) argues that the gazelle remains from Shams Ed-Din Tannira represent *G. subgutturosa*, but he

Table 4.7 Summary Statistics of Tibia Measurements (mm)

Bp	<i>Ovis aries</i>	<i>Capra hircus</i>	<i>Ovis/Capra</i>	<i>Gazella dorcas</i>	<i>Bos taurus</i>
Mean	41.90		43.75		87.04
Median	42.09		43.75		87.04
Standard Deviation	1.74				
Minimum	40.07		43.75		87.04
Maximum	43.53		43.75		87.04
Count	3		1		1
Bd	<i>Ovis aries</i>	<i>Capra hircus</i>	<i>Ovis/Capra</i>	<i>Gazella dorcas</i>	<i>Bos taurus</i>
Mean	29.67	27.92	27.42	20.06	52.09
Median	29.42	27.96	27.48	20.06	52.09
Standard Deviation	0.75	2.05	1.74		
Minimum	28.75	25.21	25.28	20.06	52.09
Maximum	30.68	31.74	31.46	20.06	52.09
Count	5	8	12	1	1
Dd	<i>Ovis aries</i>	<i>Capra hircus</i>	<i>Ovis/Capra</i>	<i>Gazella dorcas</i>	<i>Bos taurus</i>
Mean	22.07	22.04	20.79	15.88	39.24
Median	22.21	21.24	20.49	15.88	39.24
Standard Deviation	0.35	1.61	1.41		
Minimum	21.47	20.62	18.61	15.88	39.24
Maximum	22.32	24.93	24.17	15.88	39.24
Count	5	7	13	1	1
SD	<i>Ovis aries</i>	<i>Capra hircus</i>	<i>Ovis/Capra</i>	<i>Gazella dorcas</i>	<i>Bos taurus</i>
Mean	16.65	15.06	14.46		
Median	16.88	14.97	14.46		
Standard Deviation	0.78	1.36			
Minimum	15.52	13.51	14.46		
Maximum	17.30	16.80	14.46		
Count	4	4	1		

admits that the collection may be an admixture of both *G. dorcas* and the larger *G. subgutturosa*. In either case, the Mudayna specimen is smaller than all of the Shams Ed-Din Tannira tibiae which is to be expected if the specimen represents the small Dorcas gazelle. Because morphology is not useful when differentiating between gazelle species (Uerpmann 1987: 90), the only other tool available, besides size, is zoogeography.

Archaeologically, the Dorcas gazelle has been identified in Sinai, the Negev, Wadi Araba and around the Dead Sea (Uerpmann 1987: 94). This small species of gazelle thrives in hot, arid environments. Importantly, remains of Dorcas gazelles were identified 30 km northwest of Mudayna at Hesban by both horncore morphology and post-cranial bone size. The other gazelle species that occur naturally around Mudayna are of a significantly larger size than the Dorcas gazelle, making the identification of this small distal tibia as *G. dorcas* most certain. In fairness it must be noted that small gazelles have “always” (Uerpmann 1987: 94) been kept as pets and traded over long distances within Arabia and so are occasionally found well outside of their natural habitats. Because *G. dorcas* lived around Mudayna in the past, finding their remains

at the site is to be expected. The identification of the gazelle distal tibia found at Mudayna as *G. dorcas* is enforced by both the size of the bone and the paleogeography of the species.

4.1.4 Astragali

Of the 38 medium and large sized mammal astragali studied in the Mudayna collection 17 were identified as *Ovis aries*, seven as *Capra hircus*, eight as *Ovis/Capra*, and four as *Gazella gazella*. The difference between *Ovis* and *Capra* astragali is much clearer than it is with most of the other bones. The clear difference between the species, plus the dense, compact nature of the astragalus (ensuring preservation) argue that it is a good bone to use as an indicator of species ratio found at the site. In Mudayna's case, judging by the astragalus, the *Ovis:Capra* ratio would be approximately 2.4:1. The argument against using astragali for this type of interpretation is that astragali have known cultural uses as both gaming pieces and dice that will distort the archaeological assemblage by an unknown amount (Hesse and Wapnish 1985: 56). If sheep and goat astragali are equally likely to be chosen as gaming pieces then the ratio of the species' astragali will remain roughly the same. Because I am unaware of any data about species preference for gaming piece selection, the numbers of Mudayna astragali are dealt with cautiously.

Five criteria were used to distinguish between *Ovis* and *Capra* astragali (Table 4.8), all of which were very consistent. If ever two conflicting criteria appeared, the astragalus was identified as *Ovis/Capra* because no one feature takes precedent over any other. The two most obvious features were the presence of a heavy lobe on the proximal-medial face of *Ovis* astragali, and the presence of a sharp anterior-medial articular ridge on *Capra* astragali.

Table 4.8 Distinguishing Criteria of *Ovis* and *Capra* Astragali

Criteria	<i>Capra</i> (Cat. #)	<i>Ovis</i> (Cat. #)
Projecting heavy lobe on medial aspect (<i>Ovis</i>)		494, 1258, 1381, 1646, 1983, 2038, 2048, 2102, 2147, 2175, 2509, 2527, 2605, 2607, 3107
Sharp ridge on end of medial articular ridge (<i>Capra</i>)	2047, 2496, 2782, 3605, 3680	
Resembles <i>Capra</i> example in Boessneck (1969) Figure 66Aa (<i>Capra</i>)	1042, 2047, 2496, 2782, 3269, 3605, 3680	
No ridge on end of medial articular ridge (<i>Ovis</i>)		494, 1258, 1381, 1983, 2048, 2102, 2147, 2175, 2509, 2527, 2605, 2607, 3107, 3865
Resembles <i>Ovis</i> example in Boessneck (1969) Figure 66Ba (<i>Ovis</i>)		339, 494, 1258, 1381, 1646, 1983, 2038, 2048, 2102, 2147, 2175, 2509, 2527, 2605, 2607, 3107, 3865

Table 4.9 Summary Statistics of Astragali Measurements (mm)

GLI	Capra	Ovis	Gazella
Mean	31.27	31.07	27.52
Median	30.55	30.97	27.56
Standard Deviation	1.42	0.84	0.12
Minimum	30.16	30.04	27.38
Maximum	33.74	32.74	27.61
Count	6	12	3
GLm	Capra	Ovis	Gazella
Mean	29.29	29.55	25.76
Median	29.59	29.43	25.87
Standard Deviation	0.76	0.99	0.41
Minimum	28.17	28.49	25.18
Maximum	29.80	31.94	26.10
Count	4	13	4
DI	Capra	Ovis	Gazella
Mean	16.06	17.29	15.30
Median	15.91	17.30	15.33
Standard Deviation	0.35	0.65	0.56
Minimum	15.70	16.16	14.60
Maximum	16.58	18.70	15.95
Count	5	13	4
Bd	Capra	Ovis	Gazella
Mean	19.56	19.45	17.66
Median	19.32	19.39	17.68
Standard Deviation	0.78	0.23	0.74
Minimum	18.95	19.12	16.90
Maximum	20.65	19.81	18.38
Count	4	11	4

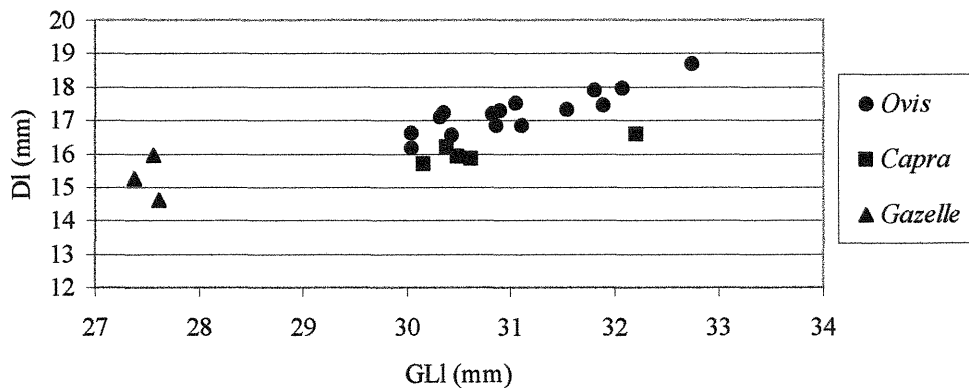


Figure 4.2 Comparison of *Ovis*, *Capra* and *Gazella* astragali greatest lateral length (GLI) vs. depth of the lateral half (DI)

A summary of the measurements taken on the *Ovis aries*, *Capra hircus* and *Gazella* astragali are shown in Table 4.9. As Figure 4.2 shows, measurements of *Ovis aries* and *Capra hircus* did not differ greatly. In general the *Ovis* astragali were slightly larger and thicker than the *Capra* astragali. Because sheep are generally more heavy set than goats, the measurement trend seen in Figure 4.2 is not surprising. An examination of Figure 4.2 shows a single *Capra* astragalus that is much larger than the four others measured. Such a large deviance from the rest of the group is likely due to sexual dimorphism. Even though the number of *Capra* astragali measured is very small, I am confident that the outlier (Catalogue number 2047) represents a male. The *Ovis* astragali show more of a continuum in size gradation. The astragalus with the largest GLI (Catalogue number 3865) certainly represents a male, and I suspect that the four astragali with GLI's hovering around 32 mm (Catalogue numbers 2525, 225, 494 and 1646) are male as well.

Four *Gazella gazella* astragali were recovered from Mudayna. The identification of these astragali is based on zoogeography and measurement data. As has already been established in the discussion about the identified *Gazella gazella* femur, *Gazella subgutturosa* is not believed to have lived near Mudayna. With *G. subgutturosa* eliminated as a candidate for the gazelle astragali, only *Gazella gazella* and *Gazella dorcas* are contenders. Figure 4.3 is a scatter plot of astragali measurements from a number of recent *G. gazella*, *G. dorcas* and the three Mudayna gazelle Mudayna specimens. It is quite clear from the size of the Mudayna specimens that they are *G. gazella*. It would also appear that the two largest specimens (catalogue numbers 1996 and 3029) are male while the third may be male or female. A fourth gazelle astragali, identified at Mudayna, was broken making the measurement of the greatest lateral length (GLI) impossible.

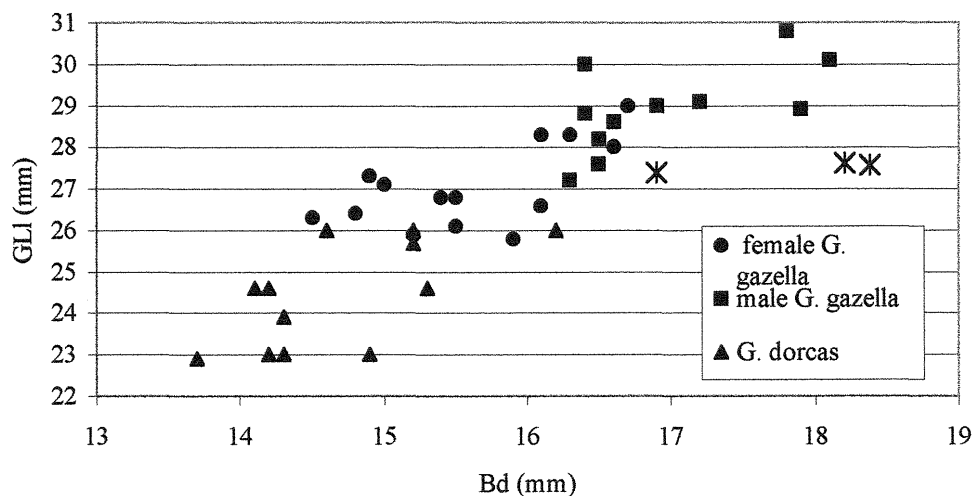


Figure 4.3 Comparison of gazelle astragali distal breadth (BD) and greatest lateral length (GLI) (Adapted from Horwitz et al. 1990: Figure 5, and von den Driesch and Wodtke 1997: Figure 11)

The specimen's distal breadth (Bd) is 17.15mm, however, placing it within the range of both male and female *G. gazella*.

4.1.5 Calcanei

A total of 66 calcanei were identified from Mudayna. 22 calcanei were clearly *Ovis aries*, a further 14 were *Capra hircus*, and 13 could only be identified as *Ovis/Capra*. Eight criteria were utilized in the distinction between *Ovis* and *Capra*. The most consistent and least subjective criteria were based around the length of the articulation process found on the sustentaculum. If the length of the articulation process was greater than half the length of the sustentaculum, the specimen was identified as *Ovis*. If the articulation process was less than half of the sustentacular length, the specimen was identified as *Capra*. The most important factor of these criteria (besides consistency) is that they are metric and therefore entirely objective. The relative length of the articular process is also useful because it can be used when only the sustentaculum is present. Another objective criterion used was the appearance of a single or doubled articular surface for the astragalus. If a single articular surface was present, the specimen was identified as *Capra*. No identification could be made on the presence of a doubled articular surface as this state appears in both *Ovis* and *Capra*.

Table 4.10 Distinguishing Criteria of *Ovis* and *Capra* Calcanei

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Long and slim (<i>Capra</i>)	2, 322	
Projecting tuber calcis (<i>Ovis</i>)	2107, 2502	8, 9, 646, 733, 923, 1422, 1447, 1501, 1650, 1671, 2035, 2100, 2548, 2802, 3279, 3325
Clearly distinguished condyle in facet of os malleolare (<i>Ovis</i>)		8, 9, 646, 647 733, 923, 1041, 1422, 1447, 1454, 1501, 1650, 1671, 2036, 2100, 2548, 2802, 3279, 3325, 3388
Long tongue-shaped articular facet (<i>Ovis</i>)		8, 9, 646, 647 733, 923, 1041, 1422, 1447, 1454, 1501, 1650, 1671, 2036, 2100, 2548, 2802, 3279, 3325, 3388
Curved on plantar surface only (<i>Capra</i>)	322, 2037	
Single articular surface for astragalus (<i>Capra</i>)	2, 25, 325, 1763, 2037, 2049, 2107, 2520, 2617, 3052, 3080	
More articulation than not on lateral process (<i>Ovis</i>)		8, 9, 646, 647, 733, 1041, 1422, 1447, 1454, 1501, 1650, 1671, 2036, 2100, 2415, 2548, 2802, 3279, 3325, 3388
Less articulation than not on lateral process (<i>Capra</i>)	2, 25, 322, 324, 325, 1763, 2049, 2107, 2520, 2617, 3052, 3080, 3324	

The measurements taken on the calcanei included both the standard measurements of greatest length (GL) and greatest breadth (GB) proposed by von den Driesch (1976) as well as two others taken specifically to compare with measurements provided for gazelles by Compagnoni (1978). The two extra measurements are the smallest breadth of the neck in a medial-lateral direction (SB (m-l)) and an anterior-posterior direction (SB (a-p)).

A single *Gazella gazella* calcaneus was identified within the Mudayna collection. Because the sustentaculum was not preserved, complete measurements could not be taken. Measurements of the breadth of the specimen's neck revealed that it was significantly slimmer than any *Ovis* or *Capra* found. The proximal tuber is fused indicating that the specimen is mature and at least one year of age (Davis 1980b). The Mudayna *G. gazella* specimen has a measurement of 6.7 mm for the smallest breadth of the neck; smaller than all of the figures Compagnoni (1978: 127) lists for the same measurement on eight *G. subgutturosa* calcanei (ranging from 8.6 mm to 7.2 mm).

Table 4.11 Summary Statistics of Calcanei Measurements (mm)

GL	<i>Bos</i>	<i>Capra</i>	<i>Ovis</i>	<i>Gazella</i>
Mean	124.11	60.71	60.98	
Median	124.11	60.33	60.18	
Standard Deviation		4.49	4.45	
Minimum	124.11	54.46	54.11	
Maximum	124.11	66.68	70.19	
Count	1	8	13	
GB	<i>Bos</i>	<i>Capra</i>	<i>Ovis</i>	<i>Gazella</i>
Mean	40.14	20.06	20.72	
Median	40.14	20.76	21.14	
Standard Deviation		1.44	1.37	
Minimum	40.14	17.88	18.45	
Maximum	40.14	21.93	22.78	
Count	1	7	11	
SB (m-l) neck	<i>Bos</i>	<i>Capra</i>	<i>Ovis</i>	<i>Gazella</i>
Mean	15.82	8.47	8.45	6.72
Median	15.82	8.44	8.38	6.72
Standard Deviation	0.62	0.62	0.83	
Minimum	15.38	7.52	7.08	6.72
Maximum	16.25	9.12	9.96	6.72
Count	2	7	14	1
SD (a-p) neck	<i>Bos</i>	<i>Capra</i>	<i>Ovis</i>	<i>Gazella</i>
Mean	27.76	14.72	13.82	12.94
Median	27.76	14.89	13.83	12.94
Standard Deviation	1.87	0.93	1.01	
Minimum	26.43	13.02	12.33	12.94
Maximum	29.08	15.54	15.68	12.94
Count	2	6	13	1

4.1.6 Fused Central and Fourth Tarsals

Of the 13 fused central and fourth tarsals identified at Mudayna, six were *Ovis aries*, two were *Capra hircus*, and one was *Ovis/Capra*. Providing the plantar surface of the specimen was preserved, differentiation between *Ovis* and *Capra* was possible by noting the presence or absence of a protuberance interrupting the proximal-distal running groove. If the protuberance was present the specimen was identified as *Capra*, when absent the designation of *Ovis* was assigned. The height of the projection on the medio-plantar surface may also be used to distinguish *Ovis* from *Capra* (*Ovis* has a higher projection than *Capra* does). Unfortunately, the projection was only fully preserved in one instance limiting its usefulness. Besides the three *Bos taurus* fused central and fourth tarsals, one large cervid tarsal was found that has been tentatively identified as belonging to *Dama mesopotamica*.

The identification of the large (GB = 31.15 mm) fused central and fourth tarsal as *D. mesopotamica* is based both on its size and on zoogeographic considerations. The size of the tarsal is too small for any truly large ungulate, but too large for any sheep, goat, or gazelle. It is (as Goldilocks would say) just right for a large cervid. Because red deer (*Cervus elaphus*) remains are “practically nonexistent” (Boessneck and von den Driesch 1995: 111) in Jordan after the Mesolithic it is most probable that the Mudayna specimen is a Mesopotamian fallow deer (*Dama mesopotamica*). It is not impossible that the Mudayna specimen actually represents the larger *C. elaphus* (unfortunately, I have no comparative measurements) as occasionally red deer finds do occur in the region. Two red deer bones (a distal astragalus and a distal metatarsus) were reported from the Ayyubid/Mamluk period at Hesban (Boessneck and von den Driesch 1995: 116) and it is thought that relic red deer populations may have survived in the Levant until the middle ages (Uerpmann 1987: 64). One possible explanation for the presence of red deer bones at Mudayna is that they were transported with a skin or fur that was being traded.

Having noted the possibility that the Mudayna cervid fused central and fourth tarsal may represent either a red deer or a fallow deer, I maintain that the most likely identification is a fallow deer. A strong argument for the *D. mesopotamica* identification is that two other certain *D. mesopotamica* bones (1st phalanges) have been identified from Mudayna while no other *C. elaphus* bones are present. One of the *D. mesopotamica* phalanges (Cat. 26) was found closely associated with the cervid fused central and fourth tarsal just above the surface of Courtyard 150. Table 4.13 shows a summary of measurements taken on all of the identifiable fused central and fourth tarsals.

Table 4.12 Distinguishing Criteria of *Ovis* and *Capra* Fused Central and 4th Tarsals

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Groove on plantar surface interrupted by a raised protuberance (<i>Capra</i>)	2443, 2531	
No protuberance (<i>Ovis</i>)		334, 2213, 2610, 2620, 3133, 3417
Short projection on medio-plantar surface (<i>Capra</i>)		
High projection (<i>Ovis</i>)		2213

Table 4.13 Summary Statistics of Fused Central and 4th Tarsal Measurements (mm)

GB	<i>Capra</i>	<i>Ovis</i>	<i>Dama</i>	<i>Ovis/Capra</i>	<i>Bos</i>
Mean	22.93	24.82	31.15	24.37	55.41
Median	22.93	25.00	31.15	24.37	55.41
Standard Deviation	0.29	1.18			11.13
Minimum	22.72	22.89	31.15	24.37	47.54
Maximum	23.13	26.24	31.15	24.37	63.28
Count	2	6	1	1	2

4.1.7 1st Phalanges

A total of 119 large (SC5) and very large (SC6) mammal 1st phalanges were studied from Mudayna. 28 *Ovis aries*, 32 *Capra hircus*, and 32 *Ovis/Capra* specimens account for the majority of the 1st phalanges. Other 1st phalanges identified to genus include examples from *Bos taurus* (6), *Gazella* sp. (4), *Dama mesopotamica* (3), and interestingly one of two *Camelus* bones found in the collection (see Figures 4.4 and 4.5). The squat, solid design (increasing survivorship) and the reongizability of 1st phalanges are likely both reasons their NISPs are so high. Most of the criteria used to distinguish between *Ovis* and *Capra* 1st phalanges were found to be quite consistent; however, two of the criteria were rather intermediate. When the height of the peripheral section of the proximal articular surface is only slightly higher than the axial section, the 1st phalanx is supposed to be an *Ovis* (Boessneck 1969: 356), but this was found not to be the case in one third of the specimens. In addition, if the 1st phalanx has a flat-convex posterior surface it is supposed to be *Ovis* (Boessneck 1969: 356), but this was also not so in one third of the specimens. The two most consistent criteria (Boessneck (1969: 356) notes they are “the best”) were the shapes of the distal articular surface (Boessneck 1969: 357). When the distal articular surface has the shape of an acute angle, the specimen is a *Capra*, when the articular surface is obtuse or open, the specimen is an *Ovis*. There was only one case out of all of the *Ovis* and *Capra* identified (60) where the shape of the distal articular surface was misleading.



Figure 4.4 Photograph of two *D. mesopotamica* 1st phalanges



Figure 4.5 Photograph of a camel 1st phalanx

Table 4.14 Distinguishing Criteria for *Ovis* and *Capra* 1st Phalanges

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Deep leading groove on proximal end (<i>Capra</i>)	3, 476, 477, 621, 727, 1632, 1893, 2012, 2266, 2312, 2459, 2662, 2698, 3051, 3327, 3399, 3709	2250
Peripheral section of proximal articular surface is much higher than the axial (<i>Capra</i>)	3, 343, 476, 477, 621, 727, 818, 965, 1745, 2012, 2021, 2312, 2459, 2662, 2698, 3327, 3500, 3709, 3736	1005, 1039, 1995, 3753
Articular surface is less high (<i>Ovis</i>)	1326, 1632, 1654, 1893, 1894, 2266, 3051, 3399	478, 479, 480, 622, 728, 819, 1684, 1819, 2050, 2127, 2250, 3236, 3326, 3460, 3506, 3642,
Proximal articular surface groove is steep (<i>Capra</i>)	3, 476, 477, 621, 965, 1326, 1632, 1654, 1745, 1894, 2012, 2021, 2266, 2459, 2662, 2698, 3051, 3327, 3399, 3500, 3709, 3736	3236
Surface groove is shallow (<i>Ovis</i>)	727, 818, 1326, 1893, 2312	478, 479, 480, 622, 728, 819, 1005, 1039, 1684, 1819, 1995, 2050, 2127, 2250, 3326, 3460, 3642, 3753,
High ridged axial ligament tubercle (<i>Capra</i>)	621, 818, 1654, 1745, 1893, 1894, 2021, 2312, 2698, 3051, 3399, 3500, 3643, 3709	479, 729, 1005
Well developed points for attachment of ligaments on lateral borders (<i>Capra</i>)	476, 477, 727, 1006, 1482, 1632, 1654, 1893, 2012, 2021, 2312, 2896, 3051, 3180, 3327, 3500, 3643, 3709, 3736	622, 1995, 2250
Concave posterior surface (<i>Capra</i>)	818, 965, 1006, 1482, 1632, 1654, 1893, 2312, 2896, 3051, 3180, 3399, 3500, 3643, 3709, 3736	1684, 1819, 2250, 2314, 3236, 3460,
Flat-convex posterior surface (<i>Ovis</i>)	727, 1326, 1745, 1894, 2021, 2266, 2698, 3327	622, 728, 819, 1005, 1039, 1408, 1995, 2050, 2109, 2127, 2265, 2815, 3236, 3326, 3642, 3733, 3753,
Distal articular surface has an acute angle (<i>Capra</i>)	3, 476, 477, 621, 727, 818, 965, 1006, 1326, 1482, 1632, 1654, 1745, 1893, 1894, 2012, 2021, 2266, 2698, 2896, 3051, 3180, 3327, 3399, 3500, 3643, 3709, 3736	1629
Distal articular surface is obtuse and open (<i>Ovis</i>)		478, 479, 622, 728, 819, 1005, 1039, 1408, 1684, 1819, 1820, 1995, 2050, 2109, 2127, 2250, 2265, 2314, 2741, 2815, 3236, 3326, 3460, 3506, 3642, 3733, 3753,

A clear metric distinction was not found between *Ovis* and *Capra* 1st phalanges when the relationship between the smallest breadth of the shaft (SD) and the greatest length of the peripheral half (GLpe) was examined (Figure 4.6). Within a species, however, the anterior and posterior phalanges were well separated. A single gazelle 1st phalanx was preserved well enough to provide complete measurements. A comparison of the measurement of the Mudayna gazelle

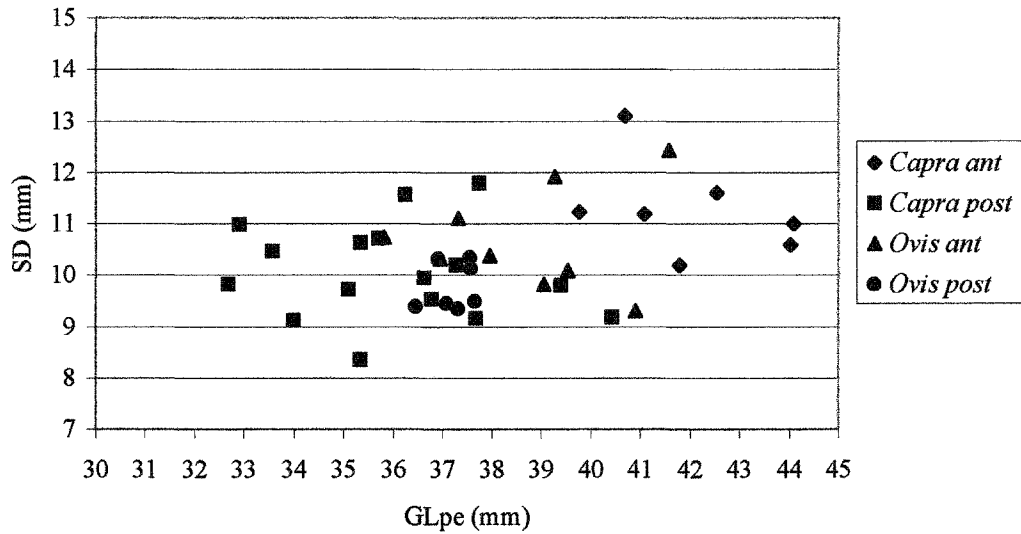


Figure 4.6 A comparison of *Ovis* and *Capra* 1st phalanges greatest length of the peripheral half (GLpe) and smallest breadth of the diaphysis (SD)

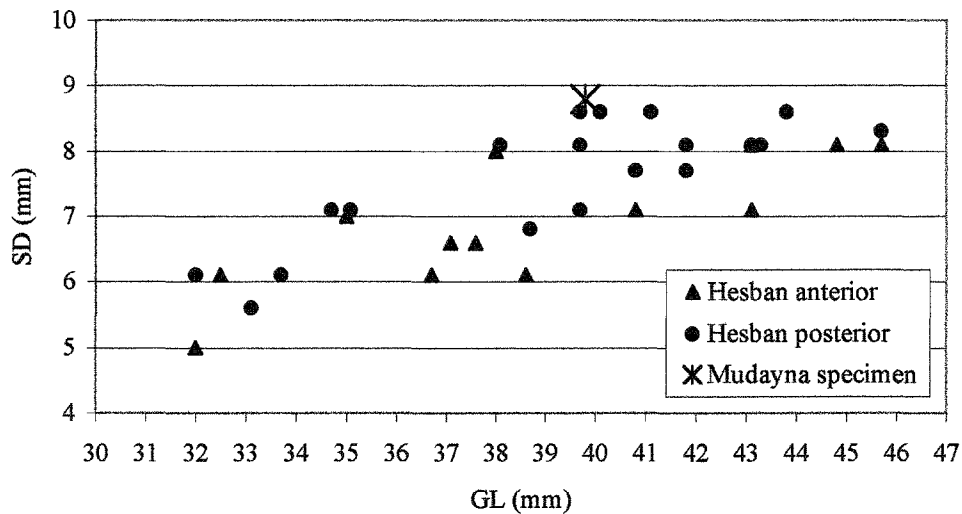


Figure 4.7 A comparison of gazelle 1st phalanges greatest length (GL) vs. smallest breadth of diaphysis (SD) (Adapted from von den Driesch and Boessneck 1995: Figure 5.18)

specimen with gazelle 1st phalanges from Hesban (Figure 4.7) shows that the Mudayna gazelle is likely a posterior 1st phalanx from a *Gazella gazella*. It is thought that the largest gazelles found at Hesban represent *Gazella gazella*, and possibly (though very unlikely) *Gazella subgutturosa*, males and that the smallest gazelles represent female *Gazella dorcas*. With this size range in mind, it is almost certain that the Mudayna specimen is a female *Gazella gazella*.

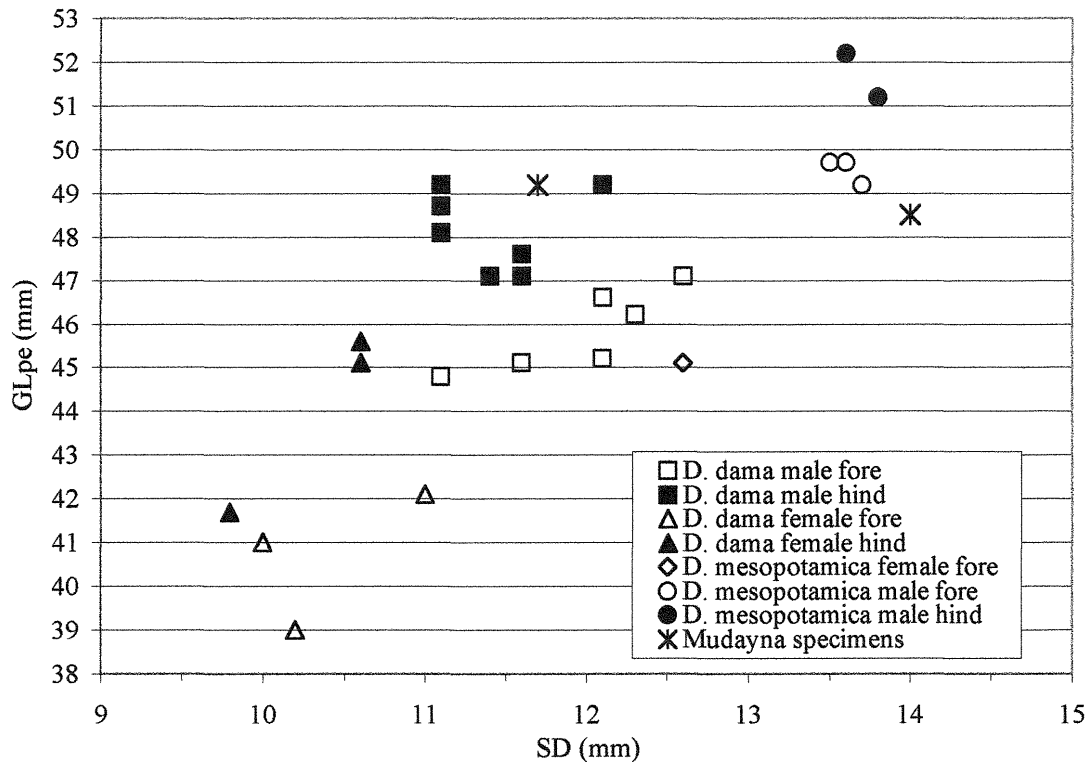


Figure 4.8 Comparison of cervid 1st phalanges greatest length of the peripheral half (GLPe) and smallest breadth of the diaphysis (SD) (Adapted from Boessneck and von den Driesch 1995: Figure 6.1)

Metric analysis of two nearly complete cervid 1st phalanges found at Mudayna has proven useful in securing their identification as *Dama mesopotamica*. When the two Mudayna specimens are compared with measurements of the greatest length (GLPe) and the smallest breadth of the diaphysis (SD) of *Dama mesopotamica* found at Hesban and *Dama dama* found in Turkey and Macedonia (Figure 4.8) their identification becomes certain. Remains of the European fallow deer (*Dama dama*) are not found west of Turkey (Uerpmann 1987: 58) so there is no chance the Mudayna specimens represent that species. *Dama dama* measurements are, however, useful for size comparisons with *Dama mesopotamica* because male *D. dama* bones are roughly the same size as female *D. mesopotamica* bones (Boessneck and von den Driesch 1995: 115). As Figure 4.8 shows, the measurements of the two Mudayna cervid 1st phalanges correspond nicely with the male *D. dama* hind phalanges and the male *D. mesopotamica* fore phalanges. Because no *D. dama* are found in the region, the first phalanx must actually have come from a female *D. mesopotamica*.

Six cattle (*Bos taurus*) 1st phalanges have been identified from Mudayna; four posterior and two anterior. The discovery of only six 1st phalanges does not provide enough data for accurate statistical analysis of Iron Age cattle size. It appears that generally the cattle 1st

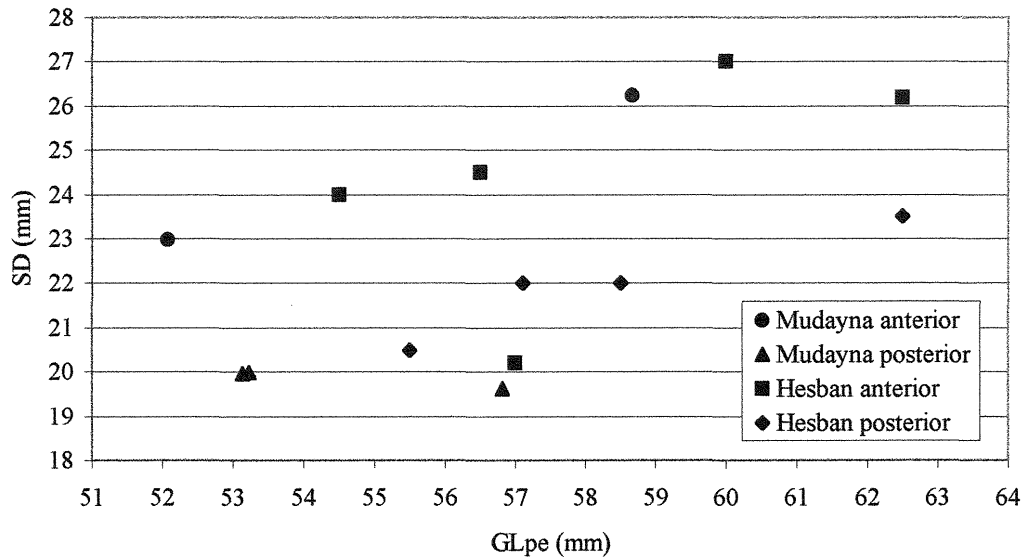


Figure 4.9 The greatest length of the peripheral half (GLPe) and the smallest breadth of the diaphysis (SD) of Mudayna cattle 1st phalanges and Hesban cattle 1st phalanges (adapted from von den Driesch and Boessneck 1995: Figure 5.6 and Figure 5.7)

phalanges found at Mudayna are within the range of, or slightly smaller than, their Iron Age counterparts at Hesban. Measurements taken on other Mudayna cattle bones are also similar to the Iron Age cattle recovered from Hesban. Details of the other cattle measurements taken are presented in chapter six.

One of the more interesting faunal finds from Mudayna was a *Camelus* 1st phalanx. Unfortunately, the distal articular surface of the bone was broken off in antiquity so complete measurements could not be taken. The University of Saskatchewan faunal comparative collection does not house a camel, but reference to a diagram of a camel 1st phalanx, published by Walker (1985: 186), and comparison to a horse 1st phalanx left no doubt about its identification. Identification, to the level of species, of the camel phalanx found at Mudayna is not possible morphologically (Wapnish 1984: 181), but I have followed other researchers (von den Driesch and Boessneck 1995: 84-85; Compagnoni and Tosi 1978: 99) perhaps erroneously (Uerpmann 1987: 48-52) in designating the specimen as *Camelus dromedarius* based on zoogeography. Presently, the dromedary camel is the only species found within the Middle East (Uerpmann 1987: 48). The dromedary is better suited to the hot, arid environment than its cousin the two-humped bactrian, who prefers a colder steppe climate (Wapnish 1984: 174). The bactrian and dromedary's different ecological preferences are part of the argument scholars have put forth for the identification of dromedaries (being at home environmentally) at Near Eastern archaeological sites. The possible implications for the appearance of *Camelus* bones at Mudayna

Table 4.15 Summary Statistics of 1st Phalanx Measurements (mm)

GLpe	Capra	Ovis	Gazella	Bos	D. mesopotamica	Ovis/Capra	Camelus
Mean	37.90	37.87	39.78	54.78	48.82	34.68	
Median	37.49	37.49	39.78	53.23	48.82	34.68	
Standard Deviation	3.37	1.63		2.81	0.48	2.73	
Minimum	32.69	35.32	39.78	52.08	48.48	32.75	
Maximum	44.10	41.57	39.78	58.66	49.16	36.61	
Count	24	18	1	5	2	2	
Bp	Capra	Ovis	Gazella	Bos	D. mesopotamica	Ovis/Capra	Camelus
Mean	12.80	13.16	11.19	27.15	15.15	13.19	38.3
Median	12.77	12.90	11.19	26.37	14.58	13.05	38.3
Standard Deviation	1.26	0.97	0.23	4.46	1.39	0.53	
Minimum	9.81	11.78	11.02	22.89	14.14	12.66	38.3
Maximum	15.96	15.79	11.35	32.97	16.73	13.85	38.3
Count	27	18	2	4	3	6	1
SD	Capra	Ovis	Gazella	Bos	D. mesopotamica	Ovis/Capra	Camelus
Mean	10.11	10.22	8.36	21.46	12.59	10.72	20.24
Median	10.07	10.26	8.70	20.00	12.06	10.56	20.24
Standard Deviation	1.31	0.82	0.79	2.65	1.25	0.73	
Minimum	7.67	9.28	7.46	19.61	11.69	9.67	20.24
Maximum	13.09	12.43	8.93	26.23	14.01	11.48	20.24
Count	28	22	3	6	3	5	1
Bd	Capra	Ovis	Gazella	Bos	D. mesopotamica	Ovis/Capra	Camelus
Mean	12.02	12.41	10.72	25.44	15.25	12.03	
Median	11.97	12.24	10.72	25.16	15.25	11.85	
Standard Deviation	1.48	1.18	0.53	2.92	1.40	0.70	
Minimum	9.61	10.91	10.34	22.81	14.26	11.13	
Maximum	16.01	16.05	11.09	30.13	16.24	13.41	
Count	29	25	2	5	2	8	

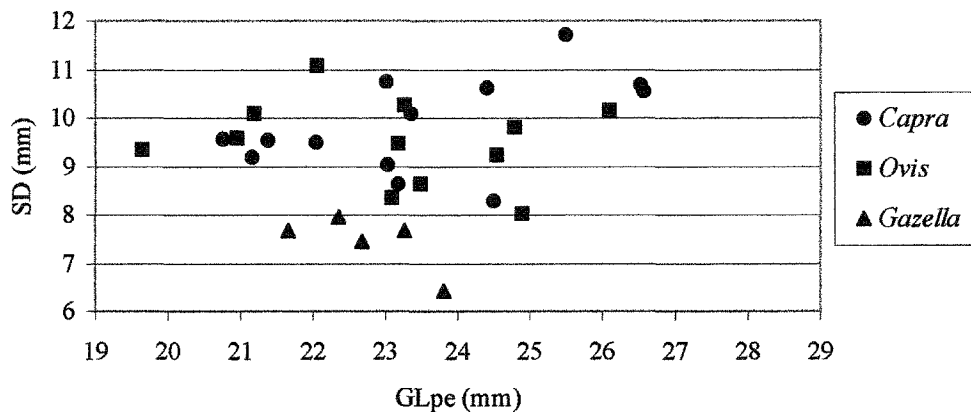
will be discussed further in chapter six. A summary of the measurements taken from the Mudayna *Camelus* 1st phalanx, and the other identifiable 1st phalanges, are presented in Table 4.15 above.

4.1.8 2nd Phalanges

Large (SC5) and very large mammals (SC6) were represented by 57 2nd phalanges. 18 2nd phalanges were identified as *Ovis aries*, 15 as *Capra hircus* and a further 11 as *Ovis/Capra*. Distinguishing between *Ovis* and *Capra* 2nd phalanges was fairly straight forward providing that enough of the distal end of the bone was preserved. Table 4.16 shows the six criteria used to differentiate between the two species. Because all of the criteria are based around the distal trochlear condyle, finding the proximal half of the 2nd phalanx does not allow for identification to species. 2nd phalanges preserve well, and were often found intact, but were only recovered about half as often as 1st phalanges. The differences in recovery rates of the 1st and 2nd phalanges is likely, in large part, a product of the limited screening program in place at

Table 4.16 Distinguishing Criteria of *Ovis* and *Capra* 2nd Phalanges

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Strongly indented trochlear condyle (<i>Capra</i>)	481, 730, 1040, 1619, 1895, 1931, 2155, 2167, 2229, 2532, 3378, 3406, 3507, 3560, 3561	1932, 2816
Weakly indented trochlear condyle (<i>Ovis</i>)		340, 482, 623, 624, 731, 732, 1704, 1718, 1764, 1817, 2677, 2899, 2966, 3419, 3425
Ridged trochlear condyle (<i>Capra</i>)	481, 730, 1040, 1619, 1895, 1931, 2155, 2167, 2229, 2532, 3378, 3406, 3507, 3560, 3561	
No ridge on trochlear condyle (<i>Ovis</i>)		482, 623, 624, 731, 732, 1704, 1718, 1764, 1817, 1932, 2677, 2816, 2899, 2966, 3419, 3425
Strongly projecting axial distal trochlear condyle (<i>Capra</i>)	481, 730, 1040, 1619, 1895, 1931, 2229, 2532, 3406, 3507, 3560, 3561	2677, 2899
Weakly projecting axial distal trochlear condyle (<i>Ovis</i>)	2167	340, 482, 623, 624, 731, 732, 1704, 1718, 1764, 1817, 1932, 2816, 2966, 3419, 3425

**Figure 4.10** *Ovis*, *Capra* and *Gazella* 2nd phalanx measurements comparing greatest length of the peripheral half (GLPe) and smallest breadth of the diaphysis (SD)

Mudayna. Because of their small size, 2nd phalanges are probably simply overlooked twice as often as 1st phalanges when screening is not being consistently employed.

A metric analysis comparing the “greatest length of the peripheral half” (GLPe) and the “smallest breadth of the diaphysis” (SD) of the *Ovis*, *Capra* and *Gazella* 2nd phalanges is shown in Figure 4.10. No clear separation exists between the *Ovis* and *Capra* phalanges (in fact they are thoroughly mixed), but the *Gazella* cluster at the bottom of the chart. It is unfortunate that *Ovis*

and *Capra* 2nd phalanges can not be distinguished metrically, but because the morphological criteria differentiating the two species are so strong, a metric separation is unnecessary.

I have identified the five *Gazella* 2nd phalanges that appear in Figure 4.10 as being from *Gazella gazella* based on both size and zoogeography. As previously mentioned, it is not thought that *G. subgutturosa* (a gazelle of a similar size as *G. gazella*) was found in the region around Mudayna. The choice of gazelles is, then, limited to two: *G. dorcas* and *G. gazelle*. A comparison between measurements provided by Ducos (1968: 167-68) for *G. subgutturosa* (Uerpmann 1987: 100) from Ain-Mallaha and measurements from the Mudayna specimens show that the Mudayna specimens are slightly larger (Table 4.17), particularly the “greatest breadth of the proximal end” (Bp). They are not, however, too large to be considered *Gazella gazella*, but are certainly too large to be from a *G. dorcas*.

Table 4.17 Summary Statistics of 2nd Phalanx Measurements (including gazelle phalanges from Ain-Mallaha (Ducos 1968: 167-168) (mm))

Glpe	Capra	Ovis	Gazella	Bos	Ovis/Capra	Ain-Mallaha
Mean	23.50	23.07	22.75	36.87	22.38	
Median	23.18	23.18	22.68	35.88	22.77	
Standard Deviation	1.93	1.80	0.83	4.57	0.85	
Minimum	20.77	19.65	21.66	32.87	21.17	21.20
Maximum	26.58	26.11	23.81	41.85	23.26	24.40
Count	13	13	5	3	6	27
Bp	Capra	Ovis	Gazella	Bos	Ovis/Capra	Ain-Mallaha
Mean	13.44	13.06	10.58	27.29	12.00	
Median	13.03	12.75	10.55	28.86	12.12	
Standard Deviation	1.20	0.76	0.60	3.66	0.95	
Minimum	12.08	12.05	9.99	23.11	10.58	7.80
Maximum	15.98	14.26	11.55	29.90	13.04	9.80
Count	13	13	5	3	6	27
SD	Capra	Ovis	Gazella	Bos	Ovis/Capra	Ain-Mallaha
Mean	9.82	9.49	7.43	24.30	9.08	
Median	9.55	9.47	7.66	23.90	8.98	
Standard Deviation	0.95	0.83	0.59	0.84	0.99	
Minimum	8.29	8.02	6.42	23.73	7.42	5.00
Maximum	11.72	11.08	7.95	25.27	10.46	6.60
Count	14	13	5	3	7	27
Bd	Capra	Ovis	Gazella	Bos	Ovis/Capra	Ain-Mallaha
Mean	10.63	10.17	8.06	24.58	9.39	
Median	10.50	10.30	8.36	24.58	9.37	
Standard Deviation	0.94	0.71	1.28	0.27	0.87	
Minimum	9.00	8.95	5.84	24.39	8.28	7.00
Maximum	12.15	11.00	8.93	24.77	10.78	8.80
Count	11	12	5	2	7	27

4.1.9 3rd Phalanges

Even fewer 3rd phalanges were recovered from Mudayna than 2nd phalanges. Seven *Ovis* 3rd phalanges, four *Capra* 3rd phalanges and two *Ovis/Capra* 3rd phalanges were found. The reasons for finding a lower number of 3rd phalanges are the same as the reasons that fewer 2nd phalanges were found than 1st phalanges. When the size of a bone is reduced, its recognizability is also reduced, especially when full screening does not take place. Table 4.18

Table 4.18 Distinguishing Criteria of *Ovis* and *Capra* 3rd Phalanges

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Thin (<i>Capra</i>)	1310, 3134	
Well developed processus extensorius (<i>Ovis</i>)		341, 475
Poorly developed processus extensorius (<i>Capra</i>)	3440, 3866	1481, 2715
Isosceles triangle (<i>Capra</i>)	1310, 3134	
Curved (<i>Ovis</i>)	3440, 3866	195, 341, 475, 619, 1481, 2751, 3429
Not curved (<i>Capra</i>)	1310, 3134	
Saddle in front of processus extensorius (<i>Ovis</i>)		341, 475, 1418, 2715
No saddle (<i>Capra</i>)	3440, 3866	

Table 4.19 Summary Statistics of 3rd Phalanx Measurements (mm)

DLS	<i>Capra</i>	<i>Ovis</i>	<i>Dama</i>	<i>Bos</i>
Mean	28.38	31.16	42.08	59.74
Median	28.38	30.60	42.08	59.74
Standard Deviation	1.74	3.55		
Minimum	27.15	27.11	42.08	59.74
Maximum	29.61	38.08	42.08	59.74
Count	2	7	1	1
Ld	<i>Capra</i>	<i>Ovis</i>	<i>Dama</i>	<i>Bos</i>
Mean	21.81	24.84	34.19	46.84
Median	21.81	25.03	34.19	46.84
Standard Deviation		3.92		
Minimum	21.81	19.53	34.19	46.84
Maximum	21.81	30.01	34.19	46.84
Count	1	5	1	1
MBS	<i>Capra</i>	<i>Ovis</i>	<i>Dama</i>	<i>Bos</i>
Mean	4.89	6.28	6.67	20.29
Median	4.89	6.29	6.67	20.29
Standard Deviation	0.74	0.56		0.78
Minimum	4.37	5.72	6.67	19.73
Maximum	5.41	7.41	6.67	20.84
Count	2	7	1	2

shows the criteria used to distinguish between *Ovis* and *Capra*, and Table 4.19 presents a summary of 3rd phalanx measurements.

A single large cervid 3rd phalanx was recovered from Mudayna. While this specimen could not be assigned to a species through morphological comparison, metric data suggest that it belongs to a fallow deer (*Dama mesopotamica*). Ducos gives a range of measurements for the length of four *Dama mesopotamica* 3rd phalanges recovered from Ain-Mallaha as 37.0 mm - 41.4 mm (Ducos 1968: 163). It must be assumed that Ducos' length measurement is equivalent to the length measurements I took (DLS) following von den Driesch (1976: 101). The length of the cervid 3rd phalanx found at Mudayna is 42.08 mm, slightly larger than the largest measurement presented by Ducos but close enough for me to confidently assign the specimen to *D. mesopotamica*.

4.1.10 Scapulae

A total of 147 large (SC5) and very large (SC6) mammal scapulae were found at Mudayna. 18 scapulae were identified as *Ovis aries* and 14 were identified as *Capra hircus*. A further 40 scapulae could not be identified to anything more specific than *Ovis/Capra*. The *Ovis* and *Capra* scapulae were differentiated partially on the presence or absence of a large pecten on the neck. As may be seen in Table 4.20, *Ovis* scapulae typically have a large pecten while *Capra* scapulae had little or no pecten on their necks. Boessneck (1969: 337) notes that *Capra* tend to have a circular glenoid cavity while *Ovis* tend to have a more elliptical glenoid cavity. In an

Table 4.20 Distinguishing Criteria of *Ovis* and *Capra* Scapulae

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Large pecten opposite collum (<i>Ovis</i>)	869, 938	36, 261, 470, 598, 599, 603, 883, 979, 1024, 1052, 1593, 1698, 2177, 3092, 3657
Circular glenoid cavity LG:BG \leq 1.21 (<i>Capra</i>)	459, 600, 869, 938, 1412, 1502, 2553, 2695	1698
Elliptical glenoid cavity LG:BG $>$ 1.21 (<i>Ovis</i>)	4, 3594	36, 470, 598, 599, 603, 883, 979, 1024, 1593, 2177, 3092, 3475, 3657
Rounded off and well developed supra-glenoid tubercle (<i>Ovis</i>)	459	36, 261, 470, 598, 599, 603, 883, 979, 1024, 1593, 1698, 2614, 3092, 3475, 3657
Little or no pecten opposite collum (<i>Capra</i>)	4, 98, 459, 600, 601, 1502, 2553, 3156, 3594	
Poorly developed supra-glenoid tubercle (<i>Capra</i>)	4, 869, 938, 1412, 1502, 2553, 2695, 3156, 3594	
Pad on spinal tuberosity (<i>Ovis</i>)		3657

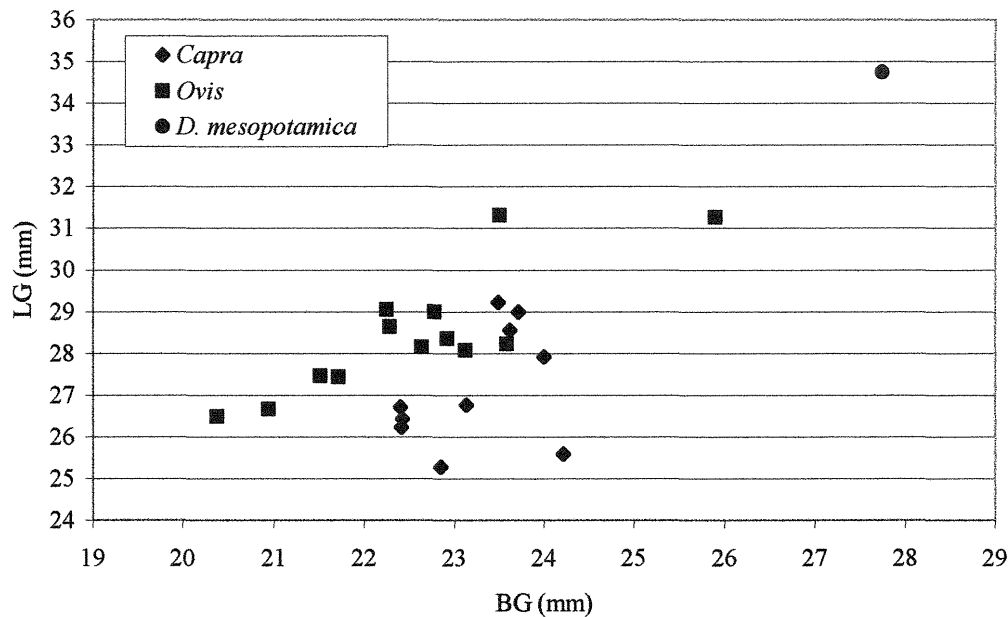


Figure 4.11 *Ovis*, *Capra* and *D. mesopotamica* scapulae greatest length (LG) vs. greatest breadth (BG) of the glenoid cavity

attempt to quantify these rather subjective criteria, Lipovitch (1999: 48) measured the greatest length (GL) and the greatest breadth (BG) of *Ovis* and *Capra* glenoid cavities and came up with a dividing ratio of LG:BG = 1.21:1. Lipovitch insists that the ratio of 1.21:1 is based on a statistically insignificant number of samples and that it should not be used for samples other than the one he studied. However, when all of the specimens had been measured and LG:BG ratios had been calculated it appeared that Lipovitch's number of 1.21:1 worked very well with the Mudayna scapulae as well. When the measurements of the glenoid cavity are plotted in a graphic form as the "greatest length" (LG) vs. the "greatest breadth" (BG) (Figure 4.11) two loose groups are formed, with some overlap between them. Generally, however, as Figure 4.11 shows, *Ovis* glenoid cavities are longer than they are wide, giving them an elliptical appearance, while *Capra* glenoid cavities approximate circles, and look as such.

Out of the scapulae that were not identified as sheep or goat, three were identified as gazelles, one as cervid and another as coming from a camel. All of the gazelle scapulae were of a similar size, but one had the upper portion of its glenoid cavity broken off so complete measurements could not be taken. Measurements of the greatest length of the glenoid process (GLP) from the two complete scapulae were compared with the GLP of gazelle scapulae reported from Hesban (Figure 4.12). It is apparent that the two Mudayna gazelle scapulae are as large as the largest gazelle scapulae reported from Hesban (*Gazella gazella*). It is through a metric analysis, rather than a morphological one that I have identified the Mudayna gazelle

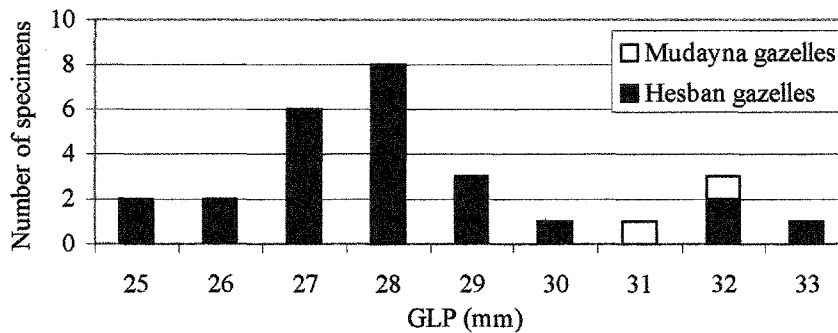


Figure 4.12 Size comparison of Hesban and Mudayna gazelle scapula GLPs (greatest length of the glenoid process) (adapted from von den Driesch and Boessneck 1995: Figure 5.17)

Table 4.21 Summary Statistics of Scapulae Measurements (mm)

SLC	<i>Capra</i>	<i>Ovis</i>	<i>Camelus</i>	<i>G. gazella</i>	<i>Ovis/Capra</i>	<i>D. mesopotamica</i>
Mean	20.16	20.75	68.50	17.33	19.27	24.05
Median	20.29	20.82	68.50	17.65	19.55	24.05
Standard Deviation	1.11	1.58		0.68	2.33	
Minimum	18.01	18.30	68.50	16.55	14.60	24.05
Maximum	21.36	23.91	68.50	17.79	21.63	24.05
Count	9	13	1	3	7	1
GLP	<i>Capra</i>	<i>Ovis</i>	<i>Camelus</i>	<i>G. gazella</i>	<i>Ovis/Capra</i>	<i>D. mesopotamica</i>
Mean	34.39	35.96		31.77	33.36	43.25
Median	34.39	35.23		31.77	33.36	43.25
Standard Deviation	1.46	2.20		0.58	0.63	
Minimum	32.20	33.74		31.36	32.91	43.25
Maximum	36.68	40.14		32.18	33.80	43.25
Count	10	14		2	2	1
LG	<i>Capra</i>	<i>Ovis</i>	<i>Camelus</i>	<i>G. gazella</i>	<i>Ovis/Capra</i>	<i>D. mesopotamica</i>
Mean	27.13	28.44	68.87	25.92	28.45	34.74
Median	26.73	28.20	68.87	25.92	28.45	34.74
Standard Deviation	1.35	1.42		0.01	1.90	
Minimum	25.28	26.48	68.87	25.91	27.10	34.74
Maximum	29.22	31.31	68.87	25.93	29.79	34.74
Count	11	14	1	2	2	1
BG	<i>Capra</i>	<i>Ovis</i>	<i>Camelus</i>	<i>G. gazella</i>	<i>Ovis/Capra</i>	<i>D. mesopotamica</i>
Mean	23.23	22.54	59.10	20.84	24.25	27.74
Median	23.32	22.46	59.10	20.43	25.00	27.74
Standard Deviation	0.68	1.33		0.75	2.04	
Minimum	22.40	20.38	59.10	20.39	21.61	27.74
Maximum	24.21	25.89	59.10	21.70	26.60	27.74
Count	10	14	1	3	5	1
S-Gc	<i>Capra</i>	<i>Ovis</i>	<i>Camelus</i>	<i>G. gazella</i>	<i>Ovis/Capra</i>	<i>D. mesopotamica</i>
Mean	22.98	19.92	40.22	19.97	21.74	30.04
Median	22.73	20.26	40.22	19.03	21.11	30.04
Standard Deviation	2.48	2.26		2.08	1.57	
Minimum	20.18	16.94	40.22	18.53	19.63	30.04
Maximum	27.75	22.92	40.22	22.36	24.04	30.04
Count	10	16	1	3	7	1

Table 4.22 A comparison of scapulae measurements from Hesban, Ain-Mallaha and Mudayna *D. mesopotamica* (adapted from Boessneck and von den Driesch 1995: Table 6.1 and Ducos 1968: Tableau VII)

Scapula	Tell Hesban			Ain-Mallaha	Mudayna
SLC	29.5			23.2-26.2	24.05
GLP	52	53	46.5	42.0-47.0	43.25
LG	41	39	35	32.0-36.0	34.74
BG		36	31	28.0-33.0	27.74
Number	1	1	1	4	1
Gender	Male	Male	Female	?	Female

scapulae as being *Gazella gazella*. The cervid scapula identification was also made on the basis of metric data. The measurements of the cervid scapula are presented in Table 4.21, along with measurements of the other identified scapulae. A comparison between the Mudayna cervid scapula measurements and a range of measurements provided by Ducos (1968: 162) for four *Dama mesopotamica* scapulae found at Ain-Mallaha match nicely (Table 4.22). Further comparison of the Mudayna cervid scapula with measurements provided by Boessneck and von den Driesch (1995: Table 6.1) for both male and female *D. mesopotamica* found at Hesban indicate that the Mudayna specimen is female (Table 4.22). The general shape of the glenoid cavity and supra-glenoid tubercle of the Mudayna *D. mesopotamica* scapula match well with photographs published of the Hesban specimens, so morphologically as well as metrically, the identification is sound.

The largest scapula recovered from Mudayna belonged to a camel. The general identification of the specimen as a camel was not difficult because of its enormous size and shape. It resembles neither a horse nor a bull and reference to a drawing of a camel scapula found in Walker (1985: 7) confirmed that the Mudayna specimen is indeed a camel scapula. Identification of the scapula to species is not possible morphologically but I have assigned it to *Camelus dromedarius* based on zoogeography.

The measurement S-Gc (the smallest distance from the spine to the glenoid cavity) was not described by von den Driesch in her 1976 work, but was taken on the Mudayna scapula because other researchers (Compagnoni 1978: 126; Boessneck et al. 1964: 59) have used it and I thought it may be useful for comparison. As it turns out, the measurement was not utilized but it is presented here because it may prove to be useful for future work. Figures 4.13 and 4.14 below are photographs of some of the scapulae recovered from Mudayna. The camel scapula shown in Figure 4.14 shows signs of having been exposed to the elements for some time prior to burial. This amount of weathering is not typically seen on specimens recovered from Mudayna; most

are in excellent condition. I suspect that the large size of the camel scapulae delayed its burial sufficiently to allow for heavy weathering to take place.

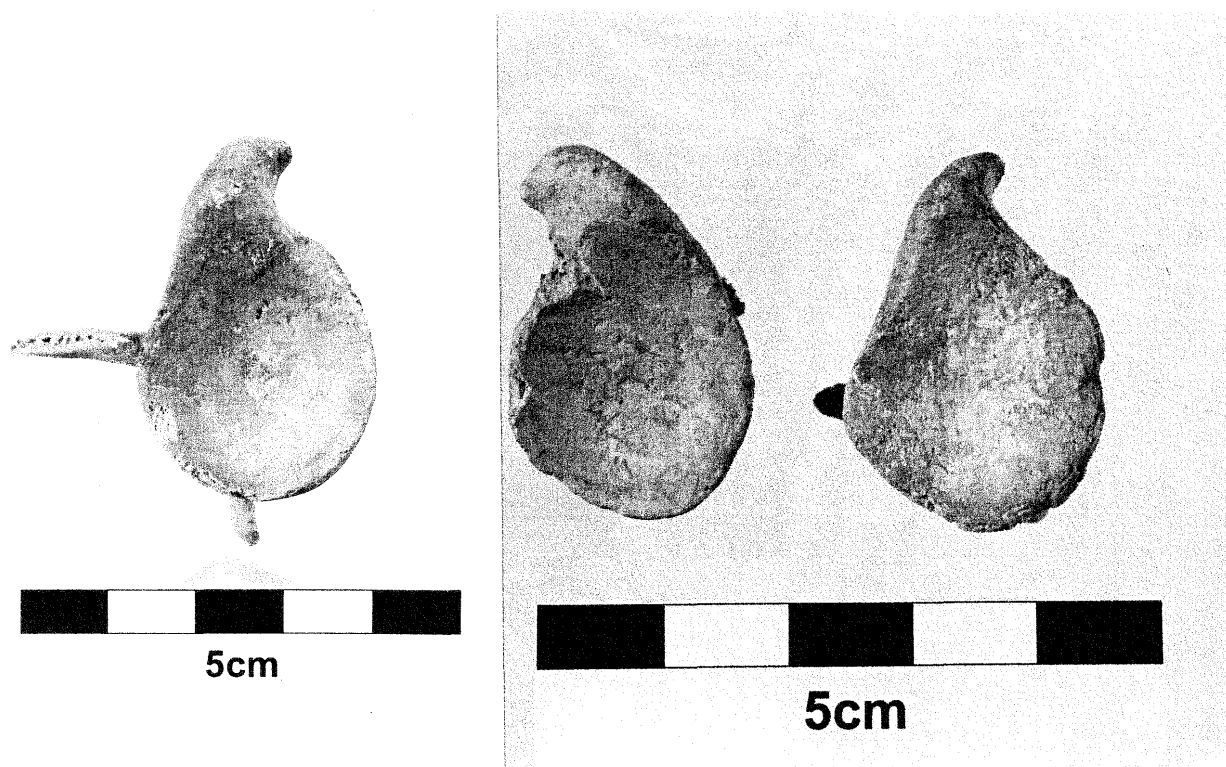


Figure 4.13 Photograph of *D. mesopotamica* scapula (left) and two *G. gazella* scapulae (right)

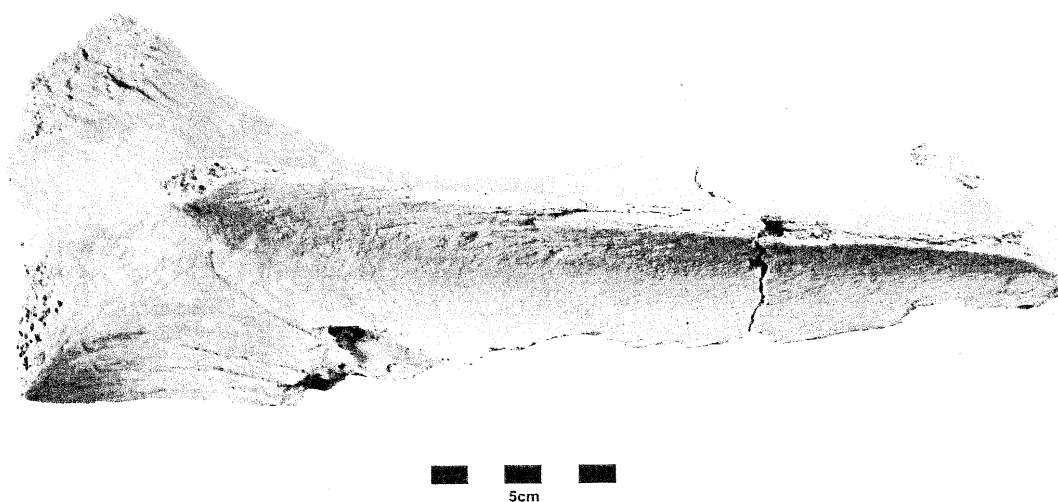


Figure 4.14 Photograph of a camel scapula

4.1.11 Humeri

From the 153 humeri specimens found at Mudayna, 18 were preserved well enough to be identified as *Ovis aries*, 16 were preserved well enough to be labeled *Capra hircus*, and a further 54 were classified as *Ovis/Capra*. Many humeri shaft fragments were recovered but few could be positively identified as anything other than Artiodactyla SC5. Because the distal end of the humerus is much more dense than the porous proximal end, the distal end preserves far more frequently. As such, most of the criteria used to differentiate between *Ovis* and *Capra* are based on the distal end of the bone. Table 4.23 presents all of the criteria used during the

Table 4.23 Distinguishing Criteria of *Ovis* and *Capra* Humeri

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Strongly tapered trochlea - medial to lateral (<i>Ovis</i>)	219	734, 1124, 2325, 3817
Granular thickening on lateral border (<i>Ovis</i>)	2985	259, 734, 1028, 1054, 2325, 3297, 3817
Crest-like lateral epicondylar process (<i>Ovis</i>)	219, 315, 887, 1035, 1425, 3030	134, 260, 693, 734, 872, 1054, 3128, 3297, 3817
Obliquely cut-off medial epicondyle (<i>Capra</i>)	64, 219, 315, 317, 820, 871, 887, 1035, 1425, 2076, 2985, 3030, 3129, 3350	3128
Medial epicondyle ends in a right/obtuse angle (<i>Ovis</i>)		134, 259, 260, 734, 1054, 1124, 2034, 2325, 3297, 3817
Distinctly ridged lateral epicondyle (<i>Capra</i>)	64, 219, 317, 820, 871, 887, 1035, 1425, 1474, 2076, 2974, 2985, 3030, 3129, 3350	
Broad lateral epicondyle (<i>Ovis</i>)		134, 259, 260, 693, 734, 872, 1007, 1028, 1054, 1124, 2325, 3128, 3297, 3817
Small pit-like fossa with a well developed posterior ridge on medial epicondyle (<i>Ovis</i>)		259, 260, 693, 872, 1007, 1124, 3128, 3297, 3817
Broad, shallow pit with raised antero-distal projection (<i>Capra</i>)	64, 219, 315, 317, 820, 871, 887, 1035, 1425, 1474, 2076, 2974, 2985, 3030, 3129, 3350	134, 734, 1028, 1054, 2034, 2325
Deeper more symmetrical lateral condylar groove (<i>Capra</i>)	219, 317, 820, 887, 1035, 1474, 2985	3128
Shallow medially pointed lateral condylar groove (<i>Ovis</i>)	871, 1425, 2076, 2974, 3030, 3129, 3350	134, 259, 260, 693, 734, 872, 1028, 1054, 2325, 3297, 3817
Broad major tubercle (<i>Ovis</i>)		76, 167, 1223
Comb-like crista-humeri (<i>Ovis</i>)		1223, 3128
Posterior foramen nutricum (<i>Ovis</i>)		1007, 3128, 3817
Lateral/Anterior foramen nutricum (<i>Capra</i>)	1425, 1474, 3350	

identification, and generally how successful each criterion was on its own. Many of the criteria, such as whether the medial epicondyle had an obliquely cut-off or right/obtuse angled end, were very reliable indicators of species, however others, such as the appearance of a crest-like protrusion on the lateral epicondyle, were less reliable. I found that the few criteria used concerning the proximal end of the humerus were unambiguous in the rare instances that they were applicable.

A single *Gazella gazella* humerus was identified from the Mudayna collection. The diminutive size of the specimen made it instantly apparent that it was not simply a small sheep or goat. When the breadth of the distal end (Bd) of the specimen is compared with a sample of gazelle humeri from Hesban it becomes clear that the Mudayna specimen is from a *Gazella gazella*. As Figure 4.15 shows, the Mudayna specimen fits into the lower end of the group of larger gazelles found at Hesban indicating that it is a *Gazella gazella* (rather than a *G. dorcas*), and (stepping out on a limb) possibly indicating that the specimen is a female.

A large immature distal humerus was found at Mudayna that is certainly from a deer and most likely from a *Dama mesopotamica*. The bone appears to have just been fusing at the time of death. Comparing the “greatest breadth of the distal humerus” (Bd) of the Mudayna specimen (43.48mm) with measurements for *D. mesopotamica* given by Boessneck and von den Driesch (1995: Table 6.1) (44.5mm) and Ducos (1968: Tableau VII) (41.8-47.0mm) show that the size is right. Judging by the appearance of the bone, it is unlikely that it would have grown a significant amount before reaching full maturity. So, while the Bd must be considered to be slightly higher than measured, it would certainly have never increased past the top of the range for *Dama mesopotamica*. A summary of measurements taken on all of the identifiable humeri found

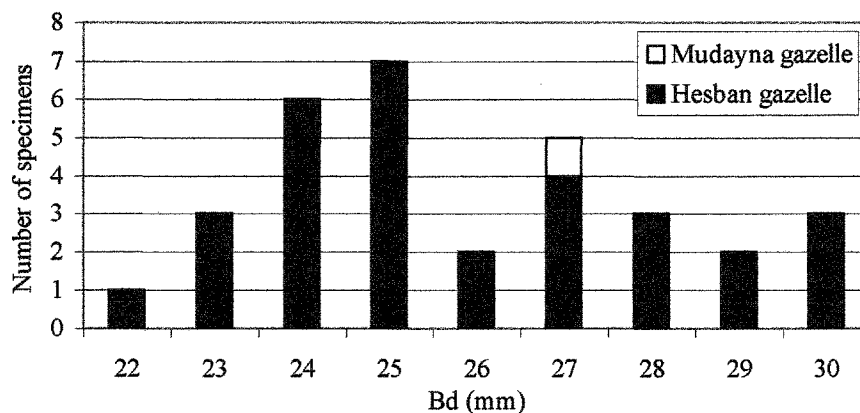


Figure 4.15 Comparison of the greatest breadth of the distal humerus (Bd) of gazelle from Hesban and Mudayna (adapted from von den Driesch and Boessneck 1995: Figure 5.17)

Table 4.24 Summary Statistics of Humeri Measurements (mm)

Bd	<i>Capra</i>	<i>Ovis</i>	<i>Gazelle</i>	<i>Bos</i>	<i>Dama (imm)</i>
Mean	32.95	33.33	27.14	73.86	43.48
Median	32.06	33.10	27.14	73.86	43.48
Standard Deviation	3.14	1.16			
Minimum	29.13	31.20	27.14	73.86	43.48
Maximum	39.73	35.34	27.14	73.86	43.48
Count	13	11	1	1	1
BT	<i>Capra</i>	<i>Ovis</i>	<i>Gazelle</i>	<i>Bos</i>	<i>Dama (imm)</i>
Mean	31.05	31.03	23.76	62.91	
Median	29.93	30.81	23.76	62.91	
Standard Deviation	2.98	1.21			
Minimum	27.57	29.43	23.76	62.91	
Maximum	37.55	32.95	23.76	62.91	
Count	14	12	1	1	
SD	<i>Capra</i>	<i>Ovis</i>	<i>Gazelle</i>	<i>Bos</i>	<i>Dama (imm)</i>
Mean	14.82	15.83			
Median	14.82	15.83			
Standard Deviation	0.78	0.63			
Minimum	14.26	15.38			
Maximum	15.37	16.27			
Count	2	2			
BP	<i>Capra</i>	<i>Ovis</i>	<i>Gazelle</i>	<i>Bos</i>	<i>Dama (imm)</i>
Mean		37.71			
Median		37.71			
Standard Deviation					
Minimum		37.71			
Maximum		37.71			
Count		1			
GLC	<i>Capra</i>	<i>Ovis</i>	<i>Gazelle</i>	<i>Bos</i>	<i>Dama (imm)</i>
Mean		138.00			
Median		138.00			
Standard Deviation					
Minimum		138.00			
Maximum		138.00			
Count		1			

at Mudayna is presented in Table 4.24. Keep in mind that (while immature measurements were not normally included) the measurement listed for the *Dama* is of an immature individual.

4.1.12 Radii

A total of 127 radii fragments from large (SC5) and very large (SC6) mammals were found at Mudayna. The majority of the radii specimens are shaft fragments and not identifiable further than *Ovis/Capra* and in fact 48 of the shaft fragments were too small to be identified as anything other than Artiodactyla SC5. Radii shaft fragments are particularly identifiable (as radii, but not as species) because of the general shape of the bone and the lengthy articular

surface for the ulna on the posterior face. 17 radii specimens were identified as *Ovis aries* and 9 specimens were identified as *Capra hircus*. A single complete, though broken, radius was identified as an *Ovis* providing the opportunity to ensure that the proximal criteria and the distal criteria were working together. Because more proximal radii were found than distal radii, the

Table 4.25 Summary Statistics of Radii Measurements (mm)

Bp	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	35.32	33.96	71.88	31.00
Median	35.03	33.28	71.88	31.00
Standard Deviation	2.29	2.38		
Minimum	32.84	31.00	71.88	31.00
Maximum	39.09	39.57	71.88	31.00
Count	6	9	1	1
BFp	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	33.05	30.65	66.63	29.38
Median	32.69	30.49	66.63	29.38
Standard Deviation	2.33	1.91		
Minimum	30.29	28.05	66.63	29.38
Maximum	37.17	35.01	66.63	29.38
Count	6	9	1	1
Bd	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	29.67	31.84	62.46	32.33
Median	29.66	32.18	62.46	32.33
Standard Deviation	0.43	1.46	1.81	
Minimum	29.24	29.70	61.18	32.33
Maximum	30.10	33.72	63.74	32.33
Count	3	5	2	1
BFd	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	26.22	26.55	55.24	28.74
Median	26.41	26.37	55.24	28.74
Standard Deviation	0.59	1.01	2.25	
Minimum	25.56	25.58	53.65	28.74
Maximum	26.69	27.98	56.83	28.74
Count	3	5	2	1
SD	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	18.22	14.42	37.34	16.24
Median	18.22	16.90	37.34	16.24
Standard Deviation		4.55		0.23
Minimum	18.22	9.17	37.34	16.07
Maximum	18.22	17.18	37.34	16.40
Count	1	3	1	2
GL	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean		160.07		
Median		160.07		
Standard Deviation				
Minimum		160.07		
Maximum		160.07		
Count		1		

Table 4.26 Distinguishing Criteria of *Ovis* and *Capra* Radii

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Strongly developed lateral bicipital tuberosity on proximal end (<i>Ovis</i>)		209, 210, 823, 974, 1059, 1228/1231, 1607, 1762, 2222, 3276, 3431, 3616
Fused ulnar shaft (<i>Capra</i>)	5, 345, 613, 2053, 2130, 3018	
Sulcus on lateral proximal surface (<i>Capra</i>)	5, 345, 613, 895, 2130, 3018	
Deeply indented facet on the distal end for the articulation of the intermediate carpal (<i>Capra</i>)	1821, 1867, 2053	
Drop-shaped facet on the distal end for the articulation of the radial carpal (<i>Ovis</i>)		211, 474, 1228/1231, 1606, 2358
Shallow facet on the distal end for the articulation of the intermediate carpal (<i>Ovis</i>)		474, 1228/1231, 1606, 2033, 2358

most commonly used criterion was the presence of a strongly developed proximal-lateral bicipital tuberosity (indicating *Ovis*). It was found that this criterion, as well as the criterion indicative of *Capra* (a sulcus on the proximal-lateral shaft) was obvious in all cases.

4.1.13 Ulnae

Of the 55 large (SC5) and very large (SC6) mammal ulnae found, seven were identified as belonging to *Ovis aries*, four as *Capra hircus*, and 18 as *Ovis/Capra*. When only the shaft of an ulna was preserved, identification of the ulna could rarely progress beyond Artiodactyla SC5 or most specifically to *Ovis/Capra* because, besides the overall size of the shaft, it displays no specific identifiable criteria. If the proximal end of the ulna was preserved a number of criteria aided in its identification as *Ovis* or *Capra*. The shape of the tuber olecrani provides two criteria useful for distinguishing between *Ovis* and *Capra*; its curvature and the presence or absence of a sloping face on the lateral edge of the tuber. As Table 4.27 shows, these four criteria were consistent between species. Another useful, but more subjective, criterion used was the length of the coronoid process. A lengthy lateral coronoid process is indicative of *Capra* while a shorter lateral coronoid process represents *Ovis*. The trouble with this criterion is deciding how long a coronoid process must be before it is considered "lengthy". The final set of criteria used (whether or not the ulna was fused to the radius) were very clearly defined but were not accurate in every case. Typically, *Capra* ulnae will fuse to the radius because they have a larger area of articulation including a longer coronoid process that offers more purchase on the radius. It is not

unusual, however, for older *Ovis* ulnae to also fuse to the radius. Because both species often end up with their ulnae fused to their radii, this criterion should only be used in association with other, more certain, criteria.

A single gazelle ulna was found among the Mudayna faunal material. The proximal end of the specimen is very well preserved, being broken approximately three centimeters down the shaft. Measurements from the Mudayna gazelle are compared with measurements from five *Gazella subgutturosa* provided by Compagnoni (1978: Table 4) in Table 4.28 below. All of the measurements, within their grouping, are quite similar except for the first one measuring the distance from the top of the olecranon to the radius articulation. Because the measurements from columns numbered one through four are all from male gazelles the range of the measurements can not be explained by sexual dimorphism. In any case, it can be seen that the Mudayna specimen fits nicely with, though is slightly smaller than, most of these groupings. I have identified the gazelle ulna from Mudayna as a *Gazella gazella* because it is too large to represent a *Gazella dorcas*.

Table 4.27 Distinguishing Criteria of *Ovis* and *Capra* Ulnae

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Strongly curved tuber olecrani (<i>Capra</i>)	826, 2131, 3018	
Non-curved tuber olecrani (<i>Ovis</i>)		465, 825, 1058, 1594, 2150
Sloping face on tuber olecrani (<i>Capra</i>)	826, 2131, 3018	
Non-sloping tuber olecrani (<i>Ovis</i>)		465, 825, 1058, 1594, 2150
Lengthy lateral coronoid process (<i>Capra</i>)	896, 2131, 3018	
Shorter coronoid process (<i>Ovis</i>)		257, 465, 742, 825, 1594
Ulna fused to radius (<i>Capra</i>)	2131, 3018	
Ulna not fused to radius (<i>Ovis</i>)	826, 896	257, 465, 742, 825, 1058, 1594

Table 4.28 A comparison of ulnae measurements from five *Gazella* and one Mudayna specimen (adapted from Compagnoni 1978: Table 4) (mm)

Description of Measurement	1	2	3	4	5	Mudayna
Olecranon top - radius articulation	37.20	46.70	42.00	47.00		40.15
Maximum diameter olecranon (a-p)	19.10	22.30	22.50	23.00		21.70
Minimum diameter olecranon (a-p)	18.30	19.50	18.80	19.00	16.20	19.53
Minimum width (med - lat)	6.20	7.10	6.70	7.00	5.20	5.94

A very long, immature ulna was found at Muadayna that has been tentatively assigned to *Dama mesopotamica*. The ulna certainly represents a cervid but is too large to come from a roe deer (*Capreolus capreolus*) and too small to represent a red deer (*Cervus elaphus*). It is thus simply by a process of elimination that this specimen has been labeled *D. mesopotamica*. Although this specimen is immature, its measurements are presented in Table 4.29 with the other identified ulnae to provide a comparison of its length to lengths of the *Ovis* and *Capra* identified. I have included a measurement that von den Driesch (1976) does not; namely, the length of the (immature) olecranon without the tuber olecrani attached (LOWoP). Keeping in mind that the

Table 4.29 Summary Statistics of Ulnae Measurements (mm)

LO	Capra	Ovis	Bos taurus	G. gazella	Ovis/Capra	Dama (imm)
Mean	40.75	41.58		32.03		
Median	39.98	42.44		32.03		
Standard Deviation	1.40	2.41				
Minimum	39.90	37.53		32.03		
Maximum	42.36	43.77		32.03		
Count	3	5		1		
BPC	Capra	Ovis	Bos taurus	G. gazella	Ovis/Capra	Dama (imm)
Mean	25.64	20.54	42.97	18.14	21.53	21.57
Median	25.64	20.10	42.97	18.14	21.86	21.57
Standard Deviation		1.10	2.51		0.86	
Minimum	25.64	19.84	41.19	18.14	20.56	21.57
Maximum	25.64	22.46	44.74	18.14	22.18	21.57
Count	1	5	2	1	3	1
DPA	Capra	Ovis	Bos taurus	G. gazella	Ovis/Capra	Dama (imm)
Mean	26.73	27.41		21.70	28.04	
Median	26.20	26.89		21.70	28.51	
Standard Deviation	1.14	1.73			1.99	
Minimum	25.96	25.99		21.70	25.86	
Maximum	28.04	29.89		21.70	29.76	
Count	3	4		1	3	
SDO	Capra	Ovis	Bos taurus	G. gazella	Ovis/Capra	Dama (imm)
Mean	23.21	24.67		19.53	23.37	24.42
Median	23.35	24.70		19.53	23.37	24.42
Standard Deviation	0.75	1.66			2.39	
Minimum	22.40	22.78		19.53	21.68	24.42
Maximum	23.87	26.50		19.53	25.06	24.42
Count	3	4		1	2	1
LOWoP	Capra	Ovis	Bos taurus	G. gazella	Ovis/Capra	Dama (imm)
Mean						39.85
Median						39.85
Standard Deviation						
Minimum						39.85
Maximum						39.85
Count						1

average length (proximal-distal) of an *Ovis/Capra* tuber olecrani is around 13-14mm, if the specimen identified as *D. mesopotamica* was an *Ovis/Capra* the mature length of its olecranon (LO) would be between 53-54 mm long. It becomes obvious, then, that while many of the *D. mesopotamica*'s measurements approximate those of *Ovis* and *Capra*, the length of its olecranon is simply far too great. In his doctoral thesis, Lipovitch (1999: 87) presents a single *Dama* LO measurement as 53.3mm, consistent with the suggested length of the Mudayna *Dama*.

4.1.14 Carpals

Because so few carpals were recovered from Mudayna, they will all be considered together in this section. The compact shape and dense nature of the carpals aided in their preservation, so that when they were found they were typically nearly complete. They were found infrequently, however, partially because the small size of the bones and the lack of complete screening at Mudayna conspired to allow many of them to be overlooked. Another reason why they may not appear in great number is due to canid scavenging at Mudayna, evidenced by frequent 'bite' marks on the bones. The carpals are all small enough (except perhaps some of the *Bos taurus* specimens) that they would have been easily swallowed by a hungry dog and removed from both the area (perhaps to be deposited in a more digested state elsewhere), and the archaeological record.

All of the criteria used to distinguish between *Ovis* and *Capra* carpals are from Boessneck *et al.* (1964: 74-78). There were no deer or gazelle carpals recovered from Mudayna. The following is a graphic presentation for all of the carpal criteria and measurements.

Table 4.30 Distinguishing Criteria of *Ovis* and *Capra*
Ulnar Carpals

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Large medial articular facet (<i>Capra</i>)	2641	
Small medial articular facet (<i>Ovis</i>)		2320, 2642, 3496

Table 4.31 Distinguishing Criterion of
Ovis and *Capra* Unciforms

Criterion	<i>Ovis</i> (Cat. #'s)
Large volar projection (<i>Ovis</i>)	2922, 2319

Table 4.32 Distinguishing Criteria of *Ovis* and *Capra* Radial Carpals

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Dorso-proximal and dorso-distal corners jut out equally (<i>Capra</i>)	77, 2065, 2257	
Dorso-distal corner juts out (<i>Ovis</i>)		133, 1896
Facets of distal end are more equal in surface area (<i>Ovis</i>)		133, 1896
Larger volar facet on distal end (<i>Capra</i>)	77, 1897, 2065, 2257	
Wide volar facet on proximal end (<i>Capra</i>)	77, 2065, 2257	
Thin volar facet on proximal end (<i>Ovis</i>)	1897	133, 1896

Table 4.33 Distinguishing Criteria of *Ovis* and *Capra* Intermediate Carpals

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Large medio-volar process (<i>Ovis</i>)		2445, 2318, 3389
Clearly pointed medio-volar process (<i>Capra</i>)	725, 3838	
Resembles Boessneck 1964: figure 40 Bb (<i>Ovis</i>)		2318, 3389
Resembles Boessneck 1964: figure 40 Ab (<i>Capra</i>)	725, 726, 3838	
Resembles Boessneck 1964: figure 40 Ba (<i>Ovis</i>)		2445, 2318, 3389
Resembles Boessneck 1964: figure 40 Aa (<i>Capra</i>)	725, 726, 3838	
Resembles Boessneck 1964: figure 41Bc (<i>Ovis</i>)		2318, 3389

Table 4.34 Distinguishing Criteria of *Ovis* and *Capra* Fused 2+3 Carpals

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Proximal medial articular facets approximately equal (<i>Ovis</i>)		1719, 2444, 2757, 3418
Dorsal proximal medial articular facet smaller than volar (<i>Capra</i>)	1898	
Carpal roughly square (<i>Ovis</i>)		1719, 2444, 2757, 3418
Carpal more curved (<i>Capra</i>)	1898	

Table 4.35 Summary Statistics of Ulnar Carpal Measurements (mm)

GB	Capra	Ovis
Mean	8.69	7.25
Median	8.69	7.25
Standard Deviation		
Minimum	8.69	7.25
Maximum	8.69	7.25
Count	1	1
GL	Capra	Ovis
Mean	13.79	14.83
Median	13.79	14.82
Standard Deviation		1.62
Minimum	13.79	13.22
Maximum	13.79	16.45
Count	1	3

Table 4.36 Summary Statistics of Unciform Measurements (mm)

GB	Ovis	Bos
Mean	11.51	26.74
Median	11.51	26.74
Standard Deviation	1.03	
Minimum	10.78	26.74
Maximum	12.23	26.74
Count	2	1
GL	Ovis	Bos
Mean	14.57	27.85
Median	14.57	27.85
Standard Deviation	0.54	
Minimum	14.19	27.85
Maximum	14.95	27.85
Count	2	1

Table 4.37 Summary Statistics of Radial Carpal Measurements (mm)

GB	Capra	Ovis	Bos
Mean	21.07	20.85	38.81
Median	21.17	20.85	38.81
Standard Deviation	0.58	1.75	
Minimum	20.45	19.61	38.81
Maximum	21.59	22.09	38.81
Count	3	2	1

Table 4.38 Summary Statistics of Intermediate Carpal Measurements (mm)

GB	Capra	Ovis
Mean	15.69	14.25
Median	15.69	14.28
Standard Deviation	3.10	0.17
Minimum	13.49	14.06
Maximum	17.88	14.40
Count	2	3
GL	Capra	Ovis
Mean	18.31	16.56
Median	18.31	16.50
Standard Deviation	2.13	0.26
Minimum	16.80	16.33
Maximum	19.81	16.84
Count	2	3

Table 4.39 Summary Statistics of Fused 2nd and 3rd Carpal Measurements (mm)

GB	Capra	Ovis
Mean	17.85	16.59
Median	17.85	16.65
Standard Deviation		1.42
Minimum	17.85	15.20
Maximum	17.85	17.88
Count	1	4

4.1.15 Metacarpals

Mudayna's faunal collection contained 21 *Ovis aries* metacarpals, 10 *Capra hircus* metacarpals and 25 metacarpals that could not be positively identified beyond *Ovis/Capra*. When the distal end of the metacarpal is preserved, it is not difficult to separate *Ovis* from *Capra*. The criteria for the proximal end are more subjective. In his 1969 work, Boessneck proposes a metric criteria that may be used to differentiate *Ovis* and *Capra* distal metacarpals. The procedure is as follows: "One measures the dorsovolar or dorsoplantar diameter of the peripheral trochlear section immediately adjoining the verticillus, i.e. where it is smallest, at least in (*Capra*), and puts it in proportion to the parallel diameter of the verticillus." (1969: 355) When the index is calculated for the medial trochlea, a value over 63 indicates *Ovis* and a value of under 63 indicates *Capra*. Other criteria utilized with the distal end of the metacarpus were the orientation of the verticilli and the development of the fossulae (Table 4.40).

A second metric method for distinguishing between *Ovis* and *Capra* distal metacarpals has been proposed by Payne (1969). Payne's method involves measuring the width of the trochlea and plotting it against the width of the condyle (both medial and lateral condyles are used). Payne's method may be used with both mature and immature animals. Figure 4.16 shows

Table 4.40 Distinguishing Criteria of *Ovis* and *Capra* Metacarpals

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Medial index >63 (<i>Ovis</i>)		74, 330, 1086, 1590, 1695, 2219, 2264, 2284, 3343, 3667
Medial index < 63 (<i>Capra</i>)	829, 1866	
Well developed articular surface on the volar edge of the proximal end (<i>Ovis</i>)	1376, 2129	223, 485, 486, 889, 1573, 1696, 1973, 3081
Absent or poorly developed articular surface on the volar edge of the proximal end (<i>Capra</i>)	643, 981, 1562	
Sharply angled articular surface on proximal-lateral side (<i>Ovis</i>)		223, 485, 486, 889, 1573, 1696, 3081
Smaller non-angled proximal-lateral articular surface (<i>Capra</i>)	981, 1376, 1562, 2129	
Strongly developed fossulae (<i>Capra</i>)	829, 1562, 1866, 3131	
Weakly developed fossulae (<i>Ovis</i>)		74, 330, 1086, 1590, 1695, 2219, 2264, 2284, 3343, 3667
Strongly convergent verticilli (<i>Capra</i>)	829, 1311, 1866, 3131	
Weakly convergent or parallel verticilli (<i>Ovis</i>)		74, 1086, 1590, 1695, 2219, 2264, 2284, 3343

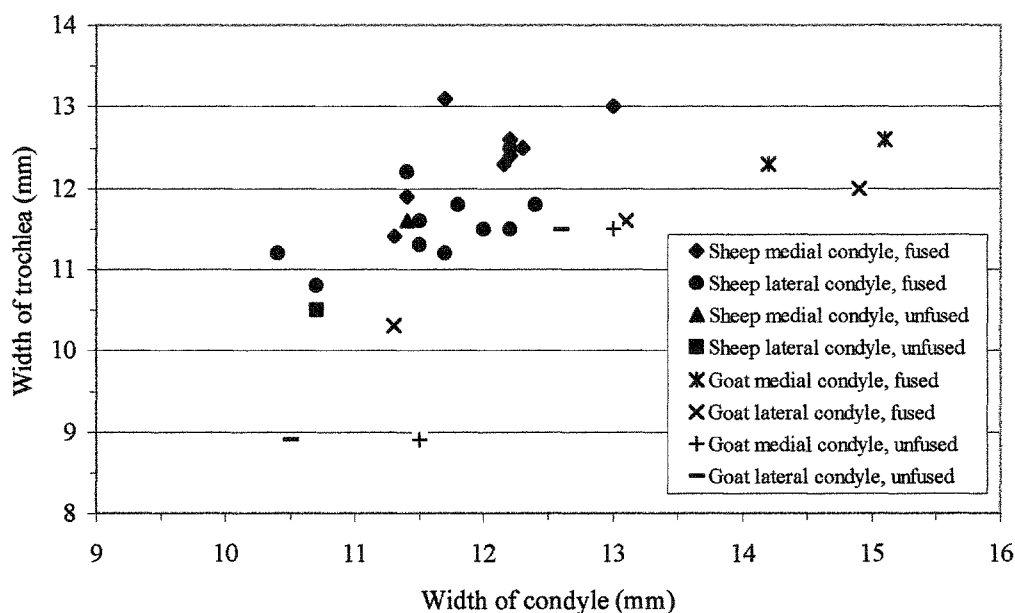


Figure 4.16 Metrical comparison of sheep and goat distal metacarpals using Payne's (1969) method

the results produced when all of the Mudayna metacarpals were subjected to Payne's metrical distinction method. All of the goat (*Capra*) metacarpals are plotted below and to the right, in a long and thin ellipse, of the sheep (*Ovis*) metacarpals that clustered in a tighter oval. The basic results produced closely resemble the results Payne achieved when he measured known sheep and goat metacarpals (Payne 1969: Figure 6 and Figure 7). The two metric criteria used helped to confirm the accuracy of the morphological criteria employed for the distal end of the metacarpals but they do little to confirm the proximal criteria.

The more accurate of the two proximal criteria was based around the shape and angle of the proximal-lateral articular surface. When a large, sharply angled articular surface was present, the specimen was classified as an *Ovis*. When the articular surface was smaller and less angled, it was identified as a *Capra*. The second, less reliable criterion depended on the development of an articular surface on the volar edge of the proximal end of the metacarpals. If this surface was well developed the specimen was likely an *Ovis*, when this surface was only poorly developed or altogether absent, the specimen was likely a *Capra*. As Table 4.40 shows, the development of the proximal-volar articular surface is variable and should probably not be used alone for species determination.

All of the measurements taken on the identifiable metacarpals are presented in Table 4.41 below. The only outstanding set of measurements occur with the breadth of the distal end (Bd) of the *Capra* metacarpals. While *Capra* metapodia are generally "shorter and wider"

Table 4.41 Summary Statistics of Metacarpal Measurements (mm)

Bp	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	24.32	26.61	54.21	25.17
Median	24.42	26.51	54.21	25.17
Standard Deviation	1.08	1.70		
Minimum	22.90	24.83	54.21	25.17
Maximum	25.54	28.61	54.21	25.17
Count	4	6	1	1
Bd	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	32.11	26.44	66.44	
Median	32.11	26.59	66.44	
Standard Deviation		0.88		
Minimum	29.92	24.75	66.44	
Maximum	34.29	27.57	66.44	
Count	2	7	1	
DD	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	11.29	9.84	21.90	9.36
Median	11.29	9.64	21.90	9.36
Standard Deviation	1.44	0.66		
Minimum	10.27	9.18	21.90	9.36
Maximum	12.30	10.87	21.90	9.36
Count	2	8	1	1
SD	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	15.21	16.07		14.08
Median	15.21	15.41		14.08
Standard Deviation	0.30	2.11		0.04
Minimum	14.99	14.21		14.05
Maximum	15.42	20.08		14.11
Count	2	6		2
GL	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	117.01			
Median	117.01			
Standard Deviation				
Minimum	117.01			
Maximum	117.01			
Count	1			

(Boessneck 1969: 354) than those of *Ovis*, the separation is quite large. The most probable explanation for the size difference is the fact that only two mature *Capra* metacarpals were found and one of them happened to be very robust (and almost certainly male). If more *Capra* metacarpals had been discovered the average size likely would have been much smaller.

4.1.16 Metatarsals

Slightly fewer large (SC5) and very large (SC6) metatarsals were found at Mudayna compared to metacarpals, and significantly fewer metatarsals were identified to species. Only 10 *Ovis aries* metatarsals and 11 *Capra hircus* metatarsals were located. A further 27 metatarsals

could only be identified as *Ovis/Capra*. Boessneck (1969: 355) developed a metric index to distinguish *Ovis* metatarsals from *Capra* metatarsals that is measured in the same fashion as his metacarpal index mentioned above. The determinative indices are different for the metatarsals, however, as there was found to be an area of overlap between 59 and 62.5. If the medial index was below 59, the specimen was identified as a *Capra*. If the index was above 62.5, the specimen was identified as belonging to an *Ovis*. Unfortunately, very few distal metatarsals were recovered from Mudayna, limiting the usefulness of Boessneck's index.

Table 4.42 Summary Statistics of Metatarsal Measurements (mm)

Bp	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	21.57	21.83	43.85	21.01
Median	21.28	21.68	43.85	21.08
Standard Deviation	1.03	0.83	1.32	0.42
Minimum	20.49	20.88	42.91	20.49
Maximum	23.31	23.17	44.78	21.39
Count	6	5	2	4
Bd	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	28.02	26.54	52.53	
Median	27.30	26.54	52.53	
Standard Deviation	3.95	0.01	4.10	
Minimum	24.40	26.53	49.63	
Maximum	33.10	26.55	55.43	
Count	4	2	2	
SD	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	12.50	12.90	27.53	12.09
Median	12.50	12.92	27.53	12.09
Standard Deviation	0.62	0.32		
Minimum	12.06	12.56	27.53	12.09
Maximum	12.94	13.21	27.53	12.09
Count	2	4	1	1
DD	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean	10.56	11.21	25.67	
Median	10.56	11.21	25.67	
Standard Deviation		0.17		
Minimum	10.56	11.09	25.67	
Maximum	10.56	11.33	25.67	
Count	1	2	1	
GL	<i>Capra</i>	<i>Ovis</i>	<i>Bos</i>	<i>Ovis/Capra</i>
Mean		141.87		
Median		141.87		
Standard Deviation				
Minimum		141.87		
Maximum		141.87		
Count		1		

Table 4.43 Distinguishing Criteria of *Ovis* and *Capra* Metatarsals

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Medial index < 59 (<i>Capra</i>)	329, 642, 3694	
Medial index > 62.5 (<i>Ovis</i>)		1087, 3387, 3505
Strong dorsally projecting proximal articular facet (<i>Ovis</i>)		328, 641, 1591, 1592, 2110, 3387, 3669, 3670
Weak dorsally projecting proximal articular facet (<i>Capra</i>)	15, 327, 493, 1697, 3172, 3749, 3901	
Large proximally projecting proximo-dorsal articular surface (<i>Capra</i>)	15, 327, 493, 1697, 3172, 3749,	3387
Small proximally projecting proximo-dorsal articular surface (<i>Ovis</i>)	3901	328, 641, 1591, 1592, 2110, 3669, 3670
Prominent fossulae (<i>Capra</i>)	329, 642, 1812, 3694	
Weak fossulae (<i>Ovis</i>)		3387, 3505
Strongly convergent verticilli (<i>Capra</i>)	329, 642, 3694	
Weakly convergent or parallel verticilli (<i>Ovis</i>)		3387, 3505
Presence of large synovial pits (<i>Capra</i>)	493	

Other non-metric criteria also were employed to distinguish between *Ovis* and *Capra* metatarsals. Because the proximal end of the metatarsal was recovered more frequently than the distal end, the proximally based criteria were depended upon more heavily. The first criterion was the strength of the dorsally projecting proximal articular surface. If the articular surface was large, the specimen was identified as an *Ovis*; if the surface was small, the specimen was registered as a *Capra*. As Table 4.43 shows, this criterion was quite effective within the Mudayna collection. A second, slightly less consistent, criterion depended on the proximally projecting articular surface. A large projection was indicative of a *Capra*, while a small projection was found on the *Ovis* specimens. Some overlap was found to occur with this criterion, but generally it was found to be accurate.

4.1.17 Atlases

The atlas is an important bone for zooarchaeologist because, depending on the preservation of the bone, one may discover not only what species the bone is from, but also the sex of the animal. A total of 31 large (SC5) and very large (SC6) atlases were recovered from Mudayna. Nine atlases were from *Ovis aries*, five from *Capra hircus*, and seven were classified as *Ovis/Capra*. A single *Gazella gazella* atlas was found at Mudayna. Identification of the

Table 4.44 Distinguishing Criteria of *Ovis* and *Capra* Atlases

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Short transverse processes (<i>Ovis</i>)	840	539, 919, 3054, 3494, 3722
Dorsal tuberosity cranial and steeply sloped (<i>Capra</i>)	96, 540, 840, 1102	
Bumpy, caudal dorsal tuberosity (<i>Ovis</i>)		103, 364, 539, 919, 1768, 3054, 3089, 3494, 3722
Deep ventral depressions (<i>Capra</i>)		539, 3722
Heavy ventral tuberosity (<i>Ovis</i>)		103, 364, 539, 919, 1768, 3054, 3089, 3494, 3722
Narrow, ridge-like ventral tuberosity (<i>Capra</i>)	96, 540, 840, 1102, 3053	

Table 4.45 Summary Statistics of Atlas Measurements (mm)

GL	<i>Capra</i>	<i>Ovis</i>	<i>G. gazella</i>
Mean	52.68	52.25	
Median	52.68	50.52	
Standard Deviation		3.20	
Minimum	52.68	49.71	
Maximum	52.68	56.64	
Count	1	5	
GLF	<i>Capra</i>	<i>Ovis</i>	<i>G. gazella</i>
Mean	49.86	47.19	
Median	50.67	46.90	
Standard Deviation	4.04	1.79	
Minimum	44.24	44.28	
Maximum	53.86	49.63	
Count	4	7	
BFcr	<i>Capra</i>	<i>Ovis</i>	<i>G. gazella</i>
Mean	50.33	49.53	41.30
Median	51.68	49.80	41.30
Standard Deviation	3.15	0.62	
Minimum	46.73	48.65	41.30
Maximum	52.58	50.19	41.30
Count	3	6	1
BFcd	<i>Capra</i>	<i>Ovis</i>	<i>G. gazella</i>
Mean	46.24	46.77	35.27
Median	44.50	46.42	35.27
Standard Deviation	4.02	1.94	
Minimum	43.39	44.20	35.27
Maximum	50.84	49.38	35.27
Count	3	7	1

Table 4.46 A comparison of gazelle atlas measurements (the greatest breadth of the cranial articular surface - BFcr and the greatest breadth of the caudal articular surface - BFcd) from Shahr-I Sokhta and Mudayna (adapted from Compagnoni 1978: 126)

Atlas	1	2	3	4	Mudayna
BFcr (mm)	41.8	37.8	44.6	41.5	41.30
BFcd (mm)	37.0	34.2	38.6	37.0	35.27

gazelle atlas (Figure D-3) was aided greatly by three photographs and a table of measurements published by Compagnoni (1978: 121, 126) of *Gazella subgutturosa* atlases. As Table 4.45 shows, the measurements of the two gazelle atlas articular surfaces (greatest breadth of the cranial articular surface - BFcr and the greatest breadth of the caudal articular surface - BFcd) are clearly smaller than any of the measurements taken on the *Ovis* or *Capra* specimens. Table 4.46 shows that the Mudayna specimen measurements are within the range of measurements taken from four *Gazella subgutturosa*, a gazelle similar in size to *Gazella gazella*. Based on the metric data, and the zoogeography of gazelles, it is certain that the gazelle atlas recovered from Mudayna represents a *G. gazella*. The sexing of the recovered atlases is discussed in Chapter five.

4.1.18 Axes

Much like the atlas, the axis may tell the zooarchaeologist the sex, as well as the species, of the animal to whom the bone once belonged. Unfortunately, only five axes (three *Ovis* and two *Capra*) were found that could be specified as *Ovis* or *Capra*. 23 axes were recovered that could only be classified as *Ovis/Capra*. The reason so few axes could be identified to species lies in the fact that three of the four criteria (Table 4.47) used for specification are based on the shape of the spinous process, part of the bone that is rarely recovered intact. The most frequently found portions of the axis were the dens and the cranial articular surface, portions that cannot be identified beyond *Ovis/Capra*.

A single axis (Cat. # 3362) has been identified as coming from a *Dama mesopotamica*. Table 4.48 below shows that the breadth of the cranial articular surface (BFcr) of the *Dama* specimen is larger than the largest *Capra* specimen, though not by a great deal. A measurement that von den Driesch did not present in her 1976 work, but which researchers occasionally make on axes, is the breadth of the dens (Bdens) (Bokonyi 1977). It is through a comparison of the

Table 4.47 Distinguishing Criteria of *Ovis* and *Capra* Axes

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Broad spinous process (<i>Ovis</i>)		102
Lacking one or both transverse canals (<i>Capra</i>)	97, 131, 365	
Sloping arch on caudal end of spinous process (<i>Ovis</i>)		102, 104
Short cranial projection of spinous process (<i>Ovis</i>)		102, 104

Table 4.48 Summary Statistics of Axes Measurements (mm)

BFcr	Capra	Ovis	Ovis/Capra	D. mesopotamica
Mean	52.70	41.82	44.71	56.2
Median	52.37	41.82	45.73	56.2
Standard Deviation	1.99	1.99	2.35	
Minimum	50.89	40.41	41.26	56.2
Maximum	54.83	43.22	46.99	56.2
Count	3	2	7	1
LCDe	Capra	Ovis	Ovis/Capra	D. mesopotamica
Mean	60.43	61.58	61.55	
Median	60.43	61.58	61.55	
Standard Deviation	5.44	2.93		
Minimum	56.58	59.51	61.55	
Maximum	64.27	63.65	61.55	
Count	2	2	1	
SBV	Capra	Ovis	Ovis/Capra	D. mesopotamica
Mean	25.54	22.02	24.27	
Median	24.10	22.02	23.83	
Standard Deviation	2.89	0.56	1.96	
Minimum	23.65	21.62	22.04	
Maximum	28.86	22.41	27.07	
Count	3	2	6	
BFcd	Capra	Ovis	Ovis/Capra	D. mesopotamica
Mean		20.81	23.81	
Median		20.81	23.75	
Standard Deviation		0.37	1.93	
Minimum		20.55	21.52	
Maximum		21.07	26.21	
Count		2	4	
Bpacd	Capra	Ovis	Ovis/Capra	D. mesopotamica
Mean		31.70	31.65	
Median		31.70	31.65	
Standard Deviation				
Minimum		31.70	31.65	
Maximum		31.70	31.65	
Count		1	1	
Bdens	Capra	Ovis	Ovis/Capra	D. mesopotamica
Mean	23.36	19.90	22.01	29.63
Median	23.63	19.90	21.97	29.63
Standard Deviation	0.49		1.15	
Minimum	22.80	19.88	19.15	29.63
Maximum	23.65	19.91	23.96	29.63
Count	3	2	13	1
H	Capra	Ovis	Ovis/Capra	D. mesopotamica
Mean		51.47		
Median		51.47		
Standard Deviation				
Minimum		51.47		
Maximum		51.47		
Count		1		

breadth of the *Dama* and *Capra* dens' that the large size of the *Dama* specimen becomes apparent. While the breadth of the dens of the *Dama* axis is clearly larger than any *Ovis* or *Capra* specimen, it is also too small to have come from a red deer (*Cervus elaphus*). Bokonyi (1977: 73) gives measurements from two red deer axes found at Sarab, Iran (breadth of the cranial articular surface - BFcr = 67mm, 72.5mm; breadth of the dens - Bdens = 31.5mm, 35mm), all of which are larger than the Mudayna specimen's. It seems reasonable, considering the measurements discussed, that the specimen belonged to a *Dama mesopotamica*. Sexing of the axes is discussed in chapter five.

4.1.19 Pelves

A total of 146 large (SC5) and very large (SC6) mammal pelvis fragments were found at Khirbat al-Mudayna. 33 specimens were identified as *Ovis aries*, 12 as *Capra hircus*, and a further 58 specimens as *Ovis/Capra*. Because (one side of) the pelvis is a fusion of three separate bones (the ilium, ishium and pubis) the criteria used to distinguish between *Ovis* and *Capra* pelves are concentrated in three different areas of the bone. The general shape of the ilial body is a good basic indicator of species, but most of the criteria found on the ilium depend on the shape of the rectusgrube and a muscle attachment, the psoas tubercle, found on the medial wall of the ilium. The principle criterion used when the pubis was found was the slope of the pubic floor. In *Capra* specimens, the pubic floor gradually slopes towards the pubic ridge while in *Ovis* specimens the pubic floor slopes sharply and forms a small pit in front of the pubic rami. The ishium holds few criteria that may be used for species identification. The only strictly ishial criterion used in this study was the length of the ishial tuberosity. A long ishial tuberosity indicates an *Ovis* specimen, while a short ishial tuberosity indicates the bone is from a *Capra*. Unfortunately, because of the projecting nature of the tuberosity, it is rarely completely preserved and so could not be used very often. Occasionally, one side of the pelvis was found nearly complete, allowing the criteria found on different areas of the bone to be considered together. It was found that the criteria were consistent in their species designation and rarely would two conflicting designations be given from different parts of the same bone.

A single, very slender, gazelle ishium (Cat. # 2375) was found at Mudayna. The bone was too fragmented to be identified to species however I suspect that it represents a *Gazella gazella*. Officially, however, it has been classified as *Gazella* sp. A measurement of the breadth of the gazelle ishium (SB) is shown in Table 4.50. When compared to the measurements of the *Ovis* and *Capra* ishial breadths it is significantly smaller. Physically, the specimen is rugged and has well defined muscle attachments, indicating that it is in no way immature, but rather

Table 4.49 Distinguishing Criteria of *Ovis* and *Capra* Pelves

Criteria	<i>Capra</i> (Cat. #'s)	<i>Ovis</i> (Cat. #'s)
Generally longer and narrower (<i>Capra</i>)	302, 939, 2015	1655
Less long and narrow (<i>Ovis</i>)		92, 303, 305, 1062, 1168, 1807, 2413, 3902
Ventral ilium forms high vault (<i>Capra</i>)	302	
Wide less arched ventral ilium (<i>Ovis</i>)		92, 305, 513, 897, 983, 1062, 1168, 1500, 1655, 1807, 2413, 2888, 3478, 3902
Linea glutea ventralis runs along lateral edge (<i>Capra</i>)	939	897, 3487
Linea glutea ventralis basically forms ventral edge (<i>Ovis</i>)		92, 305, 513, 514, 983, 1807, 2413, 2888, 3902
Medial termination of Rectusgrube protrudes like a pad (<i>Capra</i>)	302, 304, 939, 954	
Medial termination of Rectusgrube flatter less pad like (<i>Ovis</i>)		92, 305, 513, 514, 897, 982, 1062, 1063, 1168, 1500, 1655, 2413, 3426, 3478, 3900, 3902
Tuberculum psadicum lies completely on medial side of ilium (<i>Capra</i>)	304, 939, 954	92, 1168
Tuberculum psadicum reaches ventral edge of ilium (<i>Ovis</i>)		305, 513, 514, 897, 982, 1063, 1500, 1655, 2413, 2888, 3426, 3478, 3900
Psoas tubercle does not reach (or barely does) caudal end of Rectusgrube (<i>Capra</i>)	304, 939, 954	
Psoas tubercle runs further caudally passing end of Rectusgrube (<i>Ovis</i>)		92, 303, 305, 513, 514, 897, 982, 1062, 1063, 1168, 1500, 1655, 2413, 2888, 3478, 3900
Generally deep Rectusgrube (<i>Capra</i>)	304, 939, 954	513, 1062, 2413, 3900
Generally shallow Rectusgrube (<i>Ovis</i>)		303, 305, 514, 897, 982, 1063, 1168, 1500, 1655, 3478, 3902
Pubic floor slopes gradually forming a thicker pubic ridge (<i>Capra</i>)	139, 1322, 1565, 2015, 2066, 3693	92
Pubic floor slopes steeply forming a pit in front of pubic rami (<i>Ovis</i>)		95, 300, 301, 512, 1759, 1761, 2410, 2413, 2701, 2939, 3428, 3783
No notch at cranial end of foramen obturatum (<i>Ovis</i>)		92, 2413, 3783
Widening at the caudal end of the foramen obturatum (<i>Ovis</i>)		2413
Short ischial tuberosity (<i>Capra</i>)	3659	
Long ischial tuberosity (<i>Ovis</i>)		307, 2413, 3658

Table 4.50 Summary Statistics of Pelves Measurements (mm)

LA	Capra	Ovis	Ovis/Capra	Bos	Gazella
Mean	30.40	31.00	31.22	62.72	
Median	30.40	31.43	31.22	62.72	
Standard Deviation	1.62	1.27	0.45		
Minimum	29.25	28.64	30.90	62.72	
Maximum	31.54	32.25	31.53	62.72	
Count	2	7	2	1	
LAR	Capra	Ovis	Ovis/Capra	Bos	Gazella
Mean	25.90	26.40	26.96	44.93	
Median	25.90	26.17	26.96	44.93	
Standard Deviation	0.94	1.63	0.02		
Minimum	25.23	24.60	26.94	44.93	
Maximum	26.56	29.00	26.97	44.93	
Count	2	8	2	1	
SB	Capra	Ovis	Ovis/Capra	Bos	Gazella
Mean	8.39	9.87	10.02		6.51
Median	8.39	9.90	9.90		6.51
Standard Deviation		0.99	1.75		
Minimum	8.39	8.43	8.33		6.51
Maximum	8.39	11.15	11.83		6.51
Count	1	10	3		1
SH	Capra	Ovis	Ovis/Capra	Bos	Gazella
Mean	16.48	15.57	16.03		
Median	16.48	15.48	15.50		
Standard Deviation		2.22	2.26		
Minimum	16.48	12.40	14.09		
Maximum	16.48	18.24	18.51		
Count	1	8	3		
IsH	Capra	Ovis	Ovis/Capra	Bos	Gazella
Mean		15.74	15.37		
Median		15.86	15.31		
Standard Deviation		1.33	1.58		
Minimum		13.63	10.89		
Maximum		17.55	17.29		
Count		7	15		
IsB	Capra	Ovis	Ovis/Capra	Bos	Gazella
Mean		7.36	7.45		
Median		7.28	7.54		
Standard Deviation		0.55	0.85		
Minimum		6.79	5.89		
Maximum		8.60	8.78		
Count		8	15		
Lfo	Capra	Ovis	Ovis/Capra	Bos	Gazella
Mean		39.47	37.02		
Median		39.47	37.02		
Standard Deviation		0.01			
Minimum		39.46	37.02		
Maximum		39.47	37.02		
Count		2	1		

likely represents an aged animal.

Two measurements were included in Table 4.50 that were not defined by von den Driesch (1976) in her treatise on bone measurements. The two additional measurements, the smallest height of the ishium (IsH) and the smallest breadth of the ishium (IsB) should be considered parallels to two measurements von den Driesch does define, namely the smallest height of the ilium (SH) and the smallest breadth of the ilium (SB). The additional measurements were taken because they occasionally appear in other publications (Compagnoni 1978) and I thought they may prove useful in the future.

4.2 Summary and Discussion

The above chapter was a rather lengthy, detailed presentation of all of the criteria used to distinguish between *Ovis* and *Capra* bones. Summaries of the measurements taken on the identifiable bones were also found within this chapter. These summaries were included within the chapter, and not placed in an appendix, because they were often integral to the identification of the specimen. A complete list of measurements taken on the Mudayna fauna is found in Appendix C. The identification of rare species, and generally questionable identifications, were explained in some detail so that the reader may use his judgement to decide upon the validity of the identification. As was noted at the beginning of this chapter, the validity and transparency of much faunal identification has been called into question in the past. It was hoped that presenting a detailed account of the identification procedures used in this thesis would allow the inferences made from those identifications to be regarded as accurate (or at least regarded with *less* suspicion).

Identification of *Bos taurus* remains was not discussed in this chapter because they were not contentious. The size of the cattle remains found puts them solidly in the very large mammal (SC6) category, a category shared only with equids and camels. Differentiating between these three species is not particularly difficult and whenever an identification could not be made with certainty the specimen was classified as an Ungulate SC6 eliminating any possibility of misidentification.

The following chapter discusses aging and sexing of the *Ovis* and *Capra* remains from Mudayna and looks at herd composition and possible distribution patterns.

Chapter 5

Analysis of Sheep and Goat Remains

5.1 Introduction

Now that all of the sheep and goat faunal identifications made within this thesis have been discussed explicitly, analysis may move on to a higher level. This chapter presents data concerning the age at death, sex, ratio, and skeletal part abundance of the *Ovis* and *Capra* remains found at Khirbat al-Mudayna. First, however, NISP, MNI, weight counts, MNE, MAU and %MAU are given, as these are important for the following discussion. After all of the data have been displayed, they will be interpreted using models of herding and distribution strategies developed by Zeder (1986, 1988, 1991) and Redding (1981) in the 1980s.

5.2 Bone Counts: Raw and Manipulated

Table 5.1 is a summary of *Ovis aries* and *Capra hircus* bone counts. The MNI values were calculated by considering both the side and the maturity of the element. The MNE values given in Table 5.1 are the largest MNE value found on the specific bone. A complete list of MNE, MAU and % MAU values may be found in Appendix B.

5.2.1 Ratio of Sheep to Goat

It is obvious when consulting Table 5.1 that more sheep bones were recovered than goat bones. Trying to determine the ratio of two different species from archaeological remains has some pitfalls that one must be careful to avoid. The count that the ratio is based upon (NISP, weight, MNI etc.) will alter the ratio produced. A prime example of differing ratios is seen when the ratio of cattle bones to sheep and goat bones is calculated. If the NISP is used, a ratio of 13.82:1 (1423 *Ovis*, *Capra* and *Ovis/Capra* to 103 *Bos* bones), in favour of the sheep and goat bones, is produced. However, when the weights of the bones are considered (11202.5g for *Ovis*, *Capra* and *Ovis/Capra* to 4116.4g for *Bos*) the ratio drops dramatically to 2.72:1 in favour of the sheep and goats. The zooarchaeologist must decide which ratio most accurately answers the question being asked. For example if the goal is to determine the difference in the number of

individuals of each species that was present at the site, the weight ratio is useless because of the differential species weight. On the other hand, if total meat contribution is the target, then the weight ratio provides the most accurate measure.

Luckily, size is not an issue when comparing sheep to goats. While there is no reason to suspect that sheep and goat bones were treated equally after the animals' death, there is also no evidence to suggest that one species' bones were more intensively utilized, and fragmented, than the other. One way to counteract any bias that may have been introduced by differential fragmentation of bones between species is to produce a ratio of the total bone weights. Using a weight ratio ensures that the count of the species is not artificially inflated through extreme fragmentation, because no matter how fragmented a bone becomes, if all of its pieces are present, the weight never changes. Four different ratios of sheep to goats were calculated and importantly, they are all very similar. The weight ratio for sheep/goat is 1.52:1 (3258.4g:

Table 5.1 Summary of *Ovis aries* and *Capra hircus* elements

	<i>Ovis aries</i>						<i>Capra hircus</i>					
	NISP	Wt. (g)	MNI	MNE	MAU	%MAU	NISP	Wt. (g)	MNI	MNE	MAU	%MAU
Bone												
Cranial bones	23	299.7	7	12	6	57.14	27	313.9	7	9	4.5	56.25
Cranial teeth	0	0.0	0	0	0	0.00	1	31.4	1	1	0.5	6.25
Mandibular bones	0	0.0	0	0	0	0.00	0	0.0	0	0	0	0.00
Mandibular teeth	8	258.2	4	5	2.5	23.81	4	78.3	2	4	2	25.00
Atlas	9	199.7	9	9	9	85.71	5	119.2	5	5	5	62.50
Axis	2	51.5	2	2	2	19.05	3	94.0	3	3	3	37.50
Scapula	18	290.7	8	14	7	66.67	14	208.2	9	12	6	75.00
Humerus	18	359.6	8	15	7.5	71.43	16	304.1	10	16	8	100.00
Radius	17	210.3	10	12	6	57.14	9	137.8	4	6	3	37.50
Ulna	7	51.1	4	7	3.5	33.33	4	35.5	3	4	2	25.00
Metacarpal	21	203.1	9	12	6	57.14	8	102.6	4	6	3	37.50
Radial Carpal	2	4.1	1	2	1	9.52	4	7.5	2	4	2	25.00
Internal Carpal	3	3.7	3	3	1.5	14.29	3	4.3	3	3	1.5	18.75
Ulnar Carpal	3	1.5	2	3	1.5	14.29	1	0.7	1	1	0.5	6.25
Fused 2+3 Carpal	4	7.9	2	4	2	19.05	1	2.1	1	1	0.5	6.25
Unciform	2	1.9	1	2	1	9.52	0	0.0	0	0	0	0.00
Pelvis	33	363.5	14	19	9.5	90.48	12	75.8	4	6	3	37.50
Femur	16	229.3	7	12	6	57.14	10	139.7	6	6	3	37.50
Patella	8	25.1	4	8	4	38.10	3	5.3	2	3	1.5	18.75
Tibia	9	148.6	3	5	2.5	23.81	10	119.3	4	8	4	50.00
Metatarsal	10	131.8	6	9	4.5	42.86	11	82.5	4	7	3.5	43.75
Astragalus	17	94.3	10	17	8.5	80.95	7	36.7	4	7	3.5	43.75
Calcaneus	22	160.1	12	21	10.5	100.00	14	105.0	8	14	7	87.50
Fused C+4 Tarsal	6	27.5	5	6	3	28.57	2	4.5	1	1	0.5	6.25
1st Phalange	28	89.8	4	27	3.38	32.19	32	104.2	5	30	3.75	46.88
2nd Phalange	18	33.9	3	18	2.25	21.43	15	24.9	2	15	1.88	23.44
3rd Phalange	7	11.5	2	7	0.88	8.38	4	3.7	1	4	0.5	6.25
Total	311	3258.4	14	N/A	N/A	N/A	220	2141.2	10	N/A	N/A	N/A

2141.2g). The ratio produced by comparing the NISPs for sheep/goat is 1.42:1 (311:220). Two different ratios, based on the MNIs of the species, were calculated. The first ratio uses the largest MNI count for both species and produces a sheep/goat ratio of 1.40:1 (14:10). The second MNI ratio used involved calculating the average MNI of each species and comparing these averages. This was done to avoid the issue of chance preservation inflating one species' MNI value. The second sheep/goat MNI ratio, then, is 1.47:1 (5.04:3.43). If all of the ratios produced are averaged, a sheep/goat ratio of 1.45:1 is produced. Because of the consistency seen in all of these ratios it is safe to say that a sheep/goat ratio of 1.45:1 accurately approximates both the depositional ratio and, as will be discussed further, the ancient herd structure.

In his 1981 Ph.D. thesis, Redding (1981: 312-317) lists a number of potential problems or situations that may occur to alter the ratio of sheep/goat bones, and the survivorship of age classes, between the time when the animals are alive and in the herd and when they are

Table 5.2 Summary of *Ovis/Capra* elements

<i>Ovis/Capra</i>	NISP	Weight (g)	MNI	MNE	MAU	%MAU
Bone						
Cranial bones	47	268.5	5	13	6.5	20.97
Cranial teeth	149	1055.3	34	62	31	100.00
Mandibular bones	47	262.9	10	37	18.5	59.68
Mandibular teeth	131	687.1	24	43	21.5	69.35
Atlas	7	57.0	7	7	7	22.58
Axis	23	217.1	19	19	19	61.29
Scapula	40	318.2	16	28	14	45.16
Humerus	54	429.8	10	33	16.5	53.23
Radius	44	336.4	12	18	9	29.03
Ulna	18	65.9	8	12	6	19.35
Metacarpal	26	160.4	9	18	9	29.03
Radial Carpal	2	2.6	1	2	1	3.23
Internal Carpal	2	2.2	1	2	1	3.23
Ulnar Carpal	0	0.0	0	0	0	0.00
Fused 2nd + 3rd Carpal	0	0.0	0	0	0	0.00
Unciform	2	2.1	2	2	1	3.23
Pelvis	58	437.3	21	31	15.5	50.00
Femur	71	587.5	14	18	9	29.03
Patella	3	5.4	2	3	1.5	4.84
Tibia	59	504.8	14	26	13	41.94
Metatarsal	27	206.2	13	23	11.5	37.10
Astragalus	8	29.8	5	7	3.5	11.29
Calcaneus	13	55.5	5	9	4.5	14.52
Fused C+4 Tarsal	1	2.0	1	1	0.5	1.61
1st Phalange	32	50.0	4	24	3	9.68
2nd Phalange	11	11.1	2	11	1.375	4.44
3rd Phalange	2	2.8	1	2	0.25	0.81
Total	877	5757.9	34	N/A	N/A	N/A

examined by a zooarchaeologist. Redding organizes the problems he presents into three categories; predepositional, postdepositional and excavation processes. Predepositional processes include animals that are killed, or die, away from the site, at for example, a winter/summer camp, and are not incorporated into the archaeological record. This process affects sites that were seasonally occupied (Redding 1981: 313) to a much greater extent than sites like Mudayna that were occupied year round, so should not have greatly affected Mudayna's sheep/goat ratio. Also, animals will die naturally on the way to and from pasture, but because there is no evidence that either sheep or goats will die more frequently than the other, this process should not affect the ratio of the species.

Postdepositional processes should not affect sheep/goat ratios as they should act equally upon both species. They will, however, alter the of age classes affecting survivorship curves but this will be discussed below.

Two excavation processes may be particularly damaging to sheep/goat ratios. The first process, Redding (1981:315) explains, is within site variation. The second process is the calculation of sheep/goat ratios from a very small (less than 25-30 identifiable elements) (Redding 1981: 316) number of elements. Because the number of elements identified from Mudayna is sufficiently large, the second process is not a concern. Within site variation is an issue that must be dealt with at Mudayna. So far, only public areas (the gate, a shrine and its associated courtyard) have been excavated. We cannot assume that the rest of Mudayna, particularly any domestic areas that may be excavated in the future, will necessarily conform to the ratio of sheep/goat bones calculated for the public areas. It may be, for example, that the majority of the bones studied to date are associated with the shrine and represent offerings and feasts for Kemosh (Moab's principle god), or a lesser known Moabite god. If the present Mudayna faunal sample is not principally associated with the shrine, it is still likely to be associated with soldiers, craftsmen, or priests who worked, and perhaps lived, in the area excavated. One would not necessarily expect this sample of bones to be the same as a sample associated with a household kitchen.

A further warning Redding offers about the validity of sheep/goat ratios is the actual identification of the bones to species (Redding 1981: 316-317). The criteria used to differentiate between sheep and goat bones has been explicitly described in Chapter four so that the reader may judge for himself the acceptability of the identifications. Because the sheep/goat ratio is consistent over four independent measures, it certainly reflects the ratio of sheep/goats deposited. That the archaeological sheep/goat ratio also reflects the ancient herd ratio is discussed below. An initial piece of evidence to support this assumption, however, is that Iron

Age Hesban, located some 30 km northwest of Mudayna, had a sheep/goat ratio of 1.77:1 (LaBianca 1995: 54), showing that herds of this composition are not only possible, but quite probable.

5.2.2 Age at Death

The age at death of sheep and goat remains may be calculated in two ways. The first method uses known approximate ages of bone epiphysis fusion and the second method uses approximate ages of dental eruption and wear. Both of these methods have inherent problems (see Watson, 1978: 97-101; and Grant 1978: 103-106 for detailed discussions of these problems), but because they are the only methods available at this time to approximate herd mortality they will be used. The largest problem with using either epiphyseal fusion or dental eruption and wear is the differential destruction of immature bones and teeth. Because immature elements are smaller and less dense, they are destroyed more easily than mature elements (Lyman, 1984: 279) and so, in turn, appear in the archaeological record less frequently. By not appearing in the archaeological record, the immature elements are automatically under-represented when age profiles are created by zooarchaeologists.

A second major problem that is not inherent in either of the aging methods, but occurs with most archaeological studies, is the combination of sheep and goat data in order to construct a database large enough to produce meaningful results. There is no reason to suspect that sheep and goats were killed at the same ages by ancient herders, or even necessarily taken to the same pastures (possibly affecting tooth wear) (Frey and Marean, 1999:129), but this assumption is made to ensure enough data are available to produce survivorship curves. The survivorship curves created represent data for both sheep and goats and in reality reflect the average of two separate sheep and goat curves.

To complicate matters further, the sex of the animals is not considered when survivorship curves are plotted. The lack of sexual differentiation is an even larger problem than the lack of species differentiation. One can imagine the possibility that sheep and goats were culled at similar ages, but it does not make sense, from a herder's point of view, to cull male and female animals in a similar fashion. Redding (1981: 283) has calculated that when the herder's primary concern is the maximization of energy offtake from the herd (equivalent to energy intake by the herder from the herd), the ideal ratio of female/male sheep is 32:1 and the ideal ratio of female/male goats is 99:1. Energy efficiency is boosted when the intake of energy (from the herd) is maximized, or the time spent acquiring energy is minimized. The difference in female/male ratios between the sheep and goats is due to fertility considerations for the males of

the two species. One buck (goat) can service 100 does (goat) while one ram (sheep) can only service 40 ewes (sheep) (Redding 1981: 282). When the herder's primary concern is herd security, defined as ensuring minimal "fluctuations in yield below the subsistence needs of the herding group" (Redding 1981: 47), the number of males will increase to ensure fertilization potential in the face of disease, predation or natural disaster. Nevertheless, the ratio of females to males should, under no circumstances, reach 1:1, because no matter what the herder's goals, more males are killed at a young age than females. Because survivorship curves combine all of the data for sheep and goats, they actually represent an average of four individual curves (male and female sheep and goats).

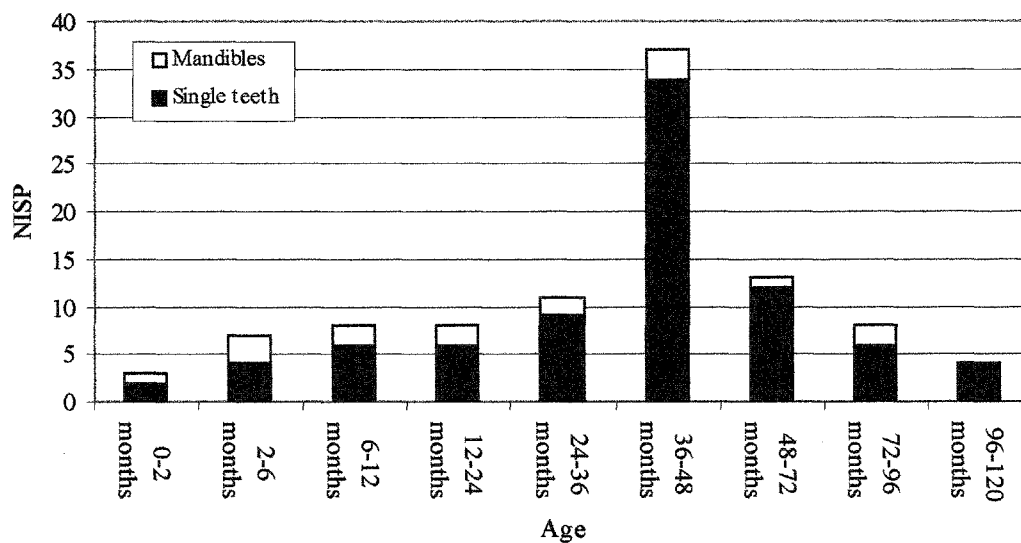


Figure 5.1 Sheep/goat mandibular tooth wear stages. Note: All of the teeth contained within a mandible were assigned to a specific age group and recorded as a single NISP.

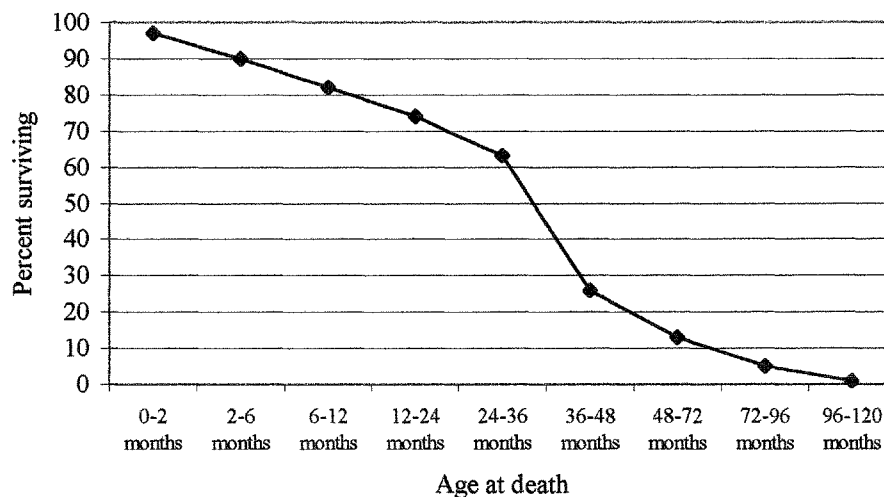


Figure 5.2 Sheep and goat mandibular wear stages survivorship curve

In spite of all of the problems associated with survivorship curves they are still useful tools when a very general picture of herd age and mortality is sought. It has been argued that tooth eruption and wear is the more accurate method of estimating herd mortality patterns (Watson, 1978: 100). Even if using epiphyseal fusion data is a less accurate method of estimating herd mortality patterns it will be used to act as a confirmation for the dental information studied.

Payne (1973) defined the dental wear categories used in this study. Figure 5.1 presents the number of individual teeth and mandibles assigned to each age category. Because there were 99 individual teeth and mandibles used during this study, Figure 5.1 may also be read to represent the percent of specimens within each age category. It appears that a relatively late kill, when the animal was somewhere around 36 months of age, was the most common pattern practiced at Mudayna. Figure 5.2 shows that as the herd aged the number of animals in each successive age group gradually declined until the animals were around 36 months old, when a sharp decrease, or intensive culling, took place. Only 25 percent of the herd survived past 48 months of age.

The fact that a late kill took place is unquestionable when presented with the overwhelming number of teeth assigned to the 36-48 month age category. I have doubts, however, about the lack of young specimens appearing in the record. Even if a planned cull of young males did not take place, the natural "average mortality rate to one year of age under extensive husbandry is 32% in sheep and 45% in goats" (Redding 1981: 114) for an average infant death rate of 38.5%. These figures are derived from herds living in Syria and Northern India, environments comparable to Jordan's. Figure 5.2 shows that over 80 percent of the herd

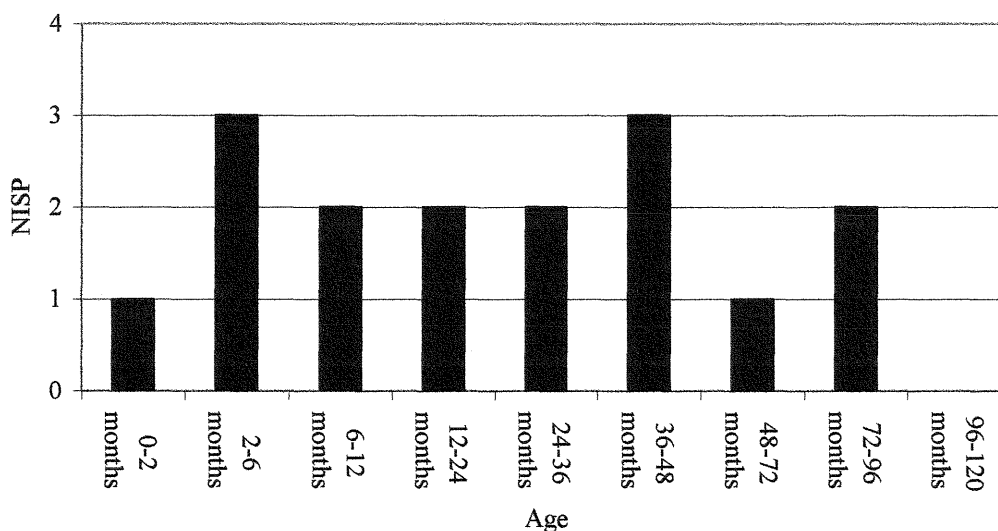


Figure 5.3 Mandibular wear stages of sheep and goats using whole or fragmented mandibles

survived past 12 months of age, a figure that is biologically impossible. Using bone density studies as an analogy (immature/less dense bones survive less frequently than mature/more dense bones) (Lyman 1982: 115), it is likely that because of the fragile and brittle nature of deciduous sheep and goat teeth, they simply do not survive as well as permanent teeth. This is especially true when the deciduous teeth have been separated from the protective casing of the mandible. Figure 5.3 is interesting because, while it is admittedly based on a small number of samples (15), it shows that when deciduous teeth (specifically those aged 2-6 months) remain intact within the mandible they occur with as much frequency as teeth aged between 36 and 48 months. The difference in the numbers of teeth recovered changes radically when the single teeth are considered. The great majority of single teeth recovered were permanent molars or,

Table 5.3 Sheep and goat epiphyseal fusion data. F = Fused, U = Unfused, JF= Just fused
%F = Percent fused.

Element	Ovis aries				Capra hircus				Ovis/Capra				Ovis+Capra+O/C			
Group A (< 12 months)	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F
Scapula	17	0	0	100%	12	0	0	100%	12	5	0	71%	41	5	0	89%
Dist. Humerus	15	0	0	100%	16	0	0	100%	16	3	0	84%	47	3	0	94%
Pelvis	29	4	0	88%	12	0	0	100%	29	22	0	57%	70	26	0	73%
Prox. Radius	12	0	0	100%	6	0	0	100%	28	0	0	100%	46	0	0	100%
Group A: Average %Fused = 86% (204/238)																
Group B (12 - 18 months)	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F
Phalanx 1	22	1	0	96%	27	3	0	90%	10	8	0	56%	59	12	0	83%
Phalanx 2	18	0	0	100%	12	2	0	86%	2	6	1	22%	32	8	1	78%
Group B: Average %Fused = 81% (91/112)																
Group C (18 - 24 months)	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F
Dist. Tibia	4	1	0	80%	8	0	0	100%	0	12	0	0%	12	13	0	48%
Group C: Average %Fused = 48% (12/25)																
Group D (18 - 30 months)	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F
Dist. Metacarpal	10	0	0	100%	3	3	0	50%	1	3	0	25%	14	6	0	70%
Dist. Metatarsal	2	3	0	40%	3	1	0	75%	3	3	0	50%	8	7	0	53%
Dist. Metapodial	1	0	0	100%	-	-	-	-	0	10	0	0%	1	10	0	9%
Prox. Ulna	4	0	1	80%	3	1	0	75%	3	4	0	43%	10	5	1	63%
Prox. Calcaneum	15	3	0	83%	8	4	0	67%	6	3	0	67%	29	10	0	74%
Group D: Average %Fused = 61% (62/101)																
Group E (30 - 42 months)	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F	F	U	JF	%F
Prox. Femur	12	2	0	86%	3	0	0	100%	7	24	0	23%	22	26	0	46%
Dist. Femur	1	1	1	33%	3	3	0	50%	10	13	1	42%	14	17	2	42%
Prox. Humerus	3	1	0	75%	0	1	0	0%	5	4	2	45%	8	6	2	50%
Prox. Tibia	3	0	1	75%	1	1	0	50%	0	7	0	0%	4	8	1	31%
Dist. Radius	5	1	0	83%	2	1	0	67%	4	10	0	29%	11	12	0	48%
Group E: Average %Fused = 44% (59/133)																
Male Pelvis %Fused = 44% Female Pelvis %Fused = 92%																

more infrequently, premolars. If single deciduous teeth and single permanent teeth survived at the same rate, Figure 5.1 would show a much larger spike at the 2-6 month category representing both natural infant deaths and active male culling. Unfortunately, no study has yet been done on the relative survivability of deciduous vs. permanent teeth so the theory that deciduous teeth will naturally survive less often than permanent teeth must remain a conjecture.

Epiphyseal fusion data were calculated using a combination of dates presented by Moran and O'Connor (1994: 280) and LaBianca (1995: 56). It must be remembered that epiphyseal fusion dates are naturally imprecise and should be treated as ranges on an almost relative, rather than absolute, scale. A number of factors may influence the timing of epiphyseal fusion including sexual dimorphism, nutritional regimen and castration (Moran and O'Connor, 1994: 273-274). Table 5.3 shows a summary of the data used to construct the survivorship curve presented in Figure 5.4.

The solid black line in Figure 5.4 is a graphic representation of the average percent of fused bones for each age category given in Table 5.3. The dotted line that joins the points shown for group B (12-18 months) and group D (18-30 months) has been added because, likely, that line more accurately reflects the true situation. There are two reason that the 'actual' survivorship curve may show an anomaly for group C (18-24 months). First, the tooth wear data suggest that the survivorship of 18-24 month old sheep and goats should be somewhere around 70 %, a figure that creates a more reasonable line between group B and group D. The line that the 'actual' survivorship curve follows creates a large resurrection of animals between 24 and 30 months of age. The resurrection effect is made possible because of the large overlap in fusion

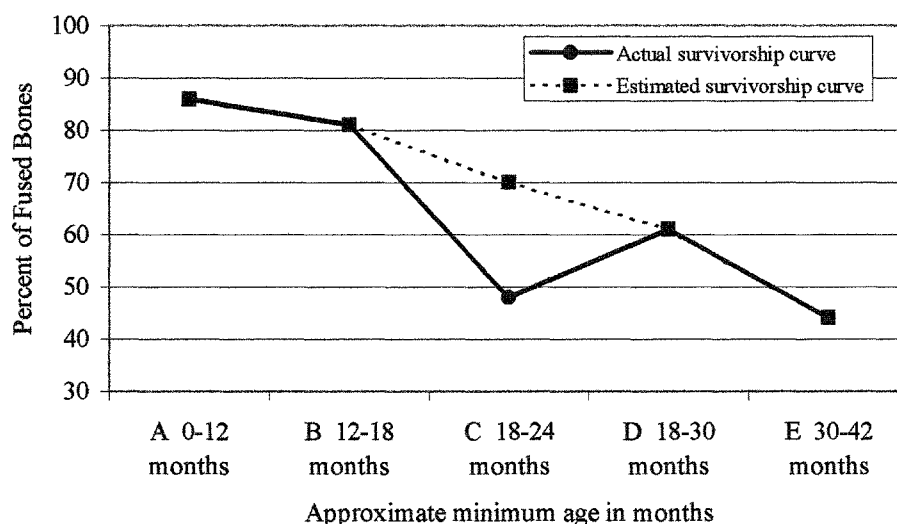


Figure 5.4 Survivorship curve of sheep and goat bones based on epiphyseal fusion

periods represented by groups C and D. The second reason that the figure for group C may be skewed is that, as Table 5.3 shows, the sample size for group C is less than a quarter that of the next smallest group (group D). Group C is also the only group based on a single element (the distal tibia). The sample size of group C (18-24 months) is small enough to allow a minor anomaly in the figures to cause a relatively large dip in the survivorship curve.

A different possibility exists that could explain the irregular shape of the epiphyseal survivorship curve. Group D may be inflated. If group D registered at somewhere around the 45 percent mark, the survivorship curve would be a more plausible shape although it would indicate a much younger cull than the dental data indicate. It is possible for epiphyseal data to appear younger than dental wear data (Frey and Marean, 1999: 130). The appearance of different cull ages may be explained by the vagary of epiphyseal fusion dates and the “differential selection of elements” (Frey and Marean, 1999: 130). The most likely option, however, is that group C is skewed, rather than group D, because of group C’s small sample size and reliance on a single element.

It is possible, of course, that the epiphyseal survivorship curve looks exactly the way it should considering the large overlap in fusion periods for groups C (18-24 months) and D (18-30 months). If one or two of the four elements (excluding metapodials) represented in group D fused at the lower end of the possible range (around 18 months), this fusion would overlap with the time period for group C’s fusion, effectively raising the proportion of fused bones within group C. If this is the case, the survivorship curve should actually follow the line of the ‘estimated’ survivorship curve more closely than the ‘actual’ survivorship curve.

Assuming that the survivorship curve should roughly follow the ‘estimated’ line more closely than the ‘actual’ line, no dramatic cull pattern appears at any time. It may be that the epiphyseal fusion data presented simply do not extend far enough in time to register the rather late culling activity (sometime after three years of age) shown in the dental wear patterns.

5.2.3 Distinguishing Sheep and Goat Sex

In the previous section, it was mentioned that Redding (1981: 283) calculated the ‘ideal’ ratios of sheep and goat female/males as 32:1 and 99:1 respectively, when energy/protein maximization is a herder’s primary concern. The number of males to females will increase as a herder’s interest in herd security increases in order to safeguard the flock against predation, disease and natural disaster. The ratio of female/male sheep and goats was calculated for the Mudayna faunal material by looking at the morphology of the pelves, axes and atlases. Metric distinction between male and female sheep and goats was used whenever sample size permitted.

In the case of sheep, metric separation was possible for scapulae and astragali. Goat distal humeri and astragali were also separated using metric analysis. Metric separation of elements between sexes is not always possible because of some size overlap that exists but when performed with a large enough sample, or in this case sufficient caution, it can be reliable (Zeder, 2001: 65).

Table 5.4 shows a breakdown of the sheep and goat sex data accumulated from the Mudayna faunal collection. From the 1423 *Ovis*, *Capra* and *Ovis/Capra* specimens excavated, a total of 111, or 8%, could be identified as either male or female. The percentage of sexable bones found at Mudayna is in line with two samples of bones that were sexed from Hesban (7.74% and 10%) but the absolute total number of bones sexed from Mudayna is three and four times larger than the Hesban samples (24 and 39 specimens) respectively (LaBianca 1995: 54). The Mudayna sample, it seems, is large enough to provide meaningful data about the ratio of female and male sheep and goats.

Some explanation of Table 5.4 may be helpful for the reader. The top three sections are self-explanatory but the fourth and fifth sections (corrected *Ovis* and *Capra* totals) require clarification. In order to designate every sexable specimen as either a sheep or a goat the seven male and five female *Ovis/Capra* pelvis specimens were divided between the sheep and goat categories roughly following the sheep/goat ratio of 1.45:1 determined earlier in this chapter. Four males and three females were assigned to sheep and three males and two females were

Table 5.4 Summary of sheep and goat sex data			
<i>Ovis aries</i>	Male	Female	%Female
Pelvis	9	22	71%
Atlas	1	8	89%
Axis	0	2	100%
Astragalus	1	10	91%
Scapula	2	11	85%
Total	12	53	82%
<i>Capra hircus</i>			
Pelvis	0	11	100%
Atlas	0	5	100%
Axis	1	0	0%
Astragalus	1	4	80%
Humerus	2	11	85%
Total	3	31	91%
<i>Ovis/Capra</i>			
Pelvis	7	5	42%
Corrected			
<i>Ovis</i> total	16	56	78%
Corrected			
<i>Capra</i> total	6	33	85%
'Herd' total	22	89	80%

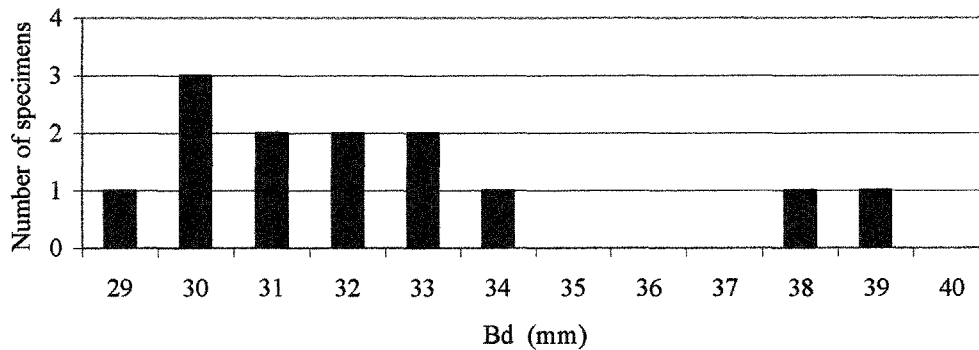


Figure 5.5 Measurements of the greatest distal breadth (Bd) of *Capra* humeri showing females on the left and males on the right.

assigned to the goat category. The corrected *Ovis* and *Capra* totals simply reflect the addition of these pelves to the existing *Ovis* and *Capra* totals. The 'herd' total was calculated by adding the corrected *Ovis* and *Capra* totals together (assuming a mixed herd). Figures 5.5, 4.2 and 4.11 show graphic examples of the metric separation of *Capra* humeri, *Ovis* and *Capra* astragali, and *Ovis* scapulae respectively.

The dominance of females over males in the Mudayna faunal sample is unmistakable. Goats show a slightly higher female/male ratio, about 6:1, than sheep whose female/male ratio is slightly less than 4:1. When considered together, the sheep and goat female/male ratio is exactly 4:1. An important assumption that is made when calculating the ratios of female/male bones at Mudayna is that none of the specimens derive from the same individual. Even if MNIs were insisted upon for distinguishing sex, females would still dominate the assemblage (female/male MNI ratios = *Ovis* atlas 8:1, *Ovis* scapula 8:1, *Capra* atlas 5:0, *Capra* pelvis 11:0). The low female/male sheep ratio (4:1), relative to goats (6:1), is explained by the same reasoning Redding used to determine that the optimal sheep female/male ratio is lower than the optimal goat female/male ratio mentioned above (Redding 1981: 283). Relatively more males are present at Mudayna than Redding (1981: 283) predicted would be seen if the herder was concerned primarily with maximizing the energy/protein obtained from the herd. The sheep and goat female/male ratios suggest that herders were more concerned with maximizing herd security at Mudayna.

An important clue to the Mudayna herd structure is found when you combine data regarding the fusion and the sex of sheep and goat pelves. Tucked away at the bottom of Table 5.3 is a line indicating that 44% of male sheep and goat (combined) pelves were fused while 92% of female sheep and goat (combined) pelves were fused. The pelvis is one of the first elements to fuse in both sheep and goats with fusion taking place before the animal reaches 12 months of age. These data indicate that 56% of sheep and goat males were slaughtered before

they reached one year of age. Possibly, the percentage of males slaughtered was even higher than 56% but because immature bones survive less frequently and are more difficult to assign to both species and sex (Zeder 2001: 74) they are underrepresented. An early cull of males, that does not appear in the epiphyseal fusion or the dental wear survivorship curves, is clearly indicated when the sex and fusion data of the Mudayna sheep and goat population are viewed in combination.

5.2.4 Meat-rich and Meat-poor Bones

The appearance (or non-appearance) of certain portions of skeletal elements at any archaeological site is important because it indicates that a certain type of activity (or activities) took place in the past (possibly the very recent past), creating the patterns, both spatial and numerical, of bones that the zooarchaeologist analyses. The problem with seeing a pattern in the faunal material and assigning a specific activity as its cause is one of equifinality (Lyman 1994: 258); a given pattern may be caused by more than one activity (cultural or natural). Before activity types may be revealed, patterns must be recognized and analyzed.

One test that may be applied to the faunal material from any archaeological site attempts to measure the relationship between the numbers of specific skeletal elements found (i.e. proximal humerus) and the 'meat value' of that element. Every bone, or portion of bone, is associated in life with the soft tissue surrounding it. The soft tissue is typically what people seek (with some exceptions), not the bone itself. In order to explain the presence of certain bones at archaeological sites, the relative values of the soft tissues associated with that bone have been measured. In 1978, Binford published data for the relative values, which he called utility indices, of the meat, marrow and grease associated with the bones of domestic sheep. Separate values were determined for all three of these categories, but because, in reality, all of the categories are interconnected, Binford (1978) developed a general utility index (GUI) for each skeletal element. Realizing that sometimes bones with low utility indices remain attached to bones with higher indices, accidentally and purposefully, Binford (1978) developed a modified general utility index (MGUI) that he thought would account for this association.

In order to test whether the faunal material from an archaeological site has, perhaps, been patterned (and, importantly, what type of pattern) by food value considerations, one may look at the relative number of 'meat-rich' (high MGUI) and 'meat-poor' (low MGUI) bones recovered. Together with this, one must determine whether the general pattern of bone elements recovered is the same pattern that is predicted if food value consideration was the dominant force behind the deposition of the skeletal remains in the first place. One would expect to find a

Table 5.5 A comparison of the %MAUs for sheep and goat meat-rich and meat-poor bones (MGUI from Binford 1978 in Lyman 1991: 226)

	<i>Ovis</i>	<i>Capra</i>	<i>Ovis+Capra+Ovis/Capra</i>	<i>Ovis aries</i>
Meat-rich bones	%MAU	%MAU	%MAU	MGUI
Atlas	85.71	62.50	65.63	18.68
Axis	19.05	37.50	75.00	18.68
Scapula	66.67	75.00	84.38	45.06
Prox. Humer	19.05	18.75	25.00	37.28
Dist. Humer	71.43	100.00	100.00	32.79
Prox. Radius	57.14	37.50	51.56	24.3
Dist. Radius	28.57	18.75	42.19	20.06
Ulna	33.33	25.00	35.94	N/A
Pelvis	90.48	37.50	87.50	81.51
Prox. Femur	57.14	25.00	53.13	80.58
Dist. Femur	14.29	37.50	39.06	80.58
Prox. Tibia	19.05	12.50	21.88	51.99
Dist. Tibia	23.81	50.00	60.94	37.7
Combined total	585.71	537.50	742.19	529.21
Average	45.05	41.34	57.09	44.1
Meat-poor bones				
Prox. Metacarpal	57.14	37.50	56.25	10.11
Dist. Metacarpal	52.38	37.50	43.75	8.45
Calcaneus	100.00	87.50	68.75	23.08
Astragalus	80.95	43.75	48.44	23.08
Prox. Metatarsal	42.86	43.75	60.94	15.77
Dist. Metatarsal	19.05	25.00	37.50	12.11
Phalanx 1	32.14	46.88	31.64	8.22
Phalanx 2	21.43	23.44	17.19	8.22
Phalanx 3	8.33	6.25	5.08	8.22
Combined total	414.29	351.56	369.53	117.26
Average	46.03	39.06	41.06	13.03

significantly higher number of 'meat-rich' bones over 'meat-poor' bones at a site if food value was the primary force behind the original deposition of the bones.

Table 5.5 is a comparison of *Ovis*, *Capra*, and the combined *Ovis*, *Capra* and *Ovis/Capra* %MAU values with the MGUI values that Binford (1978, in Lyman 1994: 226) published for domestic sheep (*Ovis aries*). The 'meat-rich' and 'meat-poor' bones have been separated following Labianca (1995: 58). An average %MAU is presented for each category to enable comparison with the average MGUI values. It is apparent that while the average MAUs and the average MGUI for the 'meat-rich' categories are relatively close in number, the same is not the case with the 'meat-poor' bones. There are far more 'meat-poor' bones than the average MGUI predicts. In fact there are more *Ovis* 'meat-poor' bones than 'meat-rich' bones and the difference between the *Capra* 'meat-rich' and 'meat-poor' bones is negligible. The combined *Ovis*, *Capra*, *Ovis/Capra* category shows the largest difference between 'meat-rich' and 'meat-poor' bones. The relative quantity of 'meat-poor' bones in the combined category does not

diminish, however, the amount of 'meat-rich' bone increases. The increase of 'meat-rich' bone in the combined category is a product of the difficulty inherent in *Ovis* and *Capra* bone differentiation. Many of the 'meat-poor' bones are small and so more frequently wholly preserved allowing for a high amount of speciation. The 'meat-rich' bones, on the other hand, were more frequently assigned to the *Ovis/Capra* category and so there are more of them.

One problem encountered with the analysis of the food value of bones relative to their %MAUs is that all vertebrae (vertebrae have a relatively high MGUI) were identified only by size class. In an attempt to determine the effect that including the vertebrae in the analysis would have, the numbers of cervical, thoracic and lumbar vertebrae that would likely occur within each MAU category was estimated. To determine how many vertebrae should be assigned to each category the MNE values for each vertebra type was determined and subsequently converted into an MAU value, depending on the number of each type of vertebrae occurring within the spine (cervical = 5, thoracic = 13, lumbar = 7). Secondly, the sheep/goat ratio of 1.45:1, determined above, was used to divide the MAU values between *Ovis* and *Capra*. Finally, the MAU values were converted into %MAU values. While admittedly an approximation, these vertebral %MAU values allow a general idea of how their inclusion may change the 'meat-rich' vs. 'meat-poor' interpretation.

Table 5.6 presents the data for the 'meat-rich' bones with the three vertebrae types added. The data for the 'meat-poor' bones do not change with the addition of the vertebrae so

Table 5.6 A comparison of the %MAUs and MGUI for sheep and goat meat-rich bones including vertebrae (MGUI from Binford 1978 in Lyman 1994:226)

	<i>Ovis</i>	<i>Capra</i>	<i>Ovis+Capra+Ovis/Capra</i>	<i>Ovis aries</i>
Meat-rich bones	%MAU	%MAU	%MAU	MGUI
Atlas	85.71	62.50	65.63	18.68
Axis	19.05	37.50	75.00	18.68
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Prox. Humer	19.05	18.75	25.00	37.28
Dist. Humer	71.43	100.00	100.00	32.79
Prox. Radius	57.14	37.50	51.56	24.30
Dist. Radius	28.57	18.75	42.19	20.06
Ulna	33.33	25.00	35.94	N/A
Pelvis	90.48	37.50	87.50	81.51
Prox. Femur	57.14	25.00	53.13	80.58
Dist. Femur	14.29	37.50	39.06	80.58
Prox. Tibia	19.05	12.50	21.88	51.99
Dist. Tibia	23.81	50.00	60.94	37.70
Cervical vert	95.24	87.50	53.13	55.33
Thoracic vert	52.38	47.50	29.06	46.49
Lumbar vert	78.10	71.00	25.63	38.90
Combined total	811.43	743.50	850.00	669.93
Average %	50.71	46.47	53.13	44.66

they were not repeated here. The MGUI average stays almost exactly the same while the average %MAUs for *Ovis* and *Capra* each increase around five percent. Interestingly, the average %MAU for the combined category decreases slightly. In general, the addition of the vertebrae types does not affect the relative values of the %MAUs or the MGUI. Ribs, another high MGUI bone type, were not included in the analysis, nor was the sternum, because they too were not identified to species. It is likely, however, that considering the negligible impact the vertebrae types had on the outcome, the absence of the ribs and the sternum do not present a problem.

A second problem encountered with the comparison of the %MAU values and the MGUI values is that only *Ovis* MGUI values were available for comparison. The size and general form of the animals suggest that the MGUI values may be similar, but it is well known that sheep provide slightly more meat weight (Redding 1981: 153) and significantly more calories (Redding 1981: 163) per animal than goats. Goats, on the other hand, provide more grams of protein (and effectively all other nutrients) per animal than sheep because much of the sheep's caloric contribution derives from a high fat content. Selective decisions, not reflected in the MGUI value but of importance none the less, between sheep and goats may also have been based in part on personal preference or taste of the animal as well as ritual considerations. This study assumes that goat MGUI values are similar enough to sheep MGUI values to not cause any major shifts in the final outcome.

Spearman rank correlation tests were run on the data (%MAUs vs. MGUI), both including and excluding the vertebral additions. None of the combinations were found to be significantly correlated for a two-tailed test with a significance level of 0.05. As might be expected, the combined *Ovis*, *Capra* and *Ovis/Capra* %MAU category (without the vertebrae data) was the closest to being significantly correlated ($r_s = 0.377$ with 21 degrees of freedom) to the MGUI values, but it too proved insignificant.

A comparison of the average %MAU values from Mudayna with two sets of average %MAU figures derived from two occupations at Hesban shows that the Hesban assemblage contained far fewer 'meat-poor' bones (LaBianca 1995: Table 4.5). The sample of bones studied from a contemporaneous Iron Age occupation at Hesban produced an average %MAU of 36.69 for 'meat-rich' bones and 10.18 for 'meat-poor' bones. A much later Ayyubid-Mamluk period sample showed an average %MAU of 54.46 for 'meat-rich' bones and 13.87 for 'meat-poor' bones. The Hesban average %MAUs for 'meat-rich' bones do not differ exceedingly from the Mudayna figures but the average %MAUs for the 'meat-poor' bones are strikingly lower. The Hesban average %MAU values for the 'meat-poor' bones are very much in line with the figure presented for the *Ovis* average MGUI in Table 5.5 suggesting that the Hesban samples are

patterned by activities involving the differential distribution of high food value skeletal elements. The same is not the case at Mudayna where the distribution patterns of high and low food value skeletal elements are very similar. According to Zeder (1988: 13), the pattern of skeletal part distribution seen at Mudayna, that is, skeletal parts recovered approximating the relative numbers of skeletal parts found in whole animals, is representative of a direct distribution system. It is assumed that “when animals are procured directly, butchery is likely to occur in the vicinity of the consuming household. As a result, the skeletal parts deposited in local dumps will occur in proportions similar to those in the complete skeleton” (Zeder 1988: 13). An indirect distribution system is expected to show a more uneven scatter of skeletal parts, with one area containing an abundance of ‘meat-rich’ bones and a separate area containing the majority of the ‘meat-poor’ bones.

5.2.5 Volume Bone Density

A second test that is typically performed on archaeological faunal assemblages in an attempt to determine what type of activity was responsible for the assemblage formation is dependant on the differential volume bone densities of specific skeletal elements (i.e. head of the femur). Because certain skeletal elements are more dense than others, they will survive more frequently when subjected to natural (as opposed to cultural) density mediated attritional processes (Kreutzer 1992: 271) such as carnivore gnawing, trampling, physical and chemical erosion and soil compaction. The technique for applying volume bone mineral densities to archaeological assemblages was first made tenable by Lyman (1982) when his research using photodensitometry introduced archaeologists to a reliable and repeatable method of determining a bone’s volume density, as opposed to its bulk density. Recent advances in computed tomography allow even more accurate volume density measures to be produced (Lam *et al.* 1998: 560).

The comparison of the density values and the %MAU (or percent survivorship) values for the Mudayna faunal collection faced similar problems (lack of comparative data, incomplete skeletal speciation) as the MGUI and %MAU comparison. Unfortunately, the solutions were not as forthcoming so less analysis could be performed. The volume bone density values that were used for the analysis were taken on domestic sheep (*Ovis aries*) and published by Lyman (1994: Table 7.6). A number of scan site density values, including the ribs and some vertebral scans, were not published and so could not be used. Density studies performed by researchers such as Kreutzer (1992) and Pavao and Stahl (1999) have shown that using “proxy measures” (Pavao and Stahl 1999: 54) of one species to represent a different, though similar, species is problematic

and may lead to incorrect results. Because sufficient goat volume bone mineral density data do not yet exist, no analysis of the *Capra* material was undertaken.

The volume bone density of the sheep remains from Mudayna were studied in two different samples. The first sample was made up from all of the *Ovis aries* remains that had been identified. Unfortunately, as mentioned above, no vertebrae (save the atlas and axis) were identified to species. Because a fair quantity of vertebrae were recovered I thought it prudent to perform a separate test that included a percentage of the vertebrae identified as large mammal (most of the unidentified large mammal bones likely represent sheep and goats but are too fragmented to positively identify). The second sample was produced by dividing the large mammal cervical, lumbar and thoracic vertebrae into the calculated sheep/goat ratio of 1.45:1. These vertebrae were combined with the sheep portion (calculated again with a ratio of 1.45:1) of the *Ovis/Capra* bones and all of the positively identified *Ovis* bones to form a larger, hopefully representative, sample of sheep bones that included vertebrae.

The ranks of the density values given for sheep in Lyman (1994: Table 7.6) were compared to the ranks of the %MAU values determined for both sheep samples using Spearman's rank correlation test. Both sheep samples had a weak positive significant correlation to the density values for a two-tailed test with a significance level of 0.05. The Spearman rank correlation coefficient (r_s) was 0.361 (corrected for ties with 73 degrees of freedom) for the identified *Ovis* category and 0.245 (corrected for ties with 73 degrees of freedom) for the combined *Ovis* category.

Lyman (1994: 258) has shown that a weak negative correlation exists between deer MGUIs and bone mineral density. This means that high density bones tend to have a lower MGUI while low density bones tend to have a higher MGUI. He has argued that the interpretation of bone density values must be made in association with the MGUI values from a site as they are interrelated. To this end, the %MAUs have been plotted against both the MGUIs and the scaled density values of the *Ovis* categories (not the combined categories) in Figure 5.6. When reading Figure 5.6, keep in mind that because of the negative correlation between MGUI and density, the scale representing density should run in the opposite direction, that is from 100 to zero. The shape of the density curve produced (the dotted line), therefore, must be considered as reverse of that shown (the highest point should be in the upper left hand corner) for the purposes of the following discussion.

Binford (1978) has proposed that the shapes of the curves produced by plotting %MAU vs. MGUI may be interpreted as signifying different strategies of carcass use and/or causes of bone destruction. He suggests that five different curve shapes represent five different utility

strategies. The curve that is of interest for this study is the 'L' shaped reverse bulk strategy as that is the shape of the curve formed by the %MAU vs. density plot. Reverse bulk strategy curves are created when either a high number of bones with low MGUI values are recovered, or as is the case at Mudayna, when a high number of bones with relatively high density values are found.

The curves shown in Figure 5.6 are quadratic polynomial trend lines created by Microsoft™ Excel. The solid line signifies the trend of the %MAU vs. MGUI. The solid line approximates a straight horizontal line, a situation not described by Binford. The shape of this line is seen because as the MGUI values of the Mudayna bones increase, very little change in the %MAU values occur (as seen in Tables 5.5 and 5.6). The dashed line on Figure 5.6 represents the trend line curve found for %MAU vs. the scaled density values. Remember that the dashed

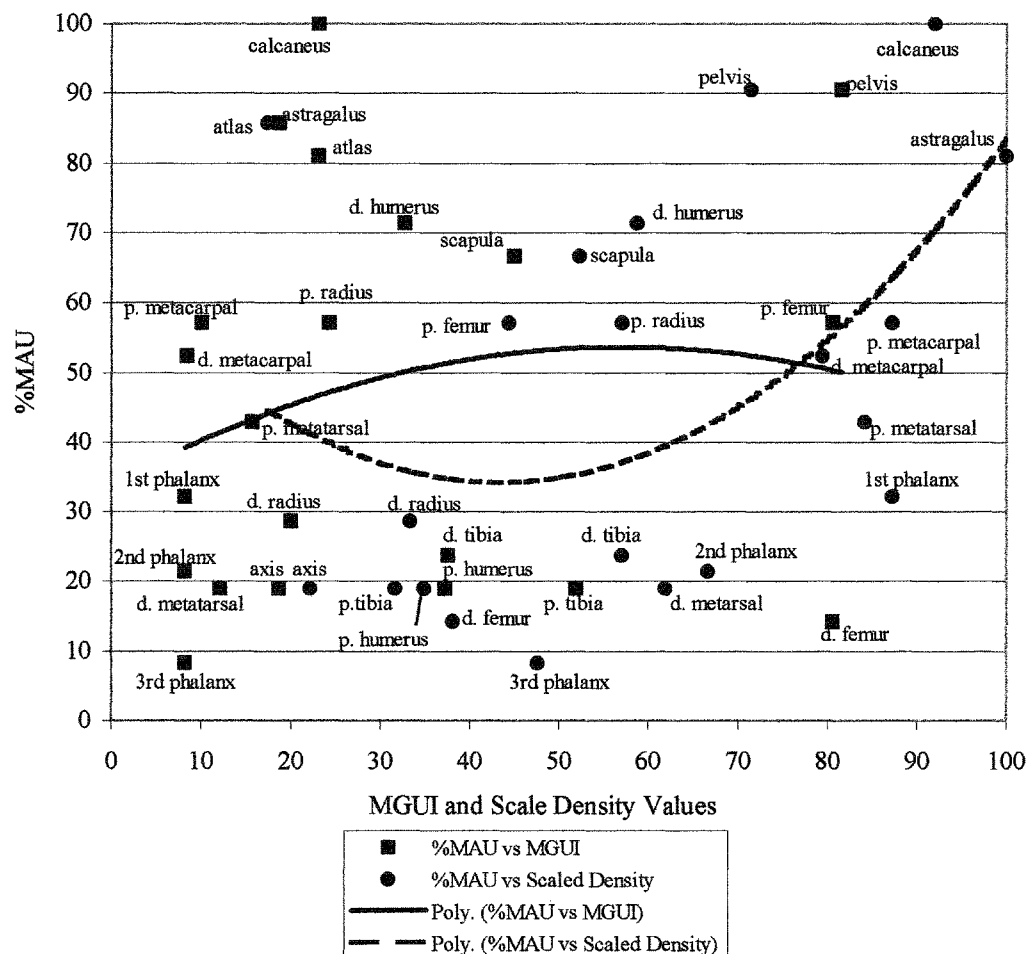


Figure 5.6 A comparison of *Ovis aries* %MAU vs both MGUI and Scaled Density Values (without vertebrae data) Note: the %MAU vs Scaled Density curve, in reality, would appear reversed

curve should appear reversed to its present position, trailing to the upper left hand corner of the graph rather than the upper right, representing an 'L' shaped reverse bulk strategy curve.

Lyman (1994: 261) performed a study where he calculated the correlation between the %MAU values and the MGUIs and density values of 184 archaeological and ethnoarchaeological assemblages of artiodactyl bones. Nine possible outcomes were produced. The outcome that matches the results of tests done on the Mudayna assemblage (%MAU:bone density = positive, significant; %MAU:MGUI = insignificant) is Class 4, a class that is defined as being from a ravaged or lag (differential fluvial transportation) influenced assemblage (Lyman 1994: Figure 7.13). The curve of a graph depicting a ravaged or lag influenced assemblage is identical to the curve of a graph produced by a reverse utility (reverse bulk strategy) assemblage ('L' shaped) because slightly (or entirely) more of the more dense skeletal elements remain. The dense skeletal elements remain in all three cases because a reverse utility assemblage is based around the collection of low MGUI (high density) skeletal elements, a ravaged assemblage has had its low density elements destroyed by carnivore gnawing and a lag assemblage has had all of the light, low density elements fluvially transported elsewhere. Grayson has also argued that a reverse utility curve "produced by destruction should be characterized by relationships between MGUI and %MAU that are not significant, but between bone density and %MAU that are both significant and positive" (Grayson 1989: 647).

Lyman's study allows important insights to be made about the taphonomy of the Mudayna faunal assemblage. The %MAU vs. MGUI correlation proved insignificant showing that the food value associated with skeletal elements was not a factor in the assemblage's creation. At the same time, there was a weak positive correlation between the %MAU values and the density values determined for the Mudayna assemblage, indicating that bone influenced the likelihood of recovery. Lyman (1994: 264) suggests that two possible solutions for this type of combination exist. The assemblage was either formed through differential fluvial transportation, lag, or through carnivore gnawing and ravaging. Because fluvial transportation was not a factor within the site of Mudayna, the only solution is carnivore ravaging. Carnivore (and rodent) tooth scrape and bite marks (Fig. D-12), as well as digestion marks (Fig. D-13), were evident on many of the faunal specimens recovered from Mudayna indicating that carnivore ravaging did in fact take place at the site. It is therefore reasonable that the greatest influence on the creation of the Mudayna faunal assemblage was not the differential selection, or access to, 'meat-rich' or 'meat-poor' skeletal elements by Mudayna's human population, but rather ravaging of the bones by the local dog population.

5.2.6 Butchering Marks

Eighteen percent of the sheep and goat skeletal elements recovered from Mudayna showed clear signs of cutmarks or butchering marks (Figs D-9, 10, 11). The percentage of bones showing cutmarks at Mudayna is slightly less than the 22.5% of bones displaying cutmarks from an Iron Age sample studied at Hesban. Some 'trowel trauma' or marks made inadvertently on the bones during excavation were discovered but, as Hesse and Wapnish (1985: 86) point out, it was not difficult to distinguish between ancient and modern cutmarks. Whenever there was any doubt as to the authenticity of a cutmark it was recorded as accidental, not cultural.

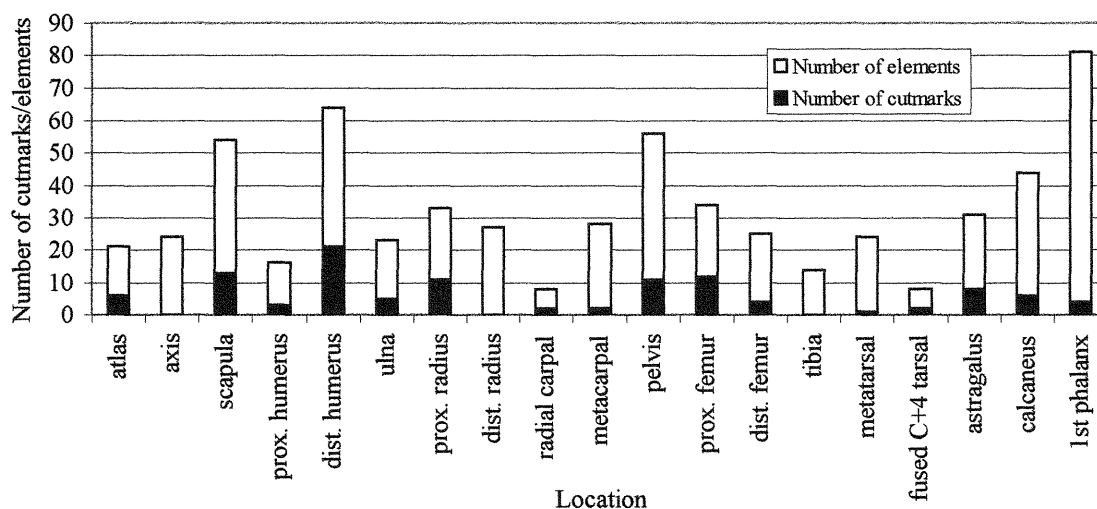


Figure 5.7 Comparison between the number of cutmarks and the number of sheep and goat elements

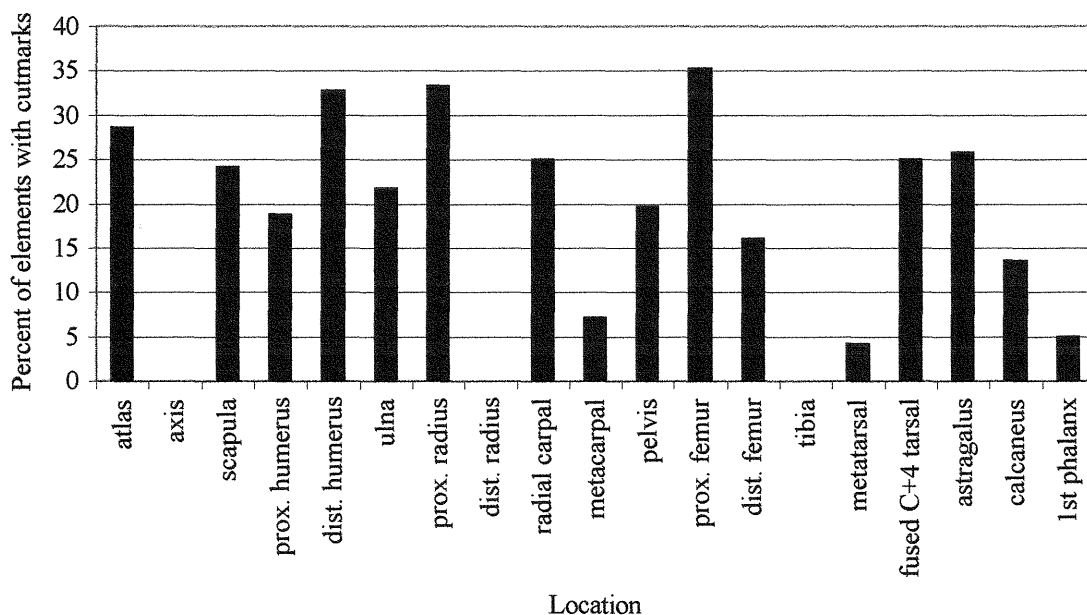


Figure 5.8 Percent of sheep and goat elements with cutmarks

Figures 5.7 and 5.8 respectively show the number of cutmarks per element and the percentage translation of elements showing cutmarks. Almost 30% of atlases show cutmarks on them while axes, of which there were more elements found, do not have a single cutmark. The initial slaughtering throat cut of the sheep and goats at Mudayna was very accurate. The joint between the distal humerus and the proximal radius received much abuse during disarticulation as over 30% of both elements show cutmarks. The hinging nature of the joint between the humerus and radius (including the ulna) makes disarticulation difficult without, at some point, having your knife blade encounter the bone.

The same problem does not exist between the distal femur and the proximal tibia. The femur and the tibia are held together by very strong ligaments but they are not physically interlocked like the humerus and radius/ulna joint. The more straightforward separation of the femur and the tibia is reflected in the small number of cutmarks present on the distal femur (16%) and by the fact that the tibia had no cutmarks at all. The separation of the distal limb bones (both the radius and the tibia) from the metapodials almost always took place at the joint between the carpals or tarsals and the respective metapodia. No cutmarks were found on the distal radius or the distal tibia and in fact very few were found on the metapodia. The carpals and tarsals bore the brunt of the butchery marks.

5.3 Summary and Discussion

Several lines of evidence that may be used to make predictions about the herd structure, herders' goals, and the type of animal distribution system functioning at Mudayna during the Iron Age were presented in this chapter. The interpretation of the data presented follows theories developed by Redding (1981) and Zeder (1986, 1988, and 1991) for ancient Near Eastern pastoralism. The first line of evidence examined is the ratio of sheep/goat remains found at Mudayna.

A sheep/goat ratio of 1.45:1 was determined for the faunal remains recovered from Mudayna. Redding (1981: 271) calculates that within a 'good' environment, when herd security is the herder's primary goal, a sheep/goat ratio of between 1:1 and 1.74:1 is optimal. Redding (1981: 27) does not define a 'good' environment save that 'good' refers to the environment from a sheep or goat's perspective. He suggests that two variables affecting the goodness of the environment may be the quality of pasture available and the temperature of the area. Was the environment around Mudayna good? With little Iron Age environmental data specific to Mudayna available, studies from other sources in the area will be utilized. The two strongest arguments for considering the environment around Mudayna as good lie in Wadi ath-Thamad's

geology and paleoenvironmental studies done in association with the Hesban excavation, 30 km northwest of Mudayna.

As mentioned in Chapter two, Mudayna is situated at a section of Wadi ath-Thamad characterized by the appearance of a number of alluvial fans that are excellent, flat, agricultural/pasture fields. These fields would have provided a rich seasonal pasturage for the sheep and goats around Mudayna after harvest. During the winter months, when all of the annual rainfall occurs, abundant high quality natural pasturage becomes available. Studies around Hesban have determined that during the Iron Age “better pasture conditions for cattle and sheep were found than can be found today” (LaBianca 1990: 141). Also “the biotic environment of the past was significantly more luxuriant and abundant” (La Bianca and Lacelle 1986: 145). The general climate around Mudayna is not thought to have changed much since the Iron Age (LaBianca 1990: 141), indicating that the temperature would not have been more or less suitable for sheep and goat raising in the past than it is now. A third source that indirectly states that the environment around Mudayna, or at least of ancient Moab in general, was excellent for raising sheep and goats is the Bible. Mesha, a ninth century B.C.E. Moabite king is referred to, in Kings II 3:4, as a “sheepmaster” who presented as tribute to Israel “an hundred thousand lambs, and an hundred thousand rams, with the wool”. The numerical accuracy of the biblical statement may be argued but the fact that, generally, Moab was thought to have a good environment for raising sheep and goats is clear. It is reasonable, then, to assume that Mudayna’s climate may be considered ‘good’ from Redding’s theoretical perspective.

The sheep/goat ratio of 1.45:1 at Mudayna indicates that the primary concern of the herder was herd security, rather than energy (calories or protein) optimization. Zeder (1991: 37), on the other hand, states that because goats reproduce more rapidly than sheep, a higher ratio of goats should be found if the herder is interested in herd security. Zeder (1991: 37) indicates that she is basing her optimal ratio on information provided in Redding 1981: 79-80, 181. The references Zeder provides are confusing, however, as none of the pages she cites discuss either sheep or goat fertility rates. Assuming that she accidentally mislabeled her references, her optimal herd composition of more goats to sheep still does not apply, according to Redding (1981: 271), when good environmental conditions are present. Only when conditions are very hot and arid, when less quality pasture is available, will an optimal sheep/goat ratio favour goats. Zeder’s confusion likely results from a misinterpretation of Redding’s data.

Redding (1981: 271) realizes that goats reproduce more rapidly than sheep and considers this when constructing his 1.74:1 ideal sheep/goat ratio. If herd security was the primary goal, the herder would be best served with a 1:1 ratio of sheep/goat to guard against any taxon-specific

disease the herd may encounter. However, precisely because goats multiply faster than sheep, they will recover from a crisis more quickly than sheep. It turns out that, reproductively, one goat is equal to 1.74 sheep (Redding 1981: 271). Therefore, a ratio of 1.74 sheep to 1 goat is the ideal ratio for herd security when the environment is 'good' and favours neither sheep nor goats.

Based on other lines of evidence presented below, it is apparent that the primary concern of herders at Mudayna was herd security and that the distribution of the animals was performed directly from the herders to the consumers. When a direct distribution system is operating "the proportions of the different domestic species consumed should approximate the proportions in which these animals are found in locally managed herds" (Zeder 1991: 38). It can be safely assumed then, that the sheep/goat ratio seen in the Mudayna remains reflects the actual herd structure operating around Mudayna in the Iron Age, and not just the depositional ratio at the site.

The second line of evidence considered is the age at death of the sheep and goats. The epiphyseal fusion data show a relatively steady decline in the number of sheep and goats in each age category and do not show a major culling event. The dental wear data, on the other hand, show a large percentage of the herd was killed when they were approximately three years old. Likely, a large number of juveniles (mostly male) were also killed, and died naturally, but because immature bones preserve less frequently than mature bones, the juveniles are underrepresented in the archaeological record.

Redding predicts that when herd security is the primary goal, males between the ages of six months and two years will be killed most frequently (Redding 1981:305) but when energy maximization is the goal, males will be slaughtered between two and three years of age. A survivorship curve that Redding produced (Redding 1981: Figure X-19) shows that, for both herd security and energy maximization models, the percent survivorship of the herd steadily declines until 36 months of age is reached. By around 42 months of age, the percent survivorship of the herd is predicted to be approximately 25%. The survivorship curve produced from the dental wear data at Mudayna (Figure 5.2) generally reflects Redding's curve but the Mudayna curve has a sharper downturn at around 36 months of age.

Zeder (1986: 97) follows Redding's predictions and notes that if herd security is reflected in the archaeological record, then likely a direct distribution system was in operation. When animals are distributed by the herder in a direct fashion, rather than through a centralized indirect operation, the concerns of the herder for herd security will guide the exchange to a greater degree than the demands of the consumer (Zeder 1986: 97). Zeder (1988: 12) also suggests that a greater variety (age, sex and species) of animals, will be found at the site when

direct distribution occurs as animals that are killed prematurely, due to illness or ritual, and animals that die accidentally will be available for immediate consumption.

In light of Redding's and Zeder's predictions, how may the Mudayna figures be best interpreted? The sex and fusion state of the pelvises recovered from Mudayna offer an important insight. From an admittedly small sample (16), only 44% of the male pelvises were fused, the other 56% of the male pelvises were immature (less than one year old). By comparison, 92% of the female pelvises from Mudayna were fused and so lived past their first year of life.

Because half of the male sheep and goats at Mudayna were killed in their first year of life, herd security was the most important goal of the herder. If the herder was after energy maximization, the males would not begin to be culled until the second and third years of life. The abundance of specimens recovered from Mudayna that represent animals in their third year of life are likely made up mostly of females culled to provision the non-herding residents of Mudayna. Specimens representing all age groups are recovered, a phenomenon Zeder (1991: 40) associates with a direct distribution system. According to the percent survivorship data of sheep and goats from Mudayna, the herding system was direct to consumer and primarily interested in the security of the herd.

The third line of evidence to be considered is the female/male ratio of sheep and goats found at Mudayna. As previously mentioned, Redding (1981: 283) has determined that, when energy maximization is the herder's prime concern, the female/male ratio of sheep will be 32:1 and the female/male ratio of goats will be 99:1. When herd security is the prime concern, however, the female/male ratio of both species will be much closer to 1:1. Because a single male may impregnate many females, there will always be more females in the herd than males. Additional males, kept past a prime slaughter age of two or three years, will not increase the fertility potential of the herd but will present additional competition for pasture, reducing the health of the females (Redding 1981: 281). Increased sedentism of herds enhance the dangers of disease and parasitism within the flock (Redding 1981: 290). The herds around Mudayna stayed within the area, spending the night in a fold, because it offered a good water supply, decent pasturage and protection from raiders. To counteract the effects disease may have on a herd, the herder will increase the number of males to safeguard against their destruction.

The combined female/male sheep and goat ratio at Mudayna is 4:1. The ratios for the individual species are slightly different with sheep at slightly less than 4:1 (3.55:1) and goats at approximately 6:1 (5.67:1). The ratio of female/male sheep and goats at Mudayna clearly suggest that the herder was primarily concerned with herd security rather than energy optimization.

The final two lines of evidence, animal part distribution and relative bone density, are considered together as they are interrelated. An analysis of the %MAUs and the MGUIs showed that there was no significant correlation between the two at Mudayna. Tables 5.5 and 5.6 emphasize the lack of correlation showing that the percentages of 'meat-rich' and 'meat-poor' bones found at Mudayna were roughly equal. A weak positive correlation was found between the %MAUs and the scaled density figures of the sheep bones found at Mudayna, signifying that some differential destruction of the less dense skeletal elements took place at the site. Because no correlation was found between %MAUs and MGUIs, the destruction is best explained by carnivore ravaging rather than by a reverse utility (high numbers of low MGUI bones) profile. Evidence of carnivore ravaging is seen on many skeletal elements from Mudayna, positively indicating that it did take place. What does the above evidence signify in terms of herding strategy and distribution systems?

Zeder (1991: 43) suggests that when high MGUI and low MGUI sections of the skeleton are found in equal numbers, as was the case at Mudayna, a direct distribution system was at work. A direct distribution system usually results from relatively small scale herding operations where herd security is the primary goal of the herder.

The previous discussion was based around theories developed to explain the patterns of sheep and goats seen when meat was the primary product being harvested. Sheep and goats also produce milk and wool/hair (sheep produce wool while goats produce a more rugged fiber that can be woven into waterproof tents), products that may have played an important role in Mudayna's economy. The production of milk will be discussed first.

Redding (1981) considered the value of milk production for pastoralists when he developed his predictions of herd management. Redding's predictions concerning the ideal ratio of sheep/goats included the nutrients that each species' milk provides along with the nutritional value of its meat, (Redding 1981: 243) so the sheep/goat ratio does not change. Redding also calculates that the sex ratio and the age structure of the herd will not change due to milk production unless milk is being produced for a very large market (Redding 1981: 299). In a situation where milk is the ultimate concern, males aged 2-3 months may be killed once the milk yield of their mother is secure. Redding (1981: 299) argues that if the males are weaned, rather than killed, at 2-3 months, the milk harvest is not much reduced and the meat yield is much more substantial. Milk production, then, should not change either the sex ratio or the age structure of the herd dramatically.

The effect that wool/hair production will have on the herd is harder to measure because very little data that may help form a predictive model have been collected. Redding (1981) did

not include the harvest of wool/hair from sheep and goats in his predictive models. He assumes, instead, that groups practicing “a mixture of herding and agriculture, and maintaining their flocks for subsistence, can obtain sufficient wool/hair to satisfy their requirements plus an excess that may be used in local exchange” (Redding 1981: 48). He concludes that fiber production will not affect herd structure. In her study of the faunal distribution system in place at Tell Drehem, a large Early Bronze Age site in Mesopotamia, Zeder (1986) focused on meat distribution and only mentions wool production incidentally. Zeder (1986: 78) states that wool production may have been so intensive during the period that special herds, and potentially special breeds of sheep were developed. The biblical reference (Kings II 3:4) to Mesha as a ‘sheepmaster’ who supplied the wool of one hundred thousand sheep to Israel, while almost certainly an exaggeration (Miller 1997: 195), indicates the importance of wool to the Moabite economy. If the production of wool/hair was a major undertaking around Mudayna, one would expect that the herders would have managed a wether flock (a flock that includes a number of castrated males). Payne (1973: 284) suggests that the survivorship curve of a wether flock would show a large percent (at least 50%) of the herd living until they were over six years of age. Animals would not be slaughtered until the quality of their wool/hair began to deteriorate or their reproductive success faltered. He further suggests that the ratio of males and females within the flock would be quite even although most of the males would be castrates, kept for their wool/hair. Neither the survivorship curve nor the female/male ratio indicates that a wether flock was in existence at Mudayna. So while wool and hair production was certainly an important part of Moab’s economy, it does not appear to have altered the herd management strategy or distribution system employed at Mudayna. The population of Mudayna undoubtedly utilized the meat, milk and wool/hair from their herds, meaning that the various ratios of species, sex and age produced from the archaeological remains reflect a combination of all of these uses. The models proposed for meat production and distribution, however, are best suited for the interpretation of the Mudayna sheep and goat remains.

When all of the above sheep and goat faunal evidence is considered, two very strong arguments are formed that 1) the herders around Mudayna were primarily concerned with herd security and 2) the distribution system that supplied meat to the population of Mudayna was direct to consumer. A direct distribution system, supplying meat to a public area of the site where soldiers, craftsmen and priests were working, and perhaps living, indicates the citizenry of Mudayna did not have their daily lives (especially areas of food procurement and herd management) controlled by a central administrative system. No central kitchen supplied meat to the soldiers occupying the gate. The craftsmen using the looms and the pottery kilns (Figs. D-16,

D-17) in the gate rooms obtained meat from the local herders, not from a state controlled, or even locally run butcher shop. The meat sacrifices offered at the shrine were likely butchered and consumed by the local population in the immediate vicinity. Because the herders did not employ a strategy of energy maximization, it is unlikely that the herds around Mudayna were being used to provision other Moabite sites in the region. All of these things suggest that the population of Mudayna was very rural and relatively small, lacking any central control over its daily operation, particularly in the area of food procurement.

It has been argued that a fortified site such as Mudayna would have acted as a regional administration center (Dearman 1989: 171). Why then, do the sheep and goat data not reflect a centralized administrative control over the distribution of food resources? The following two chapters present a summary of the remaining faunal data and offer a synthesis of these data within the known historical context of Iron Age Moab, in an attempt to explain the faunal patterns witnessed in light of the economic and socio-political climate of Iron II Moab.

Chapter 6

Identification of Rare Specimens, Small Mammals, Birds and Fish

6.1 Introduction

This chapter briefly discusses the identification and significance of the rare specimens recovered from Mudayna. Birds, small mammals and fish are all included within the 'rare' category as so few of them were recovered from Mudayna. I have previously discussed the lack of complete screening at Mudayna and believe that the near absence of microfauna is primarily linked to this policy, and is not a reflection of the actual amount of microfauna present at Mudayna. Because complete screening is a practical impossibility at a large site like Mudayna, the best solution for determining how much microfauna is actually lost during excavation is the implication of a selective screening test. One square could be fully screened and the amount of microfauna recovered from that square could act as an indication of the expected amount of microfauna from the rest of the site. A selective screening solution is not ideal, but it would at least provide a reference from which an estimate of bias could be established.

Along with the bird, small mammal and fish remains, the scant canid, pig, and equid finds are presented and discussed. The identifications of the camel, deer and gazelle material have been considered in Chapter four and so will only be mentioned in a general way. The finds of the cattle are considered in relation to their role as both meat and dairy providers as well as traction animals for the surrounding fields.

6.2 The Bones

6.2.1 Equids

Three mandibular molars and a small portion of mandibular bone represent the equid remains from Khirbat al-Mudayna. Two of the teeth were found within mandibular bone and the third tooth was an isolated find, located, however, in close proximity to the first two teeth. An age of death for the two associated molars is estimated at between two and four years old (Butler et. al. 2000: 386) as the third molar had not fully erupted and is unworn.

The teeth have been identified as *Equus asinus* using criteria described by Davis (1980a: 293-294). The first criterion, for mandibular teeth, that Davis presents is the depth to which the buccal fold penetrates between the metaflexid and the entoflexid towards the lingual fold (Davis 1980a: 293). Neither of the Mudayna specimens' buccal folds showed any penetration, a trait typical of both *Equus asinus* and *E. hemionus*. Horses (*E. caballus*) display intermediate penetration where the buccal fold does not reach all the way to the lingual fold but it does penetrate between the metaflexid and entoflexid. The second criterion studied was the shape of the lingual fold. The fold is 'V' shaped in *E. asinus*, *E. hemionus* and *E. hydruntinus* but 'U' shaped in *E. caballus* (Davis 1980a: 293). The lingual fold of both Mudayna specimens is 'V' shaped. A third criterion that Davis mentions, but one which he says is "probably not a good discriminant" (Davis 1980a: 294), is the curvature of the external walls of the protoconid and hypoconid. The walls are said to be relatively flat in *E. caballus*, *E. asinus* and *E. herionus*, a condition that appears on both of the Mudayna specimens.

The morphology of the equid mandibular molars make it certain that they are either from a domestic ass (*E. asinus*) or, less likely, a wild onager (*E. hemionus*). Davis (Davis 1980a: 297) recognizes that these two species can not be reliably differentiated on the basis of dental morphology. The probability that the bones of an ass would be recovered from an Iron Age site in central Jordan is much greater than the recovery of onager bones. The identification of six *E. hemionus* bones was tentatively made at Hesban, though none dated to the Iron Age, along with the certain identification of 71 *E. asinus* bones (15 from the Iron Age). The identification of the equid material as *E. asinus* is presented with reservation, however, as there is a slight chance the teeth could represent *E. hemionus*.

6.2.2 Pigs

A single fragment of a pig (*Sus scrofa*) molar is the only evidence that pigs were present at Mudayna. It is not uncommon for both wild and domestic pigs to be found at sites during the Iron Age in the Near East (Uerpmann 1987: 41). Pigs are wonderful supplementary sources of meat because they have a fast reproduction and growth cycle, they have a large number of young every litter and their meat is particularly high in caloric value (Zeder 1991: 30). Because pigs seem to offer a number of attractive qualities for production, their near absence at Mudayna must be explained.

Zeder (1986: 84-85, 1991: 30-32) provides several arguments for why large-scale pig production is not more common in the Near East and clarifies situations where it is likely pigs would be raised. A fundamental problem with raising pigs in a relatively arid environment like

Mudayna's is that pigs must be permanently supplied with water. Pigs have poor osmoregulatory abilities meaning they lack the ability to concentrate their urine (Wilson 1989: 68). The ability to concentrate urine is a function of the kidney. The ratio of the thickness of the kidney's medulla to that of its cortex has been used as an index of an animal's ability to concentrate its urine, thereby storing water (Wilson 1989: 85). The kangaroo rat, a desert mammal, has a medulla:cortex index of 8.5 whereas the pig has a very low medulla:cortex ratio of 1.6 (Wilson 1989: 68). Another physiological problem with raising pigs is that they can not digest cellulose-rich pasture plants (Zeder 1991: 30), but must be fed other materials, entailing more intensive care from the herders than sheep or goats require.

Intensive care for pigs is also necessary because they require constant watching. Pigs are more "quarrelsome" (Zeder 1991: 31) than sheep or goats and may do each other serious harm if left unattended. They also have a tendency to overheat when kept in a crowded large-sty situation. If a household chooses to maintain a few pigs in a small sty, raising them is not difficult. Studies have shown that in the Near East urban households typically raise pigs on a small scale to provide supplementary meat for the family (Zeder 1986: 85). So, while pigs are commonly found at larger, urban settlements, they are less frequently found at neighbouring rural sites (Zeder 1986: 85). If pigs are found at urban centers their remains are usually associated with household refuse and are rarely found in public or temple areas (Zeder 1986: 85). Zeder (1991: 31) also notes that pig raising was more common during times when the political situation of the country was in flux and little central power was established.

Mudayna was a regional center but lacked the size to be considered truly urban. It may best be classified as a regional outpost, rather than a town site. According to Zeder's research, pig raising was not common at sites like Mudayna. The few pigs that were raised at Mudayna were almost certainly done so on a small scale and consumed by the family rather than sold or traded for income. More pig remains may be found at Mudayna, but they will probably be associated with domestic refuse, rather than located in public areas like the gate complex or the shrine courtyard. In any case, pigs did not play an important part in Mudayna's economy.

6.2.3 Canids

A single, lower left canid canine is the only direct evidence that canids lived at Mudayna. The tooth itself is from a medium-large canid, but certain identification beyond that is impossible. In all likelihood, the tooth is from a domestic dog that lived at the site, but this can not be morphologically proven. Abundant indirect evidence for the presence of canids living at

Mudayna exists in the form of bite and scrape marks, as well as digestion marks, on many of the other faunal specimens. More canid remains are assuredly located at Mudayna but, like the pig remains, are not to be found within public areas such as the gate complex or the shrine courtyard. They are more likely buried in less conspicuous areas of the site.

The ancient populations of the Near East, in all periods, buried dead dogs. Excavations at Hesban discovered dog burials in strata associated with periods ranging from the Iron Age to the Late Mamluk (von den Driesch and Boessneck 1995: 73). Researchers have speculated about the existence of dog cults at Hesban during the Iron Age (von den Driesch and Boessneck 1995: 74), but nothing has ever been proven. There is certainly no evidence of this type of activity at Mudayna.

6.2.4 Cattle

Cattle (*Bos taurus*) played an important part in Mudayna's economy. They were used primarily as draft animals (Figs. D-14, D-15) in the fields around Mudayna but were also used as a source of meat when the opportunity arose. A complete list of *Bos taurus* MNE, MAU and %MAUs are located in Appendix B. Though the number of cattle owned by the population around Mudayna was much smaller than the numbers of sheep and goats (sheep/goat NISP = 1423; cattle NISP = 103; sheep MNI = 14; goat MNI = 10; sheep/goat MNI = 34; cattle MNI = 4), cattle supplied a relatively large amount of meat. When one compares the weight of the bones recovered from the three species, a measure that is related to the body weight and amount of meat available (von den Driesch and Boessneck 1995: 76), the importance of cattle as a meat source becomes obvious (total sheep/goat = 11202.5 g; cattle = 4116.4 g).

Measurements taken on the cattle bones found at Mudayna are compared with measurements provided for Iron Age cattle bones recovered from Hesban in Table 6.1.

Table 6.1 Comparison of some Mudayna and Iron Age Hesban cattle measurements

a) Tibia	Hesban	Hesban	Mudayna			
Bd	52-53 mm	52-53 mm	53.30 mm			
b) Metacarpal	Hesban	Hesban	Hesban	Hesban	Mudayna	
Bp	55 mm	57 mm	56.5 mm	48 mm	54.06 mm	
	Hesban	Hesban	Hesban	Mudayna		
Bd	55 mm	57 mm	57 mm	66.72 mm		
c) Metatarsal	Hesban	Hesban	Hesban	Hesban	Mudayna	Mudayna
Bp	42-43 mm	46-47 mm	50-51 mm	52-53 mm	42.30 mm	44.70 mm
Bd	Hesban	Mudayna	Mudayna			
	46-47 mm	55.13 mm	50.40 mm			

Measurements of Mudayna and Hesban cattle first phalanges are compared in Figure 4.9. The measurements shown in Table 6.1 show that the cattle from Mudayna were approximately the same size as the cattle found at Hesban during the same period. The cattle recovered from Iron Age Hesban have been described as “medium size” (von den Driesch and Boessneck 1995: 75), a general designation that also applies to the cattle from Mudayna. The only measurement in Table 6.1 that is outstanding is the measurement of the Mudayna distal metacarpal (Bd). At 66.72 mm it is much larger than even the male Iron Age Hesban distal metacarpals. The large Mudayna distal metacarpal is similar in size to two large distal metacarpals from the Mamluk period at Hesban (von den Driesch and Boessneck 1995: Figure 5.5). On average, at Tell Hesban, the cattle from the Mamluk period were smaller than the cattle from any other period. There were, however, several conspicuously large cattle bones (like the two large distal metacarpals similar in size to the Mudayna specimen) punctuating the Mamluk period that are thought may represent imported zebus (*Bos indicus*) (von den Driesch and Boessneck 1995: 78). It is possible that the large distal metacarpal found at Mudayna represents an early zebu specimen (Clason, A. 1978: 93; Buitenhuis 1984: 216), but at the same time it may represent an aurochs (*Bos primegenius*), a species that was found at Hesban during the Iron Age (von den Driesch and Boessneck 1995: Table 5.21). Unfortunately, it is not possible to assign this specimen to a species with certainty.

Cut marks are found on 10% of the cattle bones or roughly half as often as were found on the sheep and goat bones. Not one of the cattle bones with cutmarks was immature indicating that cattle were only eaten after they were no longer useful as draft animals. Immature cattle would have been consumed, of course, if they were killed accidentally or showed some initial stages of illness. Because cattle were the “most valuable domestic animals” (von den Driesch and Boessneck 1995: 72), it was more economical to use sheep and goats (and possibly pigs) as a consistent source of meat and use cattle for their milk and labour potential. It was not until cattle became an economic deficit, consuming more than they contributed, that they were slaughtered.

6.2.5 Birds

Only nine bird bones were recovered from Mudayna. Of those, two humeri, one tarsometatarsus, one coracoid and one skull fragment were too incomplete to be identified to species. A third humerus was found that is the size of a crane (*Grus grus*) but too incomplete for identification to be certain. The remaining three bones, one humerus, one carpometacarpus and one coracoid may be positively identified at least to the family level (Fig. D-7).

A left carpometacarpus of an eagle (*Accipitridae*) was recovered. The identification of this specimen has been narrowed down to either an Eurasian short-toed eagle (*Circaetus gallicus*) or a steppe eagle (*Aquila nipalensis*). Identification of the Mudayna specimen is based on a photograph and measurements presented for an eagle carpometacarpus recovered from Hesban (Boessneck 1995: Plate 8.4). The size of the bone (GL 85.2, Bp (19)) is slightly smaller than the specimen found at Hesban (GL 86.4, Bp 21). Morphologically it is very similar save that the symphysis between metacarpal II and metacarpal III is tighter in the Mudayna specimen. Boessneck narrowed the identification of the Hesban eagle carpometacarpus down to three contenders, the two possibilities mentioned above and a spotted eagle (*Aquila clanga*) before deciding that the Hesban specimen likely represents a spotted eagle (Boessneck 1995: 138). The morphological differences between the Mudayna eagle and the Hesban specimen rule out the possibility that it could be a spotted eagle, leaving only the steppe eagle and the short-toed eagle. Without access to comparative specimens of either of these birds, more specific identification of the Mudayna eagle carpometacarpus is not possible.

The last two bird bones found at Mudayna have been identified as pigeons (*Columbidae*). Measurements from the two specimens are shown in Table 6.2 compared with several measurements taken on the domestic pigeon (*Columba livia domestica*) and the rock dove (*Columba livia*) bones found at Hesban. Both of the Mudayna specimens are within the size range of the Hesban *Columba* bones, but are on the smaller end of the spectrum. Boessneck (1995: 148) notes that some of the smallest measurements from the Hesban pigeon bones may be explained by the presence of a small rock dove subspecies (*Columba livia gaddi*) in the area. It is possible that the Mudayna specimens belonged to this subspecies. Boessneck also notes “it is superfluous to try to distinguish between the domestic pigeon and its wild ancestor, the rock dove” (Boessneck 1995: 147), so identification of the Mudayna specimens was not pursued beyond that of *Columba livia*. Direct comparison of the Mudayna specimens with *Columba livia*

Table 6.2 A comparison of measurements from domestic pigeon and rock dove bones from Hesban with measurements from two Mudayna specimens (measurements from Boessneck 1995: Table 8.22)

Coracoid	Hesban	Hesban	Hesban	Hesban	Hesban	Hesban	Hesban	Mudayna
GL	-	34.4	-	<38.7>	36.7	-	31.8	33.26
Lm	-	32.7	31.5	36.7	34.8	<30.5>	30	31.5
Bb	14	13.5	-	-	-	-	12.9	-
BF	10	8.8	-	<11>	<10.8>	-	8.7	8.8
Humerus	Hesban	Hesban	Hesban	Hesban	Hesban	Hesban	Hesban	Mudayna
GL	45.5	43.5	47.5	46.5	47.2	42	50	42.7
Bp	18.3	16.8	19.7	19.7	19.9	-	20	17.9
SC	4.8	4.5	5.7	5.5	5.8	4.9	5.5	5.05
Bd	10.6	9.7	11.7	11.5	11.8	<10>	11.8	<9.8>

bones confirmed that the Mudayna specimens represented *Columba livia* sp. The only other option for the identification of the Mudayna bones, based on measurements, was the collared turtle dove (*Streptopelia decaocto*). This possibility was ruled out, however, after direct comparison with *Columba livia* was performed.

The two pigeon bones recovered from Mudayna do not provide enough evidence to say whether the population were breeding pigeons, or whether wild pigeons were simply building their nests within the buildings at the site. The latter scenario was certainly taking place even if active pigeon breeding did not occur. Cutmarks are not found on either of the bones, so no evidence that the population of Mudayna was using the pigeons as a food source exists.

6.2.6 Fish

Only two fish bones, a left dentale and a right premaxilla, were recovered from Mudayna (Fig. D-9). Both of these bones represent members of the fish family *Sparidae*, commonly known as sea bream. Identification of these bones was possible by comparison with photographs and measurements published of *Sparidae* remains found at Hesban (Lepiksaar 1995: 187). Table 6.3 lists the measurements of both the Hesban and the Mudayna *Sparidae* remains. Lepiksaar (1995: 187) has tentatively identified the eleven *Sparidae* jaw bones found at Hesban (five of which were recovered from Iron Age strata) as being from the gilthead (*Sparus auratus*), a Mediterranean species. His identification is tentative, however, as there are species of *Sparidae*, of approximately the same size as the gilthead, living in both the Mediterranean and the Red Sea (*Argyrops spinifer* (Baranes and Golani 1993: 308) for example) that he was unable to access for comparison. Assuming that the *Sparidae* from Hesban really do represent the gilthead, a species whose “meat has been highly valued since the classical times” (Lepiksaar

Table 6.3 Measurements of Hesban and Mudayna Sparidae finds (adapted from Lepiksaar 1995: Table 9.29)

Site	Bone	Greatest length (mm)	Estimated total fish length (cm)
Hesban	Premaxilla	24	35
Hesban	Premaxilla	27	40
Hesban	Premaxilla	24	35
Hesban	Premaxilla	28	40
Hesban	Premaxilla	31.5	45
Mudayna	Premaxilla	26.9	40
Hesban	Dentale	34.3	45
Hesban	Dentale	29	40
Hesban	Dentale	25.8 +	35
Hesban	Dentale	31.5	40
Hesban	Dentale	26	35
Mudayna	Dentale	25.6 +	35

1995: 187), it is likely that the *Sparidae* from Mudayna also represent this species.

The jawbones of the *Sparidae* are relatively dense because of the presence of large molaroid teeth. The toughness of the bone increases its resistance to density mediated taphonomic process, such as trampling or carnivore gnawing (prevalent at Mudayna), aiding its preservation. Lepiksaar (1995: 187) believes that because the jawbones of the *Sparidae* are so resistant to destruction, the MNI estimated for the fish at Hesban is realistic. With an MNI of two at Mudayna, it is obvious that the *Sparidae* did not play a major role in the economy of the site. The fact that the fish were found at Mudayna at all, however, reminds us that Mudayna was located on a secondary north-south trade route (Dearman 1989: 192-193) and would have seen travelers and traders from both the Mediterranean and the Red Sea frequently pass by its gates.

6.2.7 Tortoise

A single immature left humerus of a *Testudo graeca terrestris* was recovered from Mudayna. Two subspecies of *Testudo graeca* are found in the Levant, *T. g. terrestris* and *T. g. ibera*. The small size of the humerus found at Mudayna indicates that it came from the smaller *T. g. terrestris*. Tortoises are used for their meat as well as their shells. A hypoplastron was recovered from an Iron Age stratum at Hesban with a hole drilled through it beside the median suture (Boessneck 1995: 161). Boessneck suggests that the hypoplastron may have served a household function. The tortoise did not play a major role in Mudayna's economy, but it was used by the locals when the opportunity arose.

6.2.8 Small mammals

Several small mammal bones were recovered at Mudayna, some were identifiable to the species level, others to the family level and some only received a size class designation (SC1 or SC2). Unfortunately, because so few small mammal remains were recovered, they are not useful as environmental or economic indicators. They are listed here simply as a nod towards zooarchaeological holism.

6.2.8.1 Mongoose

A single right scapula of a mongoose (*Herpestes ichneumon*) was recovered at Mudayna (Fig. D-5). Identification of this specimen was made after seven other possible contenders, the rock hyrax (*Procavia capensis syriacus*), badger (*Meles meles canescens*), ratel (*Mellivora capensis*), weasel (*Mustela nivalis*), marbled polecat (*Vormela peregusna syriaca*), Syrian beach marten (*Martes foina syriaca*) and the porcupine (*Hystrix indica*), were ruled out because of size

or morphological differences. The weasel, polecat, beach marten, and porcupine were all too small, while the ratel was too large. The rock hyrax was ruled out through morphological considerations. The badger was the second closest candidate but it was slightly too large and direct comparison with a badger scapula showed that morphologically the specimens were not similar. The badger has a large curving projection at the distal end of the infraspinous border while the Mudayna specimen has a smaller, non-projecting, tubercle. Also the spine of the badger's scapula does not approach the glenoid cavity as closely as the Mudayna specimen's. Comparison with a diagram and a greatest length (GL 73.5) measurement of a mongoose published in Walker (1985: 19) showed that both morphologically and metrically the Mudayna specimen (GL 72.7) was a direct match for a mongoose. The mongoose, an animal admired by the Egyptians, is easily tamed and often kept as a pet to kill rodents and snakes (Harrison 1968: 263). It is possible that the mongoose found at Mudayna served just this purpose.

6.2.8.2 Hedgehog

The right mandible, containing three molars and the last premolar (Fig. D-6), and a long bone shaft of an *Erinaceus europaeus concolor* was recovered from Mudayna. The *Erinaceus europaeus* is one of three species of hedgehog found in the area including *Hemiechinus auritus* and *Paraechinus aethiopicus* (Tchernov 1994: 40). Identification of the hedgehog to species was made by comparing the shape of the last lower premolar (pm2) of the specimen with a diagram, published by Harrison (1964: 16), of same tooth for each of the hedgehog species in the Levant. The pm2 of *Erinaceus europaeus* has an elevated, tritubercular crown with a distinct internal metaconid (Harrison 1964: 15) that the other two species lack.

Interestingly *Erinaceus europaeus* is the least likely of the three hedgehog species to be found at Mudayna today because it is "unlikely to penetrate much into the arid regions" (Harrison 1964: 16), while the other two hedgehogs are more suited to desert life. The environment of Iron Age Mudayna would certainly have been more suitable for the *E. europaeus* than the environment today, but one of the other two species of hedgehog would still have fared better in a physiological sense (Shkolnik 1988: 489) as their metabolic rates are more adapted to a hot, dry climate. It is possible that the *E. europaeus* specimen was brought to Mudayna as someone's pet and did not live in the area at all. At the same time *Erinaceus europaeus* is often found in agricultural land (Harrison 1964: 16) so the fields surrounding Mudayna may have provided enough small prey (*E. europaeus* is insectivorous) to attract the hedgehog.

6.2.8.3 Mouse

Two mouse (*Mus musculus*) crania, one mandible and several limb bones were preserved at Mudayna. Identification of the specimen was made by comparing the teeth with a photograph and a diagram of *Mus musculus* teeth published in Harrison (1972: 473, 474). The only unusual thing about the appearance of *M. musculus* elements at Mudayna is that somehow they were recovered during excavation, a fate most microfauna likely did not share. *Mus musculus*, a dedicated commensal species, may be found at almost every long-term habitation site. It may have been the presence of families of mice at Mudayna, nibbling on the cereal crops produced, that inspired one resident to enlist the aid of the mongoose recovered in an attempt to keep the rodent population under control.

6.2.8.4 Gerbil

A single, apparently intrusive, fat jird (*Psammomys obesus*) partial skeleton including the cranium and right mandible was recovered from Mudayna. The specimen was found in an upper locus (its burrow was destroyed during excavation), and retains some soft tissue staining that reveals its recent deposition. The fat jird is a burrowing colonial species that “favors light soils and in particular low sandy mounds surrounding salty, succulent desert vegetation” (Tchernov 1994: 42). This species, unlike *Mus musculus*, is independent of man and its appearance at the site has no cultural significance. The Mudayna specimen is a recent deposition but *Psammomys obesus* has been found in the region throughout the Holocene (Tchernov 1994: 42) and perhaps longer. Several other (at least four) Cricetidae (hamsters, gerbils and voles) specimens were recovered from Mudayna but due to a lack of comparative material, identification has not yet been possible.

6.2.9 Camels

Two camel bones were found at Mudayna, a partial 1st phalanx and a left scapula. Camel remains are found at Levantine sites as early as the Early Bronze Age (3150-2200 B.C.E.) (Hakker-Orion 1984: 207) but it thought that these finds represent wild camels, or perhaps are intrusive. It is not until the Iron Age (1200-586 B.C.E.) that domestic camel bones are found with any frequency (Hakker-Orion 1984: 210). Wapnish (1984: 171) attributes the increase of camel bones found at archaeological sites in the Levant during the Iron Age to the Assyrian presence in the region. During the ninth century B.C.E., when the Assyrians first had contact with the population of Tell Jemmeh, Israel, the number of camel bones found at the site rose slightly. By the seventh century B.C.E., the Assyrians had a much stronger presence at Tell Jemmeh (Jemmeh was aiding the Assyrians with Egyptian invasions) and it was at this time

when the “first sizeable increase in numbers of camel bone fragments occurs” (Wapnish 1984: 171). It is possible that the camel bones found at Mudayna are also related to Assyrian caravan movements.

Camels are not raised for their meat but rather for their milk and transportation potential (Kohler 1984: 202). Camel reproduction is too slow to make raising them for slaughter, like sheep or goats, economically viable. Male camels are often killed at birth because they consume valuable milk and can not be used as pack animals until they reach four years of age (Kohler 1984: 202). Female camels, on the other hand, are only slaughtered if they are discovered to be infertile, become sick or reach an age when they are no longer useful as reproducers or pack animals. The camel 1st phalanx found at Mudayna is from an aged individual (heavy muscle attachments and a bone spur are seen on the bone) and two cutmarks are present on the proximal end of the bone. It is likely that this individual was a member of a trading caravan who became sick or injured *en route* and was sold and slaughtered at Mudayna. If camels were being raised at Mudayna then one would expect to find immature male camel bones and more mature female specimens than are found at the site.

6.2.10 Deer

The identifications of the deer specimens were discussed in Chapter four and will not be reviewed here. The only species of deer present at Mudayna during the Iron Age was the Persian fallow deer (*Dama mesopotamica*), though there were two cervid specimens unidentifiable to species. *D. mesopotamica* was also the only species of deer found at Hesban during the Iron Age (Boessneck and von den Driesch 1995: Table 5.21). Eight *D. mesopotamica* specimens were found at Mudayna weighing a total of 87.2 grams. Even when the 10.8 grams of unidentified cervid bone is added to this amount, the total of 98 grams is only impressive in its minuteness relative to the weights of sheep/goat and cattle bone found at the site (11202.5g and 4116.4g respectively). It is clear that deer did not make up a significant portion of the diet at Mudayna.

The fact that fallow deer were found at Mudayna at all is an indication that the surrounding countryside was more lush than it is today. Presently, the landscape around Mudayna does not support any type of deer and has not for at least 100 years. The problem, as Boessneck and von den Driesch (1995: 111) point out, is not one of climate change but rather one of environment change. Deforestation of the countryside, along with increased agricultural activity and hunting by humans has extirpated the deer population. By the middle ages the red deer (*Cervus elaphus*) population in Jordan was effectively gone and the fallow deer had been greatly reduced in numbers (Boessneck and von den Driesch 1995: 113). The fallow deer found

at Mudayna may be evidence of small-scale (family or individual), planned hunting excursions, opportunistic kills, or trade activity. In any case, deer were not significant portion of Mudayna's daily economy.

6.2.11 Gazelles

More gazelle bones were found at Mudayna than deer bones, but gazelles still did not contribute a significant amount to diet of the site. 19 specimens were identified as *Gazella gazella*, three as *Gazella dorcas* and a further five as *Gazella* sp. for a total of 27 gazelle bones, almost double the 16 specimens reported from Iron Age Hesban (von den Driesch and Boessneck 1995: Table 5.21). The weights of the gazelle bones are 127.5g for *G. gazella*, 71.1g for *G. dorcas*, and 32.8g for *Gazella* sp., combining for a total of 231.4g. While over double the weight of the deer remains, the gazelle remains are equivalent to only two percent of the sheep/goat remains. Gazelles were probably acquired by Mudayna's population in the same fashion as deer; through limited hunting, opportunistic kills and trade.

The fact that gazelles are more than twice as abundant at Mudayna than deer (a phenomenon apparent at Hesban as well) indicates that the environment, while rich enough to maintain a deer population, was arid enough that gazelles made it their home. The predominance of *G. gazella* over *G. dorcas* indicate that the environment was closer to Mediterranean than desert as these are (respectively) the environments to which, physiologically, the two gazelle species are best suited (Shkolnik 1988: 492). If one imagines an environmental scale with 'lush Mediterranean' at one end and 'true desert' at the other end, according to the deer and gazelle remains found at Mudayna, the environment around Mudayna during the Iron Age would have been somewhere between one half and two thirds of the way down the scale towards the desert end.

6.3 Conclusions

The presentation of the rare species recovered from Mudayna helps to flesh out the ecological picture of Moab in the Iron Age and at the same time emphasizes the importance that sheep, goats and to a lesser extent cattle played in the daily economy of Mudayna. Combined, the gazelle and deer remains only total around 3% of the sheep/goat remains recovered from the site. Zeder (1991: 39) has postulated that "the degree to which game is utilized by certain consumers may, in fact, be a reflection of the effectiveness of provisioning systems in meeting distribution requirements". If this is the case, it would appear that the direct distribution of sheep and goats from local herders to Mudayna's population was very effective indeed. The

distribution system may have been so effective that the local administration at the site realized that to interfere would be counterproductive. So long as the administration received its due, in the form of whatever taxes or tithes were imposed by the local and 'state' controllers, it was in its interest to stay out of the daily lives of the population as far as herd management and distribution were concerned.

Chapter 7

Conclusions: Mudayna Faunal Remains Considered in their Historical Context

7.1 Introduction

Previously, in Chapter one, several hypotheses developed by LaBianca (1999: 20-23) regarding the nature of the Moabite tribal kingdom were presented. These hypotheses suggested that 1) the “tribal social structure was intimately linked to their way of obtaining food” (LaBianca 1999: 20), 2) the emergence of kings did not extinguish existing tribal social structure (LaBianca 1999: 21), 3) “the emergence of supra-tribal polities did not produce dimorphic social structures on par with those in Egypt and Mesopotamia” (LaBianca 1999: 21), 4) “tribal hinterlands were administered from fortified towns” (LaBianca 1999: 21) and 5) “most people lived in the rural hinterland beyond the towns” (LaBianca 1999: 22). These hypotheses, as well as the specific function (or functions) Mudayna served are examined below in light of the faunal evidence recovered from the site. The faunal evidence from Mudayna has previously, in Chapter five, been interpreted considering Redding’s (1981) and Zeder’s (1986) theories about herd management and meat distribution strategies. These arguments will not be presented again here save to say that the herders around Mudayna were primarily concerned with herd security (ensuring a slow, steady growth of the herd in the face of potential disease and disaster), and practiced a direct to consumer distribution system when providing meat to the population of Mudayna who were not directly involved in food production (soldiers, craftsmen and priests).

7.2 Conclusions

At the end of all of the analysis, certain conclusions may be drawn, both specifically about Khirbat al-Mudayna and generally about how the Moabite tribal kingdom operated in the Iron Age II. When the conclusions presented below are considered it must be remembered that the analysis of Khirbat al-Mudayna is still at a preliminary stage. Because Khirbat al-Mudayna served a number of functions it is useful to describe what it was *not* before an attempt is made to describe what it was. First of all, Khirbat al-Mudayna was not principally a military establishment. Hesse and Wapnish (1985: 16) have outlined several indices that measure the

“military character” of a site. The first index is the ratio of transport animals (equids, camels) to barnyard stock (sheep, goats, cattle and pigs). A military site is expected to have a relatively higher proportion of transport animals to barnyard stock than a non-military site. The paucity of transport animals found at Mudayna suggests that it was not a military site. The second index is the ages at death of the barnyard stock (Hesse and Wapnish 1985: 16). Added to this may be the portions of animals recovered from the site. A military garrison is likely to be supplied market age animals prepared in a central mess. If a central kitchen were in use, one would expect to find the ‘meat-rich’ bones deposited in one area (after consumption) and the ‘meat-poor’ bones deposited in another area, disposed of as kitchen waste. The Mudayna faunal remains showed no difference in the distribution of ‘meat-rich’ and ‘meat-poor’ bones, arguing against the presence of a central kitchen. Herders supplying a garrison would likely be required to use a strategy of energy maximization to provision the troops. The administration running the garrison would require a certain amount of standardized (by age and sex of the animal) meat to be supplied to the kitchen. This was not the case at Mudayna where herders focused on herd security. Only the animals whose deaths would have the least affect on the future security of the herd were culled and supplied to the population of Mudayna. A third index suggested by Hesse and Wapnish (1985: 16) is the frequency of wild game. They suggest that soldiers would have hunted wild game for sport during their leisure time so more of these types of animals will be represented in the archaeological record. Very few deer and gazelle remains were found at Mudayna, arguing that relatively few soldiers were permanently located at the site. None of the indices suggested by Hesse and Wapnish indicate that Mudayna served a specialized military purpose.

Secondly, Khirbat al-Mudayna was not a ‘town’. The site is physically too small (80m x 140m) (Daviau 1997: 223) to have housed a ‘town’ sized population. The northern 50 meters of the site is occupied by the gate complex, shrine and courtyard and much of the southern end of the site appears to be filled by monumental buildings. These buildings have yet to be excavated, but wall lines are visible upon the surface of the site. It is likely that these buildings represent some sort of ‘administrative complex’ rather than mass housing for the herders and farmers working around Mudayna.

Third, Khirbat al-Mudayna was not strictly a supply center for other sites in the region, nor was it a wholly administrative center. Both of these site types function as specialized urban economies and should be represented by an indirect distribution of animals at the site (Zeder 1991: 251), rather than the direct distribution system in use at Mudayna. That is not to say that Mudayna did not function as either a local market or administrative center, but simply that it did not serve either one of these objectives exclusively.

If Mudayna was not strictly a military, supply or administration site, and it was not a town, then how may it be best described in light of the faunal remains? The most accurate way to think about Mudayna is as an outpost. The site undoubtedly served all of the purposes mentioned above, but did not specialize in any one of them. Mudayna also served as a regional sanctuary and protected the local roadways that were so profitable to the Transjordanian kingdoms (Thompson 1958: 162). In fact, control over the north-south running secondary roadway that passes near Mudayna (Dearman 1989: 192) was likely one of the primary factors that led to its construction. Thompson has suggested (1958: 165) that control over the trade routes through Transjordan was of more economic importance than the agricultural, pastoral or mineral resources found in the area. As a fairly isolated outpost, on the edge of the eastern desert, Mudayna was called upon to play the role of 'regional center'. This role included offering services such as sanctuary and security for both the local population and any traders passing by the site. The security offered by Mudayna was in the form of its massive fortifications, rather than by the presence of a full time garrison at the site. It may have acted as a market location for local agro-pastoralists, but it did not play the role of a central distribution center (middleman) during the trading process. All of the faunal evidence indicates that direct to consumer distribution of sheep and goat products (specifically meat) took place at the Mudayna. In other words, Mudayna did not act as a distribution center, or clearing house, for local or regional trade.

The faunal remains recovered from Khirbat al-Mudayna support LaBianca's suggestions regarding the nature of the Transjordanian kingdoms during the Iron Age. The monumental architecture of Mudayna suggests that an administrative presence was located at the site. The faunal remains recovered from the public areas at the north end of the site, however, indicate that a direct distribution system of food procurement was in place at the site. One would expect to find an indirect distribution system at an urban administrative center (Zeder 1991: 36). LaBianca has suggested that the difference between the "urban elite" (royal administrators) and the "rural tribesmen" was never pronounced in Transjordan but the society maintained a more egalitarian, traditionally tribal lifestyle (LaBianca 1999: 21-22). It appears that this was precisely the case at Mudayna. The royal administrators living at Mudayna did not interfere with the daily activities of the herders (a strategy of herd security was employed) or the (direct distribution) food procurement strategies of the soldiers, priests and craftsmen working at Mudayna. In contrast, within Mesopotamia during the Ur III period (ca. 2000 B.C.E.) the urban population who were removed from food producing activities (soldiers, priests and craftsmen) received food through indirect distribution channels (Zeder 1991: 36). It is exceedingly likely that the majority of the population living at Mudayna were directly related to, or at least belonged to the same tribal

group as, the herders and farmers working and living along the Wadi ath-Thamad. This familial, or tribal, connection served as the basis for the organization of food procurement by the population of Mudayna who were not directly involved in its production.

The faunal material recovered from Khirbat al-Mudayna has also provided information about the environment of the region during the Iron II period. Unfortunately, the paucity of small mammalian finds was such that detailed environmental data could not be produced. A general environmental picture based on the large mammal finds, however, can be produced. The presence of deer bones at Mudayna indicates that the environment was richer in vegetation, particularly trees and shrubs, than it is today. The ratio of gazelle to deer finds (approximately 2:1) shows that, while the environment was more lush, it was still a steppe environment, rather than a true Mediterranean environment. The predominance of gazelle over deer bones is also found at Iron Age Hesban (von den Driesch and Boessneck 1995: Table 5.21), 30 km northwest of Mudayna, confirming that the ratio is not produced by chance recovery. When the Mudayna gazelle bones are divided into species it is clear that mountain gazelles (*Gazella gazella*) dominate over dorcas gazelles (*Gazella dorcas*), indicating that the environment was closer to a lush steppe environment than a very arid, desert environment. The ratio of sheep/goat (1.45:1) confirms the theory that the environment was more lush than is seen today, offering superior grazing conditions more suitable for sheep.

A further important function of this study will be realized in the future when it will act as a sort of baseline against which other faunal reports may be compared. The only other extensive faunal report produced to date for historic sites in Transjordan is the Hesban report, to which this study has frequently referred. Without proper comparative reports, spanning both the geography and chronology of Transjordan, the data presented in this study, as well as the Hesban study, are isolated. Only through the comparison of various sources of faunal information will meaningful shifts in faunal patterns, again across geography and chronology, be recognized.

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Appendix A

A List of Faunal Species Presently Found Near Mudayna

Modern Faunal Species

- Mammals -

Harrison (1964) listed 142 species of land mammals that exist on the Arabian peninsula today. These species are grouped into 9 Orders as follows:

Insectivora	10	(Number present at Mudayna = 4)
Chiroptera	42	(Number present at Mudayna = 6)
Carnivora	26	(Number present at Mudayna = 16)
Artiodactyla	12	(Number present at Mudayna = 6)
Lagomorpha	2	(Number present at Mudayna = 1)
Rodentia	48	(Number present at Mudayna = 20)
Hyracoidea	1	(Number present at Mudayna = 1)
Primates	1	(Number present at Mudayna = 0)

The same mammals are grouped into geographic type as follows:

Boreal Eurasiatic Fauna	21
Saharo-Sindian Desert Fauna	24
Tropical Ethiopian Fauna	10
Indo-Asiatic Fauna	18
Indigenous Fauna	15
Human Commensal Fauna	4
Introduced Fauna	1
Pluriregional Fauna	49

Not all of these mammals are found in the region of Khirbat al-Mudayna. The following is a list of all of the wild mammalian species found within the general area (Harrison 1964, 1968, Kingdon 1990, von den Driesch and Boessneck 1995)

Insectivora:

Ernaceidae (Old World Hedgehogs): *Ernaceus europaeus* (European hedgehog)
Hemiechinus auritus (Long-eared hedgehog)
Paraechinus aethiopicus (Ethiopian hedgehog)

Soricidae (Shrews): *Suncus etruscus* (Lesser white-toothed shrew)

Chiroptera:

Hipposideridae (Leaf-nosed Bats): *Asellia tridens* (Trident leaf-nosed bat)

Pteropodidae (Fruit-eating Bats): *Rousettus aegyptiacus* (Egyptian fruit bat)

Rhinolophidae (Horseshoe Bats): *Rhinolophus clivosus* (African horseshoe bat)
Rhinolophus ferrum-equinum (Greater horseshoe bat)

Rhinopomatidae (Mouse-tailed Bats): *Rhinopoma hardwickei* (Lesser mouse-tailed bat)

Vespertilionidae (Vesper Bats): *Pipistrellus kuhli* (Kuhl's pipistrelle)

Lagomorpha:

Leporidae (Hares and Rabbits): *Lepus capensis* (Brown/cape Hare)

Carnivora:

Canidae (Dogs, Jackals, Wolves and Foxes): *Canis aureus* (Common jackal)
Canis lupus (Wolf)
Vulpes vulpes (Red fox)
Vulpes rueppelli (Rueppel's sand fox)

Mustelidae (Weasels, Polecats, Martens, Badgers and Otters)
Martes foina syriaca (Stone marten)
Vormela peregusna syriaca (Marbled polecat)
Meles meles canescens (Badger)
Mustela nivalis (Weasel)
Mellivora capensis (Ratel)

Viverridae (Genets and Mongooses): *Herpestes ichneumon* (Mongoose)
Genetta genetta (Genet)

Hyaenidae (Hyaenas): *Hyaena hyaena syriaca* (Striped hyaena)

Felidae (Cats): *Felis silvestris* (Wild cat)
Felis caracal (*Caracal caracal*) (Caracal)
Panthera pardus (Leopard)
Acinonyx jubatus (Cheetah) No longer found in the region

Hyracoidea:

Procaviidae (Hyraxes): *Procavia capensis syriaca* (Rock hyrax)

Artiodactyla:

Bovidae (Cattle, Goats, Sheep and Antelopes):
Capra ibex nubiana (Nubian ibex)
Oryx leucoryx (Arabian oryx) no longer in the region
Gazella gazella (Common/mountain gazelle)
Gazella dorcas (Dorcas gazelle)

Cervidae (Deer): *Dama dama mesopotamica* (Persian fallow deer) no longer in the region

Suidae (Pigs): *Sus scrofa* (Wild boar)

Rodentia :

Sciuridae (Squirrels, Flying Squirrels and Marmots):
Sciurus anomalus (Persian Squirrel)

Cricetidae (Hamsters, Gerbils, Voles etc.):
Cricetulus migratorius (Grey hamster)

Gerbillus cheesmani/gerbillus (Hairy-footed sand gerbil)
Gerbillus dasyurus (Wagner's gerbil)
Gerbillus henleyi (Pygmy gerbil)
Meriones libicus (Libyan jird)
Meriones crassus (Sundevall's jird)
Meriones tristrami (Tristram's jird)
Psammomys obesus (Fat jird)

Muridae (Murid Rats and Mice): *Acomys dimidiatus* (Spiny mouse)
Acomys russatus (Golden spiny mouse)
Nesokia indica (Short-tailed bandicoot rat)
Rattus rattus (House/Black rat)
Mus musculus (House mouse)
Apodemus mystacinus (Broad-toothed field mouse)

Dipodidae (Jerboas, Birch Mice and Jumping Mice):
Allactaga euphratica (Long-eared jerboa)
Jaculus jaculus (Three-toed jerboa)

Muscardinidae (Dormice): *Eliomys melanurus* (Eastern orchard dormouse)

Spalacidae (Mole Rats): *Spalax leucodon* (Lesser mole rat)

Hystricidae (Porcupines): *Hystrix indica* (Indian porcupine)

Total listed here: 54

Domestic Mammals

Bos taurus (Cattle)
Ovis aries (Sheep)
Capra hircus (Goat)
Sus scrofa domestica (Pig)
Equus caballus (Horse)
Equus asinus (Ass) Mule/Hinny
Camelus dromedarius domestica (Camel) Very few during the Iron Age
Canis familiaris (Dog)
Felis catus (Cat) Not found during the Iron Age
Oryctolagus cuniculus domestica (Rabbit) Not found during the Iron Age
Gallus gallus domestica (Chicken) Not found during the Iron Age
Anser anser domestica (Goose)
Columba livia domestica (Pigeon)

Total listed here: 10 (plus 3 birds)

Wild Mammals Found at Hesban (and not listed above)

Cervus elaphus maral (maral) Not indigenous to Jordan since the Neolithic
Bos primigenius (?aurochs)
Capra aegagrus (Wild goat) Not typically found as far south as Mudayna
Ovis orientalis (Wild sheep) Not typically found as far south as Mudayna

Equus hemionus (?Syrian onager)
Panthera leo (Lion)
Meriones tristrami (Tristram's jird)
Spalax leucodon ehrenbergi (Mole rat)
Apodemus mystacinus (Broadtoothed fieldmouse)
Microtus irani (Persian vole)

Wild birds Identified at Hesban

Struthio camelus syraicus (Ostrich)
Ciconia ciconia (White stork)
Phoenicopterus ruber roseus (Flamingo)
Neophron percnopterus (Egyptian vulture)
Gyps fulvus (Black vulture)
Accipiter nisus (European sparrowhawk) or
Accipiter brevipes (Levant sparrowhawk)
Milvus migrans migrans (Black kite)
Falco peregrinus (Peregrine falcon) or
Falco pelegrinus (Desert falcon) or
Falco biarmicus (Lanner falcon)
Falco tinnunculus (Kestrel)
Falco naumanni (Lesser kestrel)
Alectoris chukar (Chukar partridge)
Ammoperdix heyi (Arabian sand partridge)
Coturnix coturnix (Quail)
Grus grus (Crane)
Crex crex (Corncrake)
Fulica atra (Coot)
Otis tarda (Great bustard)
Chlamydotis undulata (Houbara bustard)
Cursorius cursor (Cream-coloured courser)
Burhinus oedicephalus (Stone curlew)
Pterocles orientalis (Black-bellied sandgrouse)
Columba livia (Rock dove)
Streptopelia senegalensis (Palm dove)
Tyto alba (Barn owl)
Athene noctua lilith (Little owl)
Calandrella brachydactyla (Short-toed lark) or
Calandrella rufescens (lesser short-toed lark)
Galerida cristata (Crested lark) or
Alauda arvensis (Skylark)
Lullula arborea (Woodlark)
Hippolais species (Warbler)
Oenanthe isabellina (Isabelline wheatear)
Oenanthe species (Wheatear)
Turdus merula (Blackbird)
Emberiza calandra (Corn bunting)
Emberiza species (Bunting)
Passer domesticus (House sparrow)
Petronia petronia (Rock sparrow)
Sturnus vulgaris (Common starling) or

Sturnus roseus (Rose-coloured starling)
Corvus monedula soemmeringii (Jackdaw)
Corvus ruficollis (Brown-necked raven)
Corvus corax subcorax (Common raven)

Total listed: 46

Reptiles and Amphibians Identified at Hesban

Testudo graeca terrestris (Tortoise)
Agama stellio (Hardoun)
Ophisaurus apodus (Scheltopusik)
Coluber species (Racer)
Bufo viridis (Variegated toad)

Total listed: 5

Appendix B

Ovis aries, Capra hircus, Ovis/Capra and Bos taurus
MNE, MAU and %MAU

Table B-1 MNE, MAU, and %MAU for *Ovis aries*, *Capra hircus*, *Ovis/Capra* and *Bos taurus*

	<i>Ovis aries</i>			<i>Capra hircus</i>			<i>Ovis/Capra</i>			<i>Bos taurus</i>		
	Total MNE	Total MAU	Total %MAU	Total MNE	Total MAU	Total %MAU	Total MNE	Total MAU	Total %MAU	Total MNE	Total MAU	Total %MAU
Cranial bones												
Frontal	12	6	57.14	8	4	50.00	8	4	12.90	3	1.5	60
Cornual process	8	4	38.10	9	4.5	56.25	13	6.5	20.97	4	2	80
Nasal	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0
Lacrimal	1	0.5	4.76	0	0	0.00	0	0	0.00	0	0	0
Zygomatic	2	1	9.52	0	0	0.00	8	4	12.90	0	0	0
Premaxilla	0	0	0.00	0	0	0.00	3	1.5	4.84	1	0.5	20
Temporal	3	1.5	14.29	2	1	12.50	2	1	3.23	0	0	0
Tympanic portion	1	0.5	4.76	1	0.5	6.25	1	0.5	1.61	0	0	0
Mastoid process	1	0.5	4.76	2	1	12.50	1	0.5	1.61	0	0	0
Petrous portion	6	3	28.57	9	4.5	56.25	2	1	3.23	0	0	0
Zygomatic temporal	2	1	9.52	1	0.5	6.25	6	3	9.68	0	0	0
External audit meatus	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0
Occipital	4	4	38.10	5	5	62.50	3	3	9.68	2	2	80
Occipital condyle	3	1.5	14.29	3	1.5	18.75	3	1.5	4.84	1	0.5	20
Basioccipital	0	0	0.00	2	2	25.00	3	3	9.68	0	0	0
Maxilla	0	0	0.00	0	0	0.00	6	3	9.68	1	0.5	20
Facial tuber	0	0	0.00	0	0	0.00	2	1	3.23	0	0	0
Parietal	8	8	76.19	6	6	75.00	10	10	32.26	0	0	0
Pterygoid	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0
Palatine	0	0	0.00	0	0	0.00	1	0.5	1.61	1	0.5	20
Sphenoid	0	0	0.00	0	0	0.00	1	1	3.23	0	0	0
Ethmoid	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0
Cranial teeth												
2nd premolar	0	0	0.00	0	0	0.00	15	7.5	24.19	1	0.5	20
3rd premolar	0	0	0.00	0	0	0.00	20	10	32.26	2	1	40
4th premolar	0	0	0.00	0	0	0.00	29	14.5	46.77	3	1.5	60
1st molar	0	0	0.00	1	0.5	6.25	47	23.5	75.81	5	2.5	100
2nd molar	0	0	0.00	1	0.5	6.25	62	31	100.00	3	1.5	60
3rd molar	0	0	0.00	1	0.5	6.25	37	18.5	59.68	0	0	0
Mandible												
Coronoid process	0	0	0.00	1	0.5	6.25	18	9	29.03	2	1	40
Articular condyle	2	1	9.52	2	1	12.50	18	9	29.03	2	1	40
Mandibular foramen	4	2	19.05	2	1	12.50	22	11	35.48	0	0	0
Angle of ramus	4	2	19.05	2	1	12.50	18	9	29.03	3	1.5	60
Body	6	3	28.57	2	1	12.50	37	18.5	59.68	4	2	80
Lower border	5	2.5	23.81	2	1	12.50	11	5.5	17.74	2	1	40
Diastema	5	2.5	23.81	2	1	12.50	27	13.5	43.55	1	0.5	20
Symphysis	4	2	19.05	2	1	12.50	19	9.5	30.65	0	0	0
1st incisor	0	0	0.00	0	0	0.00	4	2	6.45	0	0	0
2nd incisor	0	0	0.00	0	0	0.00	9	4.5	14.52	0	0	0
3rd incisor	0	0	0.00	0	0	0.00	5	2.5	8.06	0	0	0
Canine	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0
2nd premolar	3	1.5	14.29	1	0.5	6.25	9	4.5	14.52	0	0	0
3rd premolar	5	2.5	23.81	2	1	12.50	16	8	25.81	2	1	40
4th premolar	4	2	19.05	4	2	25.00	14	7	22.58	0	0	0
1st molar	4	2	19.05	2	1	12.50	13	6.5	20.97	2	1	40
2nd molar	5	2.5	23.81	1	0.5	6.25	43	21.5	69.35	2	1	40
3rd molar	5	2.5	23.81	1	0.5	6.25	40	20	64.52	3	1.5	60

Atlas												
Transverse process	4	4	38.10	2	2	25.00	1	1	3.23	0	0	0
Dorsal tubercle	8	8	76.19	5	5	62.50	0	0	0.00	0	0	0
Dorsal arch	9	9	85.72	5	5	62.50	2	2	6.45	0	0	0
Ventral arch	9	9	85.72	5	5	62.50	4	4	12.90	0	0	0
Caudal articular surface	9	9	85.72	5	5	62.50	3	3	9.68	1	1	40
Cranial articular surface	9	9	85.72	5	5	62.50	7	7	22.58	0	0	0
Axis												
Centrum	2	2	19.05	3	3	37.50	17	17	54.84	0	0	0
Transverse process	0	0	0.00	0	0	0.00	1	1	3.23	0	0	0
Neural arch	2	2	19.05	3	3	37.50	3	3	9.68	0	0	0
Spinous process	1	1	9.52	1	1	12.50	1	1	3.23	0	0	0
Ventral crest	2	2	19.05	3	3	37.50	17	17	54.84	1	1	40
Caudal extremity	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0
Caudal articular process	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0
Ventral articular surface	2	2	19.05	1	1	12.50	2	2	6.45	0	0	0
Dens	2	2	19.05	3	3	37.50	19	19	61.29	2	2	80
Scapula												
Glenoid cavity	13	6.5	61.91	11	5.5	68.75	14	7	22.58	0	0	0
Supraglenoid tubercle	8	4	38.10	11	5.5	68.75	6	3	9.68	0	0	0
Corocoid process	8	4	38.10	11	5.5	68.75	8	4	12.90	0	0	0
Neck	14	7	66.67	12	6	75.00	28	14	45.16	0	0	0
Acromion	1	0.5	4.76	0	0	0.00	0	0	0.00	0	0	0
Spine	7	3.5	33.33	4	2	25.00	13	6.5	20.97	0	0	0
Supraspinous fossa	2	1	9.52	3	1.5	18.75	4	2	6.45	0	0	0
Infraspinous fossa	7	3.5	33.33	4	2	25.00	12	6	19.35	0	0	0
Humerus												
Head	3	1.5	14.29	0	0	0.00	11	5.5	17.74	0	0	0
Neck	2	1	9.52	1	0.5	6.25	5	2.5	8.06	0	0	0
Major tubercle	4	2	19.05	0	0	0.00	1	0.5	1.61	0	0	0
Minor tubercle	1	0.5	4.76	0	0	0.00	0	0	0.00	0	0	0
Proximal shaft	2	1	9.52	2	1	12.50	6	3	9.68	0	0	0
Deltoid tuberosity	2	1	9.52	3	1.5	18.75	2	1	3.23	0	0	0
Teres major tuberosity	2	1	9.52	3	1.5	18.75	4	2	6.45	0	0	0
Teres minor tuberosity	2	1	9.52	1	0.5	6.25	0	0	0.00	0	0	0
Posterioro-lateral foramen	3	1.5	14.29	4	2	25.00	5	2.5	8.06	0	0	0
Mid-shaft	6	3	28.57	8	4	50.00	15	7.5	24.19	0	0	0
Distal shaft	14	7	66.67	16	8	100.00	33	16.5	53.23	3	1.5	60
Radial fossa	15	7.5	71.43	16	8	100.00	27	13.5	43.55	3	1.5	60
Lateral epicondyle	13	6.5	61.91	16	8	100.00	5	2.5	8.06	2	1	40
Medial epicondyle	13	6.5	61.91	16	8	100.00	5	2.5	8.06	3	1.5	60
Trochlea	13	6.5	61.91	14	7	87.50	8	4	12.90	3	1.5	60
Capitulum	15	7.5	71.43	15	7.5	93.75	9	4.5	14.52	2	1	40
Olecranon fossa	15	7.5	71.43	16	8	100.00	13	6.5	20.97	3	1.5	60
Radius												
Lateral glenoid cavity	12	6	57.14	6	3	37.50	6	3	9.68	1	0.5	20
Medial glenoid cavity	10	5	47.62	6	3	37.50	9	4.5	14.52	3	1.5	60
Proximal posterior shaft	12	6	57.14	6	3	37.50	15	7.5	24.19	2	1	40
Proximal anterior shaft	10	5	47.62	6	3	37.50	14	7	22.58	3	1.5	60
Radial tuberosity	1	0.5	4.76	1	0.5	6.25	0	0	0.00	0	0	0
Postero-lateral foramen	4	2	19.05	2	1	12.50	7	3.5	11.29	0	0	0
Mid-posterior shaft	8	4	38.10	5	2.5	31.25	14	7	22.58	1	0.5	20
Mid-anterior shaft	7	3.5	33.33	3	1.5	18.75	13	6.5	20.97	1	0.5	20
Distal posterior shaft	5	2.5	23.81	2	1	12.50	15	7.5	24.19	3	1.5	60
Distal anterior shaft	4	2	19.05	3	1.5	18.75	18	9	29.03	3	1.5	60

Radius cont.												
Radial carpal facet	6	3	28.57	3	1.5	18.75	7	3.5	11.29	3	1.5	60
Internal carpal facet	5	2.5	23.81	3	1.5	18.75	5	2.5	8.06	3	1.5	60
Ulna												
Olecranon	6	3	28.57	4	2	25.00	9	4.5	14.52	3	1.5	60
Olecranon tuberosity	5	2.5	23.81	3	1.5	18.75	2	1	3.23	0	0	0
Acneal process	6	3	28.57	4	2	25.00	6	3	9.68	2	1	40
Semi-lunar notch	7	3.5	33.33	4	2	25.00	12	6	19.35	3	1.5	60
Coranoid process	5	2.5	23.81	4	2	25.00	11	5.5	17.74	2	1	40
Proximal shaft	4	2	19.05	4	2	25.00	10	5	16.13	2	1	40
Mid-shaft	1	0.5	4.76	0	0	0.00	2	1	3.23	0	0	0
Radial Carpal	2	1	9.52	4	2	25.00	2	1	3.23	1	0.5	20
Internal Carpal	3	1.5	14.29	3	1.5	18.75	2	1	3.23	0	0	0
Ulnar Carpal	3	1.5	14.29	1	0.5	6.25	0	0	0.00	1	0.5	20
Fused 2+3 Carpal	4	2	19.05	1	0.5	6.25	0	0	0.00	0	0	0
Unciform	2	1	9.52	0	0	0.00	2	1	3.23	1	0.5	20
Metacarpal												
Medial proximal facet	9	4.5	42.86	4	2	25.00	11	5.5	17.74	2	1	40
Lateral proximal facet	8	4	38.10	5	2.5	31.25	11	5.5	17.74	3	1.5	60
Anterior proximal shaft	12	6	57.14	6	3	37.50	18	9	29.03	2	1	40
Posterior proximal shaft	10	5	47.62	5	2.5	31.25	12	6	19.35	1	0.5	20
Anterior distal shaft	12	6	57.14	4	2	25.00	10	5	16.13	2	1	40
Posterior distal shaft	11	5.5	52.38	4	2	25.00	9	4.5	14.52	1	0.5	20
Proximal anterior foramen	9	4.5	42.86	1	0.5	6.25	6	3	9.68	2	1	40
Distal anterior foramen	7	3.5	33.33	3	1.5	18.75	4	2	6.45	2	1	40
Proximal posterior foramen	6	3	28.57	3	1.5	18.75	7	3.5	11.29	0	0	0
Distal posterior foramen	7	3.5	33.33	3	1.5	18.75	3	1.5	4.84	1	0.5	20
Medial condyle	9	4.5	42.86	4	2	25.00	0	0	0.00	1	0.5	20
Lateral condyle	11	5.5	52.38	6	3	37.50	2	1	3.23	1	0.5	20
Pelvis												
Ilium blade	7	3.5	33.33	2	1	12.50	13	6.5	20.97	0	0	0
Ilium shaft	19	9.5	90.48	4	2	25.00	16	8	25.81	1	0.5	20
Coxal tuber	0	0	0.00	0	0	0.00	1	0.5	1.61	0	0	0
Sacral tuber	2	1	9.52	0	0	0.00	3	1.5	4.84	0	0	0
Ishial body	12	6	57.14	1	0.5	6.25	27	13.5	43.55	1	0.5	20
Ishial table	8	4	38.10	1	0.5	6.25	14	7	22.58	1	0.5	20
Ishiatic spine	6	3	28.57	1	0.5	6.25	3	1.5	4.84	0	0	0
Ishiatic tuberosity	4	2	19.05	1	0.5	6.25	1	0.5	1.61	0	0	0
Pubic body	16	8	76.19	6	3	37.50	8	4	12.90	2	1	40
Pubic symphysis	4	2	19.05	0	0	0.00	3	1.5	4.84	1	0.5	20
Acetabulum ilium	17	8.5	80.95	5	2.5	31.25	13	6.5	20.97	2	1	40
Acetabulum ishium	11	5.5	52.38	2	1	12.50	31	15.5	50.00	3	1.5	60
Acetabulum pubis	15	7.5	71.43	6	3	37.50	8	4	12.90	3	1.5	60
Femur												
Head	12	6	57.14	4	2	25.00	11	5.5	17.74	2	1	40
Neck	12	6	57.14	4	2	25.00	15	7.5	24.19	0	0	0
Greater trochanter	6	3	28.57	3	1.5	18.75	2	1	3.23	0	0	0
Lesser trochanter	8	4	38.10	3	1.5	18.75	13	6.5	20.97	0	0	0
Proximal shaft	8	4	38.10	4	2	25.00	18	9	29.03	0	0	0
Mid-shaft	3	1.5	14.29	1	0.5	6.25	16	8	25.81	0	0	0

Femur cont.												
Distal shaft	3	1.5	14.29	3	1.5	18.75	16	8	25.81	0	0	0
Posterior foramen	1	0.5	4.76	0	0	0.00	4	2	6.45	0	0	0
Supracondylar fossa	2	1	9.52	2	1	12.50	11	5.5	17.74	0	0	0
Medial epicondyle	3	1.5	14.29	3	1.5	18.75	9	4.5	14.52	0	0	0
Lateral epicondyle	3	1.5	14.29	3	1.5	18.75	8	4	12.90	0	0	0
Lateral condyle	2	1	9.52	6	3	37.50	7	3.5	11.29	0	0	0
Medial condyle	2	1	9.52	6	3	37.50	10	5	16.13	1	0.5	20
Trochlea	2	1	9.52	5	2.5	31.25	6	3	9.68	1	0.5	20
Patella												
	8	4	38.10	3	1.5	18.75	3	1.5	4.84	0	0	0
Tibia												
Lateral condyle	3	1.5	14.29	2	1	12.50	8	4	12.90	4	2	80
Medial condyle	4	2	19.05	2	1	12.50	8	4	12.90	4	2	80
Tibial tuberosity	3	1.5	14.29	2	1	12.50	4	2	6.45	3	1.5	60
Anterior crest	4	2	19.05	0	0	0.00	7	3.5	11.29	3	1.5	60
Posterolateral foramen	0	0	0.00	0	0	0.00	4	2	6.45	1	0.5	20
Proximal anterior shaft	3	1.5	14.29	0	0	0.00	7	3.5	11.29	2	1	40
Proximal posterior shaft	4	2	19.05	0	0	0.00	8	4	12.90	2	1	40
Mid-anterior shaft	3	1.5	14.29	4	2	25.00	7	3.5	11.29	0	0	0
Mid-posterior shaft	3	1.5	14.29	4	2	25.00	6	3	9.68	0	0	0
Distal anterior shaft	5	2.5	23.81	8	4	50.00	26	13	41.94	1	0.5	20
Distal posterior shaft	5	2.5	23.81	8	4	50.00	22	11	35.48	1	0.5	20
Medial malleolus	5	2.5	23.81	7	3.5	43.75	23	11.5	37.10	0	0	0
Medial cochlear groove	5	2.5	23.81	8	4	50.00	24	12	38.71	1	0.5	20
Lateral cochlear groove	5	2.5	23.81	8	4	50.00	23	11.5	37.10	1	0.5	20
Astragalus												
Proximal condyles	17	8.5	80.95	7	3.5	43.75	7	3.5	11.29	1	0.5	20
Distal condyles	16	8	76.19	5	2.5	31.25	5	2.5	8.06	1	0.5	20
Calcaneus												
Sustentaculum	21	10.5	100.00	14	7	87.50	6	3	9.68	5	2.5	100
Calcanean tuber	16	8	76.19	9	4.5	56.25	9	4.5	14.52	0	0	0
Fused C/4th Tarsal												
	6	3	28.57	1	0.5	6.25	1	0.5	1.61	3	1.5	60
Metatarsal												
Medial proximal facet	7	3.5	33.33	7	3.5	43.75	16	8	25.81	3	1.5	60
Lateral proximal facet	7	3.5	33.33	7	3.5	43.75	9	4.5	14.52	3	1.5	60
Proximal anterior shaft	8	4	38.10	6	3	37.50	23	11.5	37.10	3	1.5	60
Proximal posterior shaft	9	4.5	42.86	7	3.5	43.75	17	8.5	27.42	2	1	40
Distal anterior shaft	5	2.5	23.81	4	2	25.00	13	6.5	20.97	4	2	80
Distal posterior shaft	5	2.5	23.81	4	2	25.00	13	6.5	20.97	4	2	80
Proximal anterior foramen	1	0.5	4.76	0	0	0.00	0	0	0.00	0	0	0
Distal anterior foramen	4	2	19.05	1	0.5	6.25	2	1	3.23	4	2	80
Proximal posterior foramen	7	3.5	33.33	3	1.5	18.75	3	1.5	4.84	2	1	40
Distal posterior foramen	4	2	19.05	1	0.5	6.25	3	1.5	4.84	4	2	80
Medial condyle	2	1	9.52	3	1.5	18.75	0	0	0.00	3	1.5	60
Lateral condyle	3	1.5	14.29	4	2	25.00	1	0.5	1.61	4	2	80
1st Phalanx												
Base	17	2.13	20.24	28	3.5	43.75	9	1.125	3.63	5	0.625	25
Proximal shaft	23	2.88	27.38	30	3.75	46.88	17	2.125	6.85	5	0.625	25
Distal shaft	27	3.38	32.14	29	3.625	45.31	24	3	9.68	5	0.625	25
Trochlea	27	3.38	32.14	26	3.25	40.63	22	2.75	8.87	4	0.5	20

2nd Phalanx												
Base	18	2.25	21.43	12	1.5	18.75	3	0.375	1.21	4	0.5	20
Proximal shaft	18	2.25	21.43	14	1.75	21.88	9	1.125	3.63	4	0.5	20
Distal shaft	18	2.25	21.43	15	1.875	23.44	11	1.375	4.44	4	0.5	20
Trochlea	18	2.25	21.43	14	1.75	21.88	10	1.25	4.03	4	0.5	20
3rd Phalanx												
Base	7	0.88	8.33	3	0.375	4.69	2	0.25	0.81	1	0.125	5
Proximal shaft	7	0.88	8.33	4	0.5	6.25	2	0.25	0.81	1	0.125	5
Distal shaft	7	0.88	8.33	4	0.5	6.25	2	0.25	0.81	0	0	0
Distal end	7	0.88	8.33	2	0.25	3.13	0	0	0.00	0	0	0

Appendix C

Complete Measurement List

Table C-1 Complete measurement list (mm) (Abbreviations follow von den Driesch 1976)

Atlases	GL	GLF	BFcr	BFcd	HFcd	HFcr				
<i>Capra</i>		50.62	52.58			25.81				
	52.68	44.24	46.73	43.39	25.64	22.35				
		50.71	51.68	44.50	27.03	25.18				
		53.86		50.84	28.51	25.14				
<i>Ovis</i>		46.90	50.19	49.38	29.32	24.52				
	56.64	48.27	48.65	44.66	24.93	24.77				
	49.71	44.28		47.99	26.81	24.87				
	54.67	48.58	49.79	46.24	26.82	22.05				
		49.63	48.84	46.42	28.53	25.03				
	49.73	46.02	49.80	44.20	27.15	22.78				
	50.52	46.65	49.88	48.48	27.71	24.40				
<i>Gazella</i>			41.30	35.27	20.73	22.34				
Axes	LCDe	LAPa	BFcr	BPtr	SBV	BFcd	Bpacd	Hdens	Bdens	Ldens
<i>Bos</i>								26.82	38.32	16.79
<i>Capra</i>	56.58		54.83		24.10				22.80	
			50.89		23.65			17.18	23.63	12.57
	64.27		52.37		28.86			19.85	23.65	13.86
<i>Ovis</i>	63.65	53.60	43.22		21.62	21.07	31.70	14.84	19.91	10.99
	59.51	48.75	40.41		22.41	20.55		14.73	19.88	10.26
<i>Ovis/Capra</i>								17.62	21.48	9.15
			46.99		27.07			17.30	22.45	11.14
			46.19					15.76	21.60	10.05
			41.26					15.05	21.95	9.58
								14.70	21.66	9.44
					23.15	23.51	31.65			
				48.03	26.03	26.21				
			44.94		22.04			14.37	21.97	9.49
								17.85	23.96	10.72
	61.55		45.73		24.51	23.99		17.48	23.19	9.83
								17.15		9.79
			41.51					14.04	19.15	8.89
					22.83	21.52				
									22.43	9.56
			46.32					16.84	23.01	10.03
								16.29	21.27	
								16.08	22.07	
Scapulae	SLC	GLP	LG	BG	S-Gc					
<i>Camelus</i>	68.50		68.87	59.10	40.22					
<i>Capra</i>	19.95	34.99	29.22	23.49	25.20					
	20.29	34.25	26.78	23.14	23.36					

Scapulae	SLC	GLP	LG	BG	S-Gc
<i>Capra</i>	20.09		25.28	22.85	20.18
	21.36				23.70
	21.28	34.83	26.43	22.43	20.65
	21.06	36.26	28.56	23.62	27.75
		33.61	25.58	24.21	
	18.01	34.52	26.73	22.40	20.63
	20.47	32.28	26.22	22.41	21.24
		34.24	27.92	24.00	22.09
	18.94	32.20	26.73		
		36.68	29.01	23.72	25.04
<i>Ovis</i>		36.27	28.35	22.92	20.50
	19.16	34.91	28.07		19.72
	20.93	38.01	28.16	22.64	17.02
	19.68	33.79	26.48	20.38	17.38
	21.70	34.04	29.05	22.25	16.94
	23.91	34.54	28.63	22.28	22.75
	18.30	33.74	27.44	21.71	17.03
	20.82	34.13	27.47	21.51	22.92
	23.06	40.02	31.25	25.89	21.43
	19.26	34.47	26.67	20.94	18.66
	19.74	35.55	28.24	23.59	20.53
	20.90			22.10	20.02
					21.94
	21.67	40.14	31.31	23.50	22.70
		37.39	29.01	22.78	17.28
	20.64	36.50	28.08	23.12	21.93
<i>Ovis/Capra</i>	14.60				
	21.63			25.00	21.11
	21.00		29.79		19.63
	19.46				
					20.99
				26.60	
		32.91	27.10	21.61	23.07
				25.33	24.04
	20.34				
	18.31			22.70	22.74
	19.55	33.80			20.57
<i>Gazella</i>	17.79	31.36	25.93	20.39	18.53
	16.55	32.18	25.91	21.70	22.36
	17.65			20.43	19.03
Humeri	Bd	BT	SD	BP	GLC
<i>Bos</i>	73.86	62.91			
<i>Capra</i>	39.73	37.55			
		34.66			
	30.85	27.77			

Humeri	Bd	BT	SD	BP	GLC	
<i>Capra</i>	30.42	29.78				
	29.13	27.57				
	30.83	29.34				
	34.51	32.39				
	32.19	29.50	15.37			
	31.44	28.52				
	32.06	30.80				
	33.60	30.07				
	38.62	35.31				
	33.82	31.87				
	31.21	29.60	14.26			
<i>Ovis</i>	32.93	32.13				
	32.64	31.22				
	35.34	32.95				
	34.83	32.85				
	32.63	29.85				
	33.34	31.91				
		30.56				
	32.59	29.49				
	34.08	30.92				
				37.71		
	33.10	29.43				
	31.20	30.31	15.38		138.00	
	33.98	30.69	16.27			
<i>Ovis/Capra</i>		35.28				
			17.06			
	30.51	28.21				
		27.32				
	33.28	30.45				
	32.88	30.49				
<i>Gazella</i>						
	26.56	23.76				
<i>Dama</i>						
immature	43.48					
Radii	Bp	BFp	Bd	BFd	SD	GL
<i>Bos</i>			61.18	53.65		
					37.34	
			63.74	56.83		
	71.88	66.63				
<i>Capra</i>	35.35	32.81				
	33.34	31.70				
	39.09	37.17				
	34.70	32.56				
			30.10	26.69		
			29.24	26.41		

Radii	Bp	BFp	Bd	BFd	SD	GL
<i>Capra</i>			29.66	25.56	18.22	
	36.58	33.76				
	32.84	30.29				
<i>Ovis</i>						
	32.64	30.49				
			33.72	27.98		
	35.05	31.26				
	33.25	29.18			9.17	
	33.79	30.38				
	33.28	29.83	32.18	26.37	16.90	160.07
			32.19	27.14	17.18	
	34.15	31.14				
	31.00	28.05				
			31.43	25.58		
	39.57	35.01				
			29.70	25.70		
<i>Ovis/Capra</i>	32.91	30.54				
					16.40	
					16.07	
	31.00	29.38				
			32.33	28.74		
Ulnae	LO	BPC	DPA	SDO	LOWoP	
<i>Bos</i>						
		41.19				
		44.74				
<i>Capra</i>						
	39.90		26.20	22.40		
	42.36		28.04	23.87		
	39.98	25.64	25.96	23.35		
<i>Cervid</i>						
immature		21.08	28.39	24.42	39.85	
<i>Ovis</i>						
		19.85				
	42.44	20.47	29.89	26.50		
		20.10				
	41.43	22.46	27.23	25.50		
	42.73		25.99	22.78		
	37.53	19.84	26.54	23.89		
	43.77					
<i>Ovis/Capra</i>						
			28.51	25.06		
		22.18				
			29.76			
		20.56	25.86	21.68		
		21.86				
<i>Gazella</i>						
	32.03	18.14	21.70	19.53		

Carpals							
Radial	GB						
<i>Bos</i>	38.81						
<i>Capra</i>	21.59						
	20.45						
	21.17						
<i>Ovis</i>	22.09						
	19.61						
Unciform	GB	GL					
<i>Bos</i>	26.74	27.85					
<i>Ovis</i>	10.78	14.19					
	12.23	14.95					
Intermediate	GB	GL					
<i>Capra</i>	13.49	16.80					
	17.88	19.81					
<i>Ovis</i>	14.06	16.50					
	14.40	16.84					
	14.28	16.33					
Fused 2+3	GB						
<i>Capra</i>	17.85						
<i>Ovis</i>	15.53						
	17.76						
	15.20						
	17.88						
Ulnar	GB	GL					
<i>Capra</i>	8.69	13.79					
<i>Ovis</i>	7.25	13.22					
		16.45					
		14.82					
Innominate	LA	LAR	SB	SH	IsH	IsB	Lfo
<i>Bos taurus</i>	62.72	44.93					
<i>Capra</i>	31.54	26.56	8.39	16.48			
<i>Ovis</i>	29.25	25.23					
	31.93	29.00			16.91	6.79	39.46
	32.25	26.79					
			10.50				

Innominate	LA	LAR	SB	SH	IsH	IsB	Lfo
<i>Ovis</i>					17.55	7.41	
			8.43	12.93			
			9.65	14.62			
	30.41	25.73			13.63	7.25	39.47
	31.43	28.43	11.15	15.58	16.28	7.52	
	28.64	25.16	9.17			6.95	
	30.41	24.88	11.06	18.12	15.86	7.31	
	31.93	26.60	10.15	17.30			
			10.65	18.24			
			8.46	12.40			
		24.60			15.05	8.60	
					14.88	7.08	
			9.49	15.37			
<i>Ovis/Capra</i>	31.53	26.94					
					14.79	7.04	
					10.89	5.89	
			11.83	18.51			
					16.20	7.54	
					15.31	8.30	
					15.67	6.37	
					14.95	6.43	
					15.19	7.91	37.02
					15.52	7.63	
					15.06	8.35	
			8.33	14.09			
					17.07	7.16	
					14.87	7.44	
					16.96	8.78	
					17.29	6.64	
					16.84	8.02	
			9.90	15.50			
	30.90	26.97			13.91	8.26	
<i>Gazella</i>			6.51				
Femorae	DC	Bp	Bd	SD			
<i>Bos</i>	45.17						
<i>Capra</i>	22.77						
	21.80	46.84					
	22.64	44.40					
			40.32				
	21.16	41.43					
			38.15				
<i>Gazella</i>	20.21	45.90					
<i>Ovis</i>	24.55						

Femorae	DC	Bp	Bd	SD	
<i>Ovis</i>	20.35				
	22.96	50.65			
	24.28				
	20.09				
	21.56				
	19.53	42.97			
	22.24				
				16.30	
			36.19		
	20.49	46.20			
	23.83	46.82			
<i>Ovis/Capra</i>					
	20.36				
	21.02				
	21.12				
			41.39		
			39.68		
Patella	GB	GL			
<i>Ovis</i>					
	22.74	29.16			
	22.82				
	23.65	31.18			
	25.65	34.49			
	24.92				
Tibiae	Bp	Bd	Dd	SD	GL
<i>Bos</i>					
		52.09	39.24		
	87.04				
<i>Capra</i>					
		28.24			
		25.21	21.10	14.74	
		26.44	20.62	13.51	
		29.42	23.61	16.80	
		31.74	24.93		
		26.27	21.24	15.20	
		28.33	21.82		
		27.67	20.95		
<i>Ovis</i>					
		29.35	22.30		
	43.53				
		29.42	22.21	17.30	
	40.07				
		30.16	22.06	16.85	
		30.68	22.32	16.91	
		28.75	21.47	15.52	
	42.09				
<i>Ovis/Capra</i>					
		31.46	24.17		
		25.79	18.61		

Tibiae	Bp	Bd	Dd	SD	GL
<i>Ovis/Capra</i>		26.16	19.94	14.46	
		28.16	22.45		
	43.75				
		27.94	20.04		
		25.28	19.58		
		25.61	20.49		
			20.96		
		28.29	21.56		
		28.89	21.43		
		26.47	19.82		
		27.10	20.95		
		27.86	20.33		
<i>Gazella</i>					
		20.06	15.88		
Astragali	GLl	GLm	DI	Bd	
<i>Capra</i>					
	30.16		15.70		
	32.21	29.45	16.58	20.65	
	30.62	28.17	15.87	19.59	
	33.74				
	30.48	29.73	15.91	19.05	
	30.38	29.80	16.22	18.95	
<i>Ovis</i>					
	31.89		17.46	20.75	
	31.05	29.43	17.51		
	31.81	30.03	17.90	19.74	
	30.82	29.77	17.20		
	30.32	28.74	17.11	19.81	
	31.54	29.93	17.32	19.47	
	30.04	28.49	16.62	19.25	
		29.64	17.30	19.25	
	30.04	29.04	16.16	19.23	
	30.35		17.23		
	30.89	28.80	17.30	19.39	
	32.07	30.72	17.97		
	31.11	30.03	16.85	19.36	
		28.63		19.66	
	30.86	28.77	16.85	19.62	
<i>Gazella</i>					
	27.38	26.10	15.24	16.90	
	27.61	25.77	14.60	18.20	
		25.18	15.41	17.15	
	27.56	25.97	15.95	18.38	
Calcanei	GL	GB	SB(m-l)	SD(a-p)	
<i>Bos</i>					
			16.25	26.43	
	124.11	40.14	15.38	29.08	
<i>Capra</i>					
	54.46	17.88			

Calcanei	GL	GB	SB(m-l)	SD(a-p)
<i>Capra</i>	56.71	19.30		
			7.52	
	59.77		8.09	14.52
	66.68	20.89	9.12	15.54
	57.38	18.75	8.03	13.02
	63.64	20.89	8.44	15.19
	60.88	20.76	8.96	14.59
	66.18	21.93	9.12	15.44
<i>Ovis</i>				
	66.52	21.42		
	64.65	22.41	9.96	15.14
			7.77	13.90
	70.19	22.78	8.99	15.68
			7.08	
	60.62	21.26	8.42	14.01
	60.18	20.44	8.31	13.26
	58.80	20.30	9.43	13.83
	61.40	21.18	9.28	14.30
	58.28		8.01	13.13
	57.13		8.80	12.33
	54.11	18.45	7.77	12.35
	64.49	21.14	8.90	14.89
	56.57	18.57	7.25	13.09
	59.74	20.02	8.33	13.72
<i>Gazella</i>				
			6.72	
Central+4th T	GB			
<i>Bos</i>				
	47.54			
	63.28			
<i>Capra</i>				
	22.72			
	23.13			
<i>Ovis</i>				
	24.63			
	25.58			
	22.89			
	24.23			
	25.37			
	26.24			
<i>Ovis/Capra</i>				
	24.37			
<i>Dama</i>				
	31.15			
Phalange 1	Glpe	Bp	SD	Bd
<i>Bos</i>				
	56.82		19.61	25.16
			20.01	
	53.23	24.59	19.99	23.22

Phalange 1	Glpe	Bp	SD	Bd
<i>Bos</i>				
	53.13	22.89	19.95	22.81
	58.66	32.97	26.23	30.13
	52.08	28.15	22.97	25.90
<i>Camelus</i>				
		38.30	20.24	
<i>Capra</i>				
	44.10	13.79	10.99	12.46
		12.48		
	41.80	12.88	10.19	13.33
	36.25	13.63	11.55	13.01
	37.28	12.63	10.19	12.29
	44.03	14.08	10.58	12.68
	41.08	14.44	11.19	13.12
	33.58	13.08	10.46	11.52
	38.64	12.63	9.54	11.97
	37.74	13.32	11.78	13.88
	39.77	13.89	11.23	13.41
	35.70	13.22	10.70	12.18
	36.63	12.93	9.95	11.74
	42.55	14.62	11.61	13.59
	36.77	11.84	9.52	11.60
	39.40	12.23	9.79	11.76
		12.10		
		12.50		
				13.21
	40.43	12.77	9.18	11.65
			9.27	11.50
	34.01	11.81	9.12	10.54
	37.69	11.92	9.16	10.93
	40.70	15.96	13.09	16.01
			12.27	13.57
	35.34	13.19	10.63	12.35
	35.09	11.98	9.71	10.84
	32.69	9.81	8.45	9.61
	32.91	10.98	7.67	9.67
	35.33	11.02	8.35	10.16
			8.69	9.94
			8.30	10.01
<i>Dama</i>				
	48.48	16.73	14.01	16.24
	49.16	14.58	11.69	14.26
		14.14	12.06	
<i>Gazella</i>				
	39.78	11.35	8.70	11.09
			7.46	
		11.02		
			8.93	10.34
<i>Ovis</i>				
	36.95	13.66	10.32	12.24
	37.57	13.50	10.13	12.67

Phalange 1	Glpe	Bp	SD	Bd	
<i>Ovis</i>		14.26			
	35.81	13.41	10.73	12.14	
	39.07	12.78	9.82	12.18	
	37.08	12.03	9.45	12.14	
	37.96	12.74	10.37	12.51	
	37.67	12.08	9.48	11.29	
				13.38	
	36.90	12.80	10.32	11.23	
	37.32	12.93	9.35	12.27	
				12.35	
	39.53	12.80	10.08	11.60	
		12.86	9.28		
	37.32		11.11	14.43	
	35.32		9.36	11.15	
	37.55	14.00	10.33	12.62	
			10.45	12.50	
				13.27	
				11.45	
	41.57	15.79	12.43	16.05	
	39.27	13.69	11.91	14.15	
	37.42	13.61	10.42		
			10.51	12.81	
	40.91	12.11	9.30	10.91	
				12.01	
	36.45	11.78	9.38	10.92	
<i>Ovis/Capra</i>					
	36.61	12.70	9.67	11.78	
	32.75	13.84	11.35	12.70	
		13.08			
		13.02	10.53		
				11.73	
				11.93	
				11.13	
				11.66	
		12.66			
		13.85			
			11.48	13.41	
			10.56	11.92	
Phalange 2	GL	Glpe	Bp	SD	Bd
<i>Bos</i>					
	43.71	41.85	28.86	23.90	24.77
	35.71	32.87	23.11		
	36.61	35.88	29.90	23.73	24.39
				25.27	
<i>Capra</i>					
		23.01	14.44	10.74	10.69
		22.05	12.18	9.50	9.97
		23.03	12.69	9.03	11.27
		23.35	13.03	10.09	10.50
		21.16	12.70	9.19	9.00

Phalange 2	GL	Glpe	Bp	SD	Bd
<i>Capra</i>		24.41	14.11	10.62	11.61
		25.50	15.98	11.72	
		20.77	12.08	9.56	9.94
				9.35	
		23.18	12.95	8.63	
		26.58	14.62	10.54	
					12.15
		21.38	13.27	9.54	10.37
		26.53	14.57	10.69	11.59
		24.50	12.16	8.29	9.89
<i>Gazelle</i>		23.81	10.35	6.42	5.84
		22.68	10.75	7.45	8.36
		21.66	10.55	7.66	8.93
		22.35	10.83	7.95	8.92
		23.26	11.81	7.68	8.24
<i>Ovis</i>		22.69	12.69	9.36	10.82
		21.19	12.71	10.09	10.40
		24.79	14.20	9.81	10.93
		20.95	12.64	9.58	9.98
		23.18	13.36	9.47	
		26.11	13.62	10.16	10.79
		19.65	12.75	9.35	9.65
		23.09	12.15	8.36	9.44
		24.55	13.31	9.24	10.20
		24.90	12.05	8.02	8.95
		23.49	12.21	8.64	9.23
		22.06	13.80	11.08	11.00
		23.26	14.26	10.27	10.64
<i>Ovis/Capra</i>		23.26	10.58	7.42	8.28
		22.83	11.71	8.60	9.37
					8.67
		21.46	11.33	8.72	8.82
		22.71	12.53	9.37	9.74
		21.17	12.78	8.98	10.05
		22.86	13.04	9.98	
				10.46	10.78
Phalange 3	DLS	Ld	MBS		
<i>Bos</i>	59.74	46.84	19.73		
			20.84		
<i>Capra</i>	29.61				
			4.37		
	27.15	21.81	5.41		
<i>Dama</i>	42.44	34.19	6.67		

Phalange 3	DLS	Ld	MBS		
<i>Ovis</i>	28.76		5.86		
	30.60	25.03	6.36		
	38.08	30.01	7.41		
	31.90		6.35		
	27.11	19.53	5.72		
	32.28	26.63	6.29		
	29.36	23.00	5.98		
Metacarpal	Bp	Bd	DD	SD	GL
<i>Bos</i>	54.21				
		66.44	21.90		
<i>Capra</i>	22.90				
	24.40				
	24.43		10.27	14.99	117.01
		34.29	12.30		
		29.92			
	25.54			15.42	
<i>Ovis</i>		26.59	10.77		
	28.61			20.08	
	27.65			16.51	
	24.83				
	28.13				
		27.57	10.87		
		26.03	9.47	14.21	
	25.37			14.81	
		26.98	9.39		
			9.18	15.52	
		26.46	9.24	15.29	
		24.75	9.99		
	25.08				
		26.70	9.81		
<i>Ovis/Capra</i>	25.17				
			9.36	14.11	
				14.05	
Metatarsal	Bp	Bd	SD	DD	GL
<i>Bos</i>		49.63		25.67	
	44.78		27.53		
	42.91				
		55.43			
<i>Capra</i>	21.55		12.06		
	22.16				
		29.13			
	21.01				
		24.40			

Metatarsal	Bp	Bd	SD	DD	GL
<i>Capra</i>	20.49	33.10			
		25.46			
	20.90				
<i>Ovis</i>	23.31		12.94	10.56	
	21.68		12.56		
	21.79				
	23.17				
			12.70		
	20.88	26.55	13.13	11.09	141.87
		26.53	13.21	11.33	
	21.63				
<i>Ovis/Capra</i>					
	21.30				
	20.86				
	20.49				
	21.39		12.09		

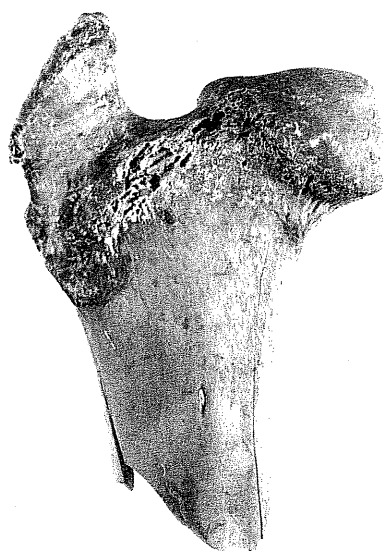
Appendix D

Miscellaneous Photographs



5cm

Figure D-1 *Gazella dorcas* cranium, anterior view



5cm

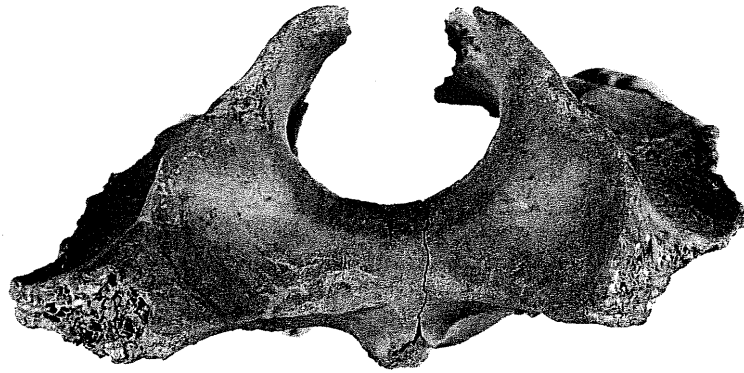


5cm

A

B

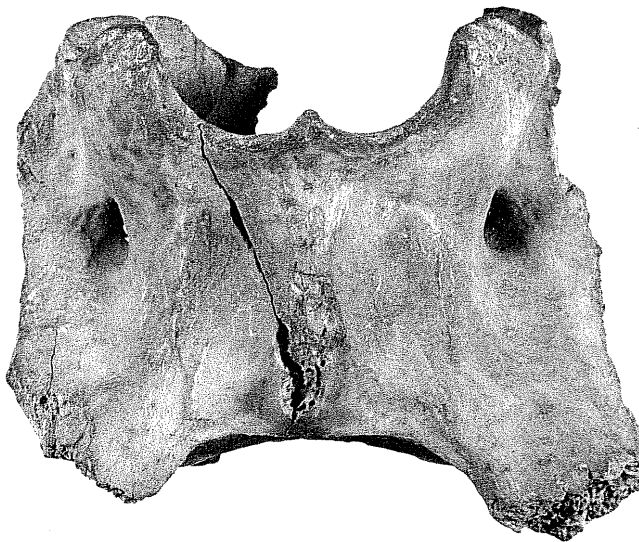
Figure D-2 *Gazella gazella* right femur,
A. cranial view of proximal end
B. caudal view of proximal end (note cutmarks on greater trochanter)



A



5cm

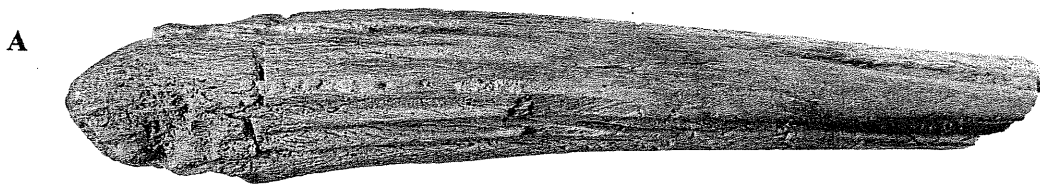


B

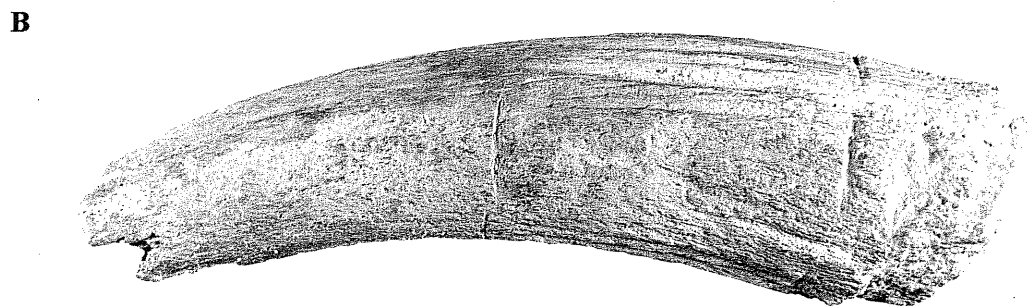


5cm

Figure D-3 *Gazella gazella* atlas,
A. caudal view
B. ventral view

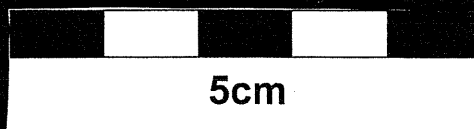


5cm



5cm

Figure D-4 *Gazella gazella* right horncore,
A. anterior view
B. lateral view



5cm

Figure D-5 *Herpestes ichneumon* right scapula



Figure D-6 *Erinaceus europaeus concolor* right mandible with the last premolar and all three molars



Figure D-7 Bird bones

- A. *Accipitridae* left carpometacarpus
- B. *Columba livia* right coracoid
- C. *Columba livia* right humerus



Figure D-8 *Sparidae* jaw bones
 A. right premaxillare
 B. left mandible



Figure D-9 Cutmarks on a distal left goat humerus

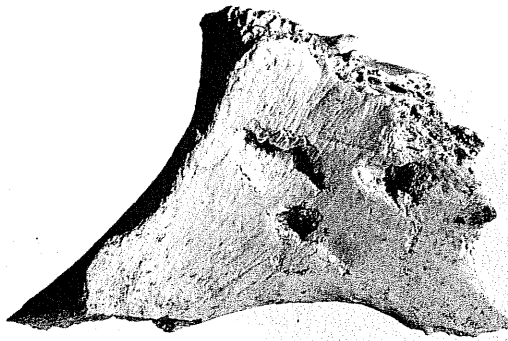


Figure D-10 Cutmark on a camel proximal 1st phalanx



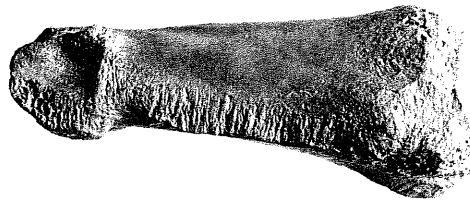
Figure D-11 Cutmarks on a calcined right gazelle astragalus

A



5cm

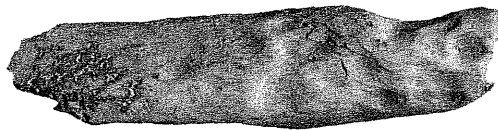
B



5cm

Figure D-12 Bite marks

- A. carnivore gnawing on a right sheep pubis
- B. rodent gnawing on a sheep 1st phalanx



5cm

Figure D-13 Digestion marks on an unidentified bone fragment

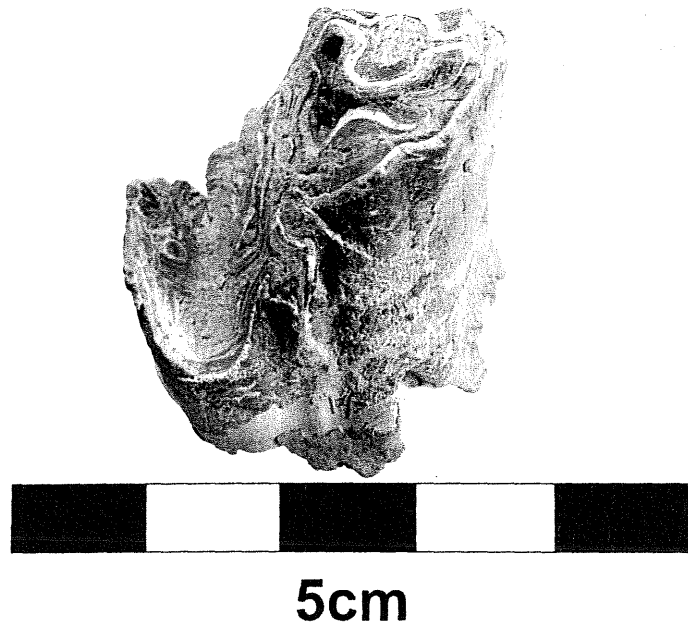


Figure D-14 An upper *Bos taurus* molar with bit wear



Figure D-15 *Bos taurus* caudal vertebra with degenerative sclerotic bone growth



Figure D-16 A burned split-rib pottery burnisher. Note the cross-grain scoring

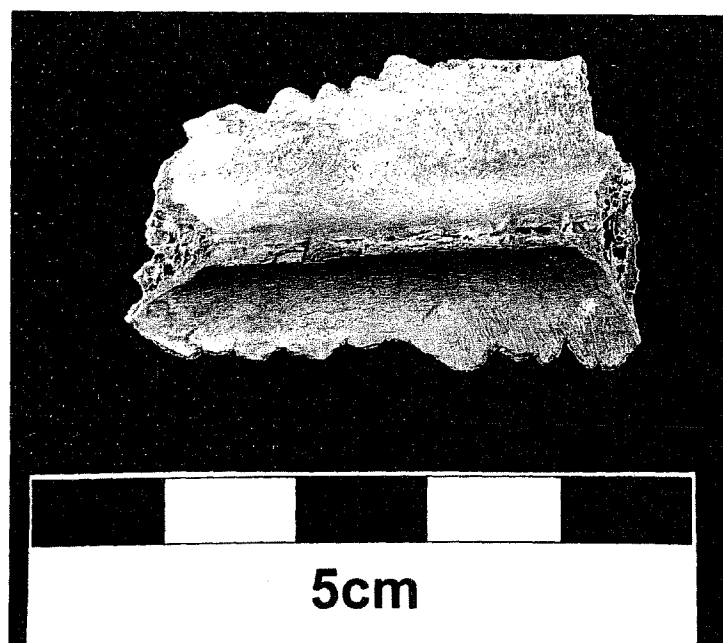


Figure D-17 A worked scapula fragment