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Retracing the steppes : a zooarchaeological analysis of changing subsistence patterns in the late Neolithic at Tell Sabi Abyad, northern Syria, c. 6900 to 5900 BC

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RETRACING THE STEPPES
A Zooarchaeological Analysis of Changing Subsistence Patterns in the Late Neolithic
at Tell Sabi Abyad, Northern Syria, c. 6900 to 5900 BC

Proefschrift

Ter verkrijging van
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Chapter 1 Introduction

1.1 Research background

As you journey through the Syrian desert-steppe from the capital of Damascus to the Ar-Raqqah region, one thing that strikes you is the vastness of the area and its apparent lack of life. Today, intensive farming has all but obliterated the natural environment. It is now hard to imagine this area as being part of the 'Fertile Crescent', the cradle of modern civilisations, agriculture and animal husbandry. All that is left to remind us of this period of prehistory are the enigmatic settlement mounds or 'Tells' that are scattered throughout Northern Syria. Once you are aware of the presence of these Tells however, you realise that this was once a place full of life and human settlements.

One of the least known periods of Syria, and the Near East in general, is the Pottery Neolithic at the end of the Neolithic period. This period shows a vast amount of regional differentiation in terms of site types, chronologies, material culture and subsistence patterns. Despite the lacuna of sites fully investigated dating from the Late Neolithic (c. 6900 – 5300 BC¹) this period is now acknowledged as one of the most important stages in the history of the Near East. It is during this period that the foundations for modern civilisations were laid; this is the period when humans first made fine ceramics, created seals to denote personal property, developed advanced networks for trade (i.e. obsidian) and started complex forms of animal husbandry, including the development of secondary products.

It is this intriguing snapshot of human history that forms the basis of the following research, which centres around one particular site: Tell Sabi Abyad. Tell Sabi Abyad is located in the upper Balikh region of northern Syria. The site is situated approximately 30 kilometres from the Syro-Turkish border and about two kilometres south of the modern village of Hammam et-Turkman. The village at Tell Sabi Abyad dates back to the seventh and sixth millennium BC. Eight thousand years ago Tell Sabi Abyad was a well established settlement consisting of mud-brick houses, courtyards, and work areas inhabited by only a few dozen people probably consisting of several family groups. Research into the Late Neolithic has revealed a plethora of different site types existing together with evidence of a dispersed population living in small, transitory villages, seasonal campsites and a few longer-lasting large settlements. Tell Sabi Abyad was the latter and may have acted as a central place within the Balikh valley.

The research undertaken in this thesis is centred around the faunal material excavated in Operation III, an area on the north-western part of the mound (see chapter 2). This carefully excavated area has produced some of the most comprehensive data sets in Syria, giving a thorough insight into life in the Late Neolithic.

The Late Neolithic people were experienced agriculturists who farmed crops of wheat, barley, flax and pulses and although they had herds of domestic animals (sheep and goats) they continued to domesticate new species (cattle) (see chapter 3). These people were able to build complex structures such as multi-roomed, possibly multi-storied buildings, with storage facilities, ovens and benches. They were creative and made beautiful objects out of stone, bone, shell, clay and pottery (see chapter 2). They were undoubtedly spiritual; they carefully buried their dead in the village, sometimes with beautiful objects such as jewellery and astoundingly delicate stone bowls, and there are other signs of a possibly ritual aspect to their day to day lives including 'special deposits' of wild cattle horncores, mysterious images on painted pottery and figurines. They were not an isolated community but part of a wide ranging network of trade with links to the north evident through the presence of fine Anatolian obsidian.

¹ All dates are calibrated unless otherwise stated.

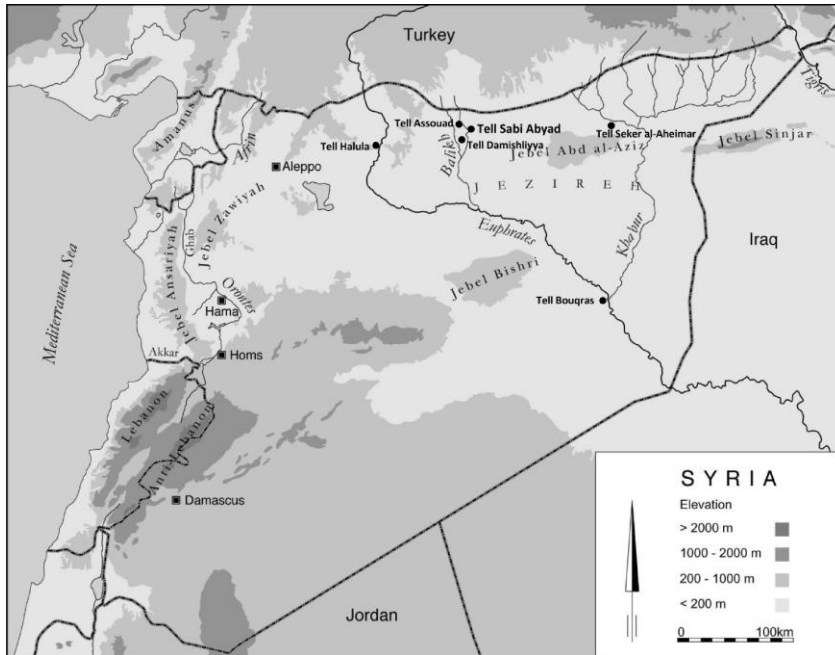


Fig 1.1: Site location

The developments we see in the Late Neolithic were started thousands of years earlier at the beginning of the Holocene around 12,000 years ago. It was in the Natufian period that the foundations of sedentary life were laid and in the proceeding Pre-Pottery Neolithic A (PPNA) that people first started to manipulate plants and started on the road to plant domestication, followed a few thousand years later in the Pre-Pottery Neolithic B (PPNB) by the first domestic herd animals such as sheep and goats. Their origins in a hunter-gatherer lifestyle provided them with the all knowledge of plants and animals necessary to successfully undertake domestication. The emergence of pottery in the Pottery Neolithic (PN) completes the full 'Neolithic package'. Throughout these earlier periods people were honing their skills in tool manufacture, producing new flint and obsidian blades, and developing the tools required for agriculture such as sickles and grinding stones. This transition to a fully sedentary and agricultural way of life was not entirely horizontal however. Zooarchaeological research has revealed a great deal of autonomy and individuality between different sites of the same period in the Near East; while some appear to have almost fully invested in domestic animals such as sheep and goats, others have stuck to a more traditional way of life relying on the hunting of animals such as onager, gazelle and aurochs (see chapter 3). It is obvious that this period of time is a complex one in terms of economy.

It would be misleading to think of this period of our history as an idyllic time of plenty. Farming in this period would be very labour intensive and the food produced arguably less palatable than that gathered. Farming in such a marginal area also meant that rainfall was probably highly variable year to year and crops could often fail. Neither was the Neolithic a 'Garden of Eden'. The settlements were heavily polluted with all kinds of organic matter, as shown by the abundance of plant and animal remains, as well as other refuse, found in and around the houses during excavation. This refuse would have attracted vermin, disease and illness. Stock rearing also had a negative effect on human health with many human diseases coming from animals, such as tuberculosis from cattle and parasitic worms. There are signs of serious disease affecting the Neolithic people such as meningitis and tuberculosis (Smit *per comms*; Roberts and Manchester, 1995).

Archaeological research has revealed that this period was characterised by a great deal of change in settlement patterns and cultural change. Several reasons have been put forward for these changes in including environmental degradation either caused by the people themselves or a climate change (see chapter 4). Tell Sabi Abyad is exceptional in that it is one of the few sites that apparently survived this

troubled time. Excavations reveal that Tell Sabi Abyad apparently did not escape unscathed as there is evidence for a series of major alterations in the nature of settlement with the abandonment of the western side of the site and the foundation of a new settlement on the east side of the mound. There were other changes too with the appearance of new architecture, changes in material culture, the appearance of new tools, the introduction of sealings and a change in subsistence strategies. Were these changes due to a climate event that occurred at around the same time, c. 6200 BC, known as the 8.2k climate event (Rohling and Pälike, 2005; Alley and Ágústsdóttir, 2005; Baldini *et al.* 2002; Alley *et al.*, 1997 Barber *et al.*, 1999; Bauer *et al.*, 2004; Klitgaard-Kristensen *et al.*, 1998; Renssen *et al.*, 2002; Teller *et al.*, 2002; Wiersma and Renssen, 2006)? This is one of the questions I will try to answer.

1.2 Research questions, aims and objectives

The subsequent study was undertaken as part of the research programme 'Abrupt Climate Change and Cultural Transformation in Syria in Late Prehistory (c. 6900 - 5900 BC) co-ordinated by Prof. Dr. P. M. M. G. Akkermans and Prof. Dr. J. van der Plicht. This programme consists of multidisciplinary research into the material, technological, economic, social, and ecological changes in the Balikh valley during the Late Neolithic, the seventh and early sixth millennium BC, as well as establishing an accurate chronological framework for the site in this period.

Aims and objectives

The main aim of this project is to analyse abrupt climate change and cultural transformation in the Balikh Valley in the Late Neolithic (c. 6900 – 5900 BC), a period that is central to research into the development of the first complex societies in the ancient Near East. This project is primarily based on the analysis of an extensive sample of animal bones from well-defined archaeological contexts from the site of Tell Sabi Abyad. More specifically, the aims of this PhD project are to analyse the changing patterns of animal exploitation at Tell Sabi Abyad and to put this in its temporal and regional context. Within this remit there are several explicit objectives:

- Analyse and record faunal material from the Pre Pottery Neolithic B (PPNB) through to Pottery Neolithic (PN) phases (c. 6900 – 5900 BC)
- Study the taphonomy of the material
- Reconstruct the local spectrum of domestic and wild faunal
- Assess the process of animal domestication, the role of domestic animals in the subsistence economy, the composition of herds, animal husbandry development and secondary product exploitation.
- Investigate the contribution of hunting to the diet.
- Explore animal exploitation through time.
- Consider the relationship between the fauna and its natural environment, particularly considering the 8.2k cal BP climate change event.
- Explore the possibilities for isotope studies into diet, mobility, and climate change.

These analyses will be undertaken in order to help answer certain key research questions.

Research Questions

The archaeozoological analysis was undertaken with several research questions in mind:

- What was the local spectrum of wild and domestic fauna, how and to what extent were these animals exploited and how did this change through time?
- What was the domestication status of the animals exploited and what was the role of domestic animals in the subsistence economy in the different phases?
- How did the composition of herds, the strategies of herd management and animal husbandry develop through time?
- What was the relationship between the fauna and its natural environment?
- Is there any evidence of the effects of climate change in the faunal material?

This study will focus explicitly on answering these key research questions. Little is known about many aspects of animal based subsistence in the Late Neolithic in the Balikh Valley and in Northern Syria in general (see chapter 3), and it is hoped that this research project will shed light on this pivotal period of prehistory.

1.3 Research problems

There are several problems associated with research in this area and time period to consider. One of the main problems with research in this area is the lack of analysed and/or published faunal reports from sites of the seventh millennium BC. There are so few studies, particularly ones of a large sample size, that the scope for comparative studies is severely limited. As such the analysis of Tell Sabi Abyad material is very important. Another difficulty worth mentioning is that all material was recorded in the field without a reference collection available. Near Eastern material is particularly problematic to identify without reference material as there are so many morphologically similar species of animal such as medium ungulates (sheep, goat, gazelle, and roe deer). To overcome this problem an intensive study of the differentiation of medium ungulates was undertaken before fieldwork.

Attacking such problems as detecting climate change in the faunal material is complicated to say the least. Such a task is daunting and the only way to tackle it is to look intensively at the animal bones and consider all the other factors coming into play, such as culture. Off course every settlement is unique, but looking in-depth at one site as a case study is a good way to look at local trends.

1.4 Thesis outline

This book is divided into nine chapters, including this brief introduction. Chapter 2 provides the stratigraphic background for this research and includes a brief discussion of settlement in the Balikh, the settlement structure and architecture of Tell Sabi Abyad, the pottery, lithics and small finds at the site. Chapter 3 provides the geographical, environmental, palaeobotanical and zooarchaeological framework of the region and this research. Chapter 4 explores the issue of climate change in archaeology and discusses the 8.2k event and the possible effects of such an event on culture and subsistence in the Balikh Valley in the Late Neolithic period. Chapter 5 outlines the zooarchaeological methodologies used in this research as well as important considerations to the data analysis (i.e. taphonomy). Chapter 6 reviews all the zooarchaeological analysis undertaken. Chapter 7 contains the test study into isotope analysis of ovicaprid diet at Tell Sabi Abyad and a discussion of the results. Chapter 8 is concerned with the interpretation of the vast quantities of zooarchaeological data analysed in chapter 6. In this chapter the temporal changes in animal exploitation, intra-site spatial differences in animal exploitation, animal domestication, husbandry and herd management, environmental exploitation and the relationship between the fauna and its natural environment, food processing, and secondary product production will all be considered in detail based on the new data analysed in this research project. This new data is then integrated with previous research at both Tell Sabi Abyad and contemporary sites in the region. Finally the faunal data will be discussed with the 8.2k event in mind, with any evidence for or against climate change as a forcing factor thoroughly examined. Chapter 9 addresses the research questions outlined in this chapter in light of the new data presented in chapter 6 and 7, and the discussions of chapter 8. Some final comments and possible new directions for future research conclude this study.

Chapter 2 Settlement Archaeology of Tell Sabi Abyad

2.1 Introduction

Tell Sabi Abyad is located in the upper Balikh region of northern Syria. The site is situated approximately 30 kilometres from the Syro-Turkish border and about two kilometres south of the modern village of Hammam et-Turkman. Tell Sabi Abyad is part of a cluster of mounds, locally known as Khirbet Sabi Abyad, dating back to the seventh and sixth millennium BC (see fig 2.1). It is the continued excavation of the largest of these mounds, known as Tell Sabi Abyad I, which provided the animal material for this study². Tell Sabi Abyad measures in the region of 240 x 170 metres at its base and rises between five and ten metres above the surrounding fields. Much of the prehistoric mound is deeply buried with the earliest deposits occurring at a depth of two to four metres below the modern field level. With a maximum surface of four to five hectares Tell Sabi Abyad is the largest site in its immediate environment. The mound as it appears today is misleading as it is not a single coherent site; it is in fact four low, contiguous mounds, each with its own history of settlement that have merged over time giving the illusion of one single site (fig 2.2) (Akkermans *et al.*, 2006). These four small, adjoining settlement mounds arose in the seventh millennium, two of them in the early half of the period and another two to the east of the original ones after 6200 BC (Akkermans *et al.*, 2006). Although intensive and contemporaneous use sometimes led to the merging of the separate occupations, they seem generally to have maintained a considerable degree of individuality and autonomy. The settlement shifted in the course of time, and during much of its history large parts of the mound were left empty. This pattern of intrasite movement and localised abandonment of occupation was part of the natural development cycle of the prehistoric communities at Tell Sabi Abyad (Akkermans *et al.*, 2006) and at other Late Neolithic settlements in the Balikh (Akkermans, 1993). Occupation of the mound seems to have begun c. 6900 BC if not before, and it continued until c. 5700 BC (Early Halaf).

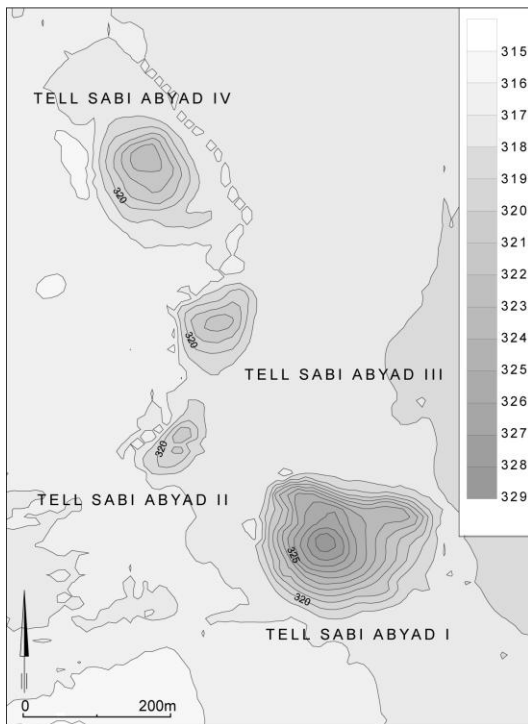


Fig 2.1: Tell Sabi Abyad Mounds

² Tell Sabi Abyad I will from now on simply be referred to as Tell Sabi Abyad

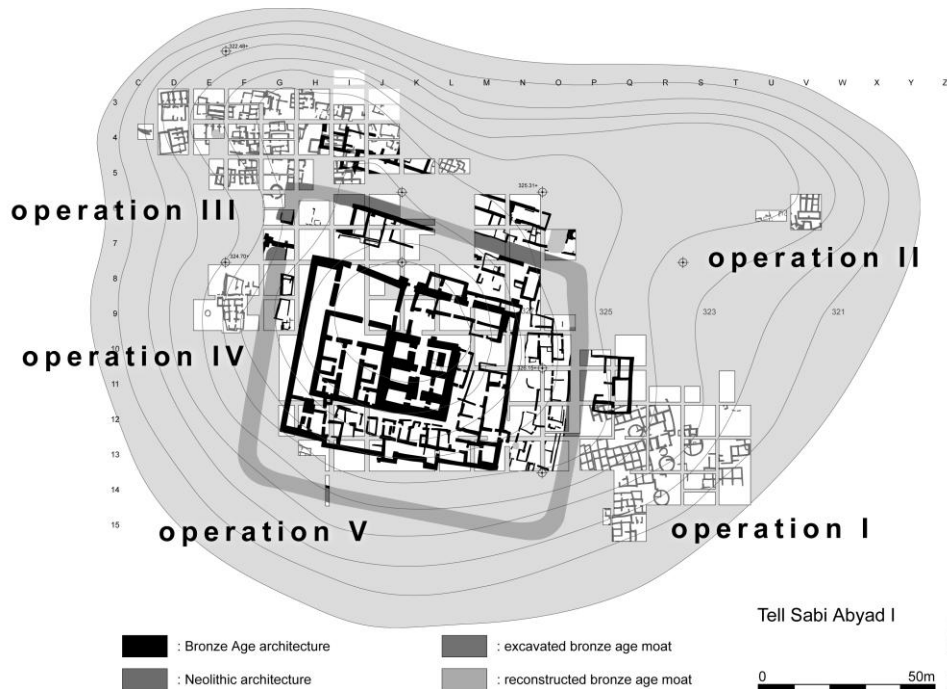


Fig 2.2: Excavation areas

The site was excavated using 9 x 9 metre square trenches, often with a section baulk running through the middle of the trench. Sometimes half squares of 4.25 x 9 metres were excavated. Each square trench is given a letter and number responding to its grids reference (see figure 2.2). There are five main areas of excavation at the mound: Operation I to V. The starting point for excavations at Tell Sabi Abyad was the broad horizontal exposure on the relatively low and gently sloping south-eastern portion of the site: Operation I. An area of 1,400 m² was excavated in Operation I from 1986 - 1999, with at least 11 main levels of settlement identified and dated to 6200 – 5800 BC (Akkermans, 1989; Akkermans and Verhoeven, 1995; Akkermans *et al.*, 2006). Four further areas in different parts of the tell were then excavated. Operations II, IV and V involve only small areas of between 100 and 400 m² and contained stratified deposits assigned to the seventh or early sixth millennium BC. The north-western area known as Operation III is the focus of this study. In the excavation seasons 2002 to 2008 over 1,600 m² were excavated in this area revealing a very complex settlement history. These extensive excavations and the comprehensive stratigraphic analysis that followed (Kaneda in prep.) clearly indicate that the mound at Operation III is not composed of a single compilation of habitation horizons but is instead made up of three distinguishable sequences of occupation (see fig 2.3).

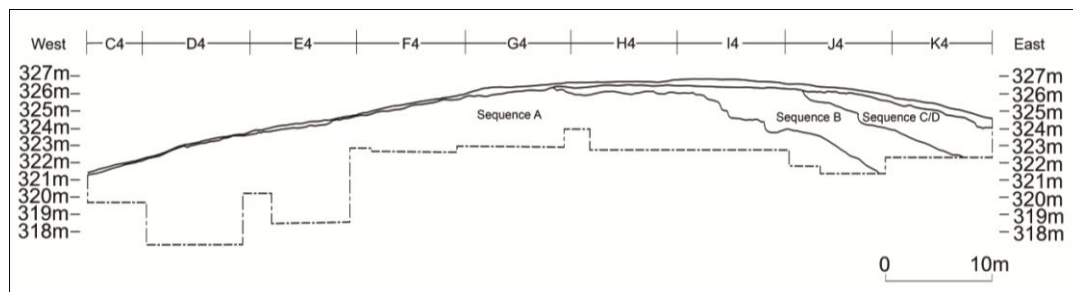


Fig 2.3: Tell Construction at Operation III

The stratigraphy of Operation III is discussed in more detail in section 2.4.

The excavations at Tell Sabi Abyad in northern Syria have provided important new information on the nature and development of the Pottery Neolithic settlement at the site in the seventh and sixth millennium BC (Akkermans *et al.*, 2006) (fig 2.4). The fieldwork has produced a long sequence of small and continually shifting occupations, in the order of 0.5-1.0 ha, each with rich assemblages of very early ceramics and other artefacts.



Fig 2.4: Extensive excavations at Tell Sabi Abyad Operation III

2.2 Stratigraphy and chronology

The stratigraphic analyses were carried out by Kaneda as part of her research project (Kaneda in prep.). The results of this analysis are briefly summarised here. There are three sequences of mound formation at Operation III (fig 2.3) named A, B and C. Sequence A represents the earliest occupation and dates to c. 6900 to 6200 BC (PPNB to Early PN). The settlement at Sequence A was abandoned around 6200 BC and a new settlement was founded on the eastern slope of the mound. This new settlement area is known as Sequence B. Sequence B dates from c. 6200 – 5900 BC (Pre-Halaf and Transitional pottery periods). There are noticeable differences between Sequence A and B with current dates suggesting that the transition between these two periods was realised within a very short span of time around 6200 BC. It is important to emphasise however that there is no collapse. There is change, but not total site abandonment. There is in general a tendency for the village to shift from west to east with each new level constructed slightly to the east on the ruins of the previous habitation. The transition from Sequence A to Sequence B can to some degree be seen as the final step in this progressive, continuous, long-term movement from west to east. Finally, Sequence C was founded on top of Sequence B c. 5900 BC and continued to at least c. 5500 BC (Early Halaf to Late Halaf periods). Within Sequence A twelve occupation levels were identified, A1 to A12, within Sequence B eight levels were identified, B1 to B8, and within Sequence C a further eight levels were identified. How these levels fit into the chronological sequence at Tell Sabi Abyad and the adjacent mounds of Tell Sabi Abyad II and III are summarised in figure 2.5.

Date cal. BC	Period	Tell Sabi Abyad I - operations					Tell Sabi Abyad II	Tell Sabi Abyad III
		I	II	III	IV	V		
5700	Middle Halaf			level C-1				
5800	Early Halaf	level 1						
		level 2						
5900		level 3	level 1	level C-2/8				
	Transitional	level 4	level 2					
		level 5	level 3	level B-1		phase III		
6000		Burnt Village	level 4	level B-2				
	Pre-Halaf	level 7		level B-3				
		level 8		level B-4				
6100		P-15 - 8		level B-5		phase II		
		P-15 - 9		level B-6				
6200		P15 - 10		level B-7				
	Early Pottery Neolithic			level B-8				
				level A-1				
6300				level A-2				
				level A-3	level 1	phase I		
6400		P-15 - 11		level A-4	level 2			
				level A-5				
6500				level A-6				
				level A-7				
6600				level A-8				
				level A-9				
6700				level A-10			level 1	trench H7
	Initial PN			level A-11				
6800				level A-12			level 2	trench H8
6900								
7000	Late PPNB						level 3	trench H9
7100							level 4	

Fig 2.5: Chronology summary*Radiocarbon dates*

For Sequence A there are 121 radiocarbon dates and for Sequence B there are 40 radiocarbon dates available. The material dated was charcoal, charred seeds and wood from secure contexts. The radiocarbon measurements were undertaken at the Centre for Isotope Research in Groningen. A summary of the radiocarbon dates can be found in table 2.1 and for more detail I refer you to Kaneda (in prep.).

Table 2.1: Radiocarbon dates by level

Level	Radiocarbon dates (all dates are cal BC)
C	No dates available
B1	No dates available
B2	No dates available
B3	6040 – 5995
B4	6050 – 6015
B5	6075 – 6040
B6	6095 – 6065
B7	6125 – 6080
B8	6180 – 6105
A1	6335 – 6225
A2	6385 – 6330
A3	6395 – 6375
A4	6455 – 6390
A5	6495 – 6455
A6	6505 – 6485
A7	6605 – 6495
A8	6630 – 6590
A9	6675 – 6620
A10	6750 – 6675
A11	6825 – 6740
A12	6865 – 6770

Although radiocarbon dates place the end of level A1 to 6225 BC and the beginning of level B8 to 6180 BC, these dates have a probability distribution and Bayesian analysis has shown that the end of Sequence A occurred 6250 – 6220 BC and that Sequence B began 6240 – 6135 BC (error margin 1-sigma). There are clear changes in settlement structure and material culture at the A1/B8 transition (see below).

2.3 Settlement structure and architecture

Excavations at Operation III Sequence A exposed large numbers of architectural remains with compounds frequently being built or rebuilt either on the slope of the mound or on a levelled surface, often using the in-filled walls of earlier buildings as a form of foundation platform. Different building forms and patterns were revealed, mostly made of roughly-shaped handmade mud-bricks formed out of the local clay. Roofs were made using wooden poles covered in a layer of reeds covered in a thick layer of mud. Both round and rectangular architecture was uncovered with rectangular shapes being by far the most common. Apparently, the inhabitants of Tell Sabi Abyad felt the need to build two very different forms of buildings at Operation I (Verhoeven, 1999: 214). In Operation III, round buildings were only present late in the A sequence (from level A4, c. 6455 - 6390 BC) and were very rare. Buildings in each occupation level were constructed repeatedly in the same location or next to deserted buildings. Some buildings demonstrate identical or comparable features over subsequent occupation levels suggesting continuity in building location and form over several generations. In some instances buildings were deliberately filled in with either refuse, the debris of demolished buildings or with mud-bricks to create the foundation for a new building. There are large buildings measuring up to 9 x 9 metres, as well as small buildings with multiple rooms measuring in some cases only 1 x 1.5 metres. These small rooms seem too small and narrow to have been used as a living space and are hypothesised to be storage rooms.

For an in-depth analysis of each stratigraphic level I refer you to the PhD study of Akemi Kaneda. In the following section a brief summary of the settlement area uncovered for each level will be given and a plan of each level is shown in figures 2.6 to 2.25 (some of the levels are split into sub-phases based on architecture and other features; where there are sub-phases only one sub-phase is shown). These plans are included to give an impression of the excavated area containing material from each level only and for an in-depth description I again refer you to Kaneda (in prep.).

Level A12 (6865 – 6770 BC)

This level represents the earliest occupation phase analysed in this study. Only trench E4 contained this occupation phase. The excavated area consists of parts of a large building with an open area to the north. The core of the living area in this phase seems to be located to the south or east of the excavated area. The total excavated area is approximately 33 m². Faunal deposits were analysed from all contexts in trench E4.

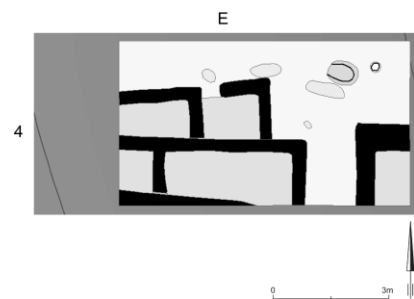


Fig 2.6: Level A12 sub-phase A

Level A11 (6825 – 6740 BC)

As in level A12 this level consists of buildings and open areas. A small fire pit was also present (trench E3). Trenches D4, E3 and E4 contained this occupation phase. The excavated area extends to around 109 m². Faunal data from all contexts was analysed from trenches E3 and E4. Material from trench D4 was not included in the recorded sample.

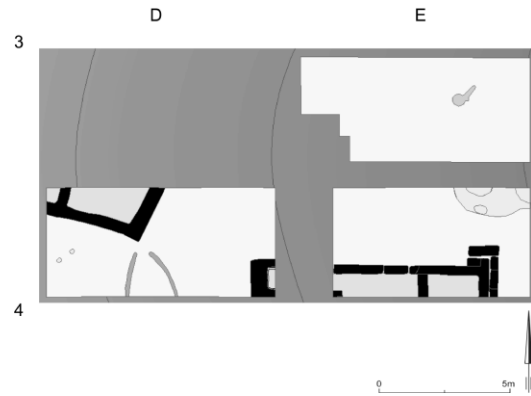


Fig 2.7: Level A11 sub-phase A

Level A10 (6750 – 6675 BC)

The excavated area of this level extends to c. 129 m² and includes trenches C4, D4, E3 and E4. There are large areas of open area in this level with a number of pits and fire-pits. There are also buildings present. It seems as if this area may have been on the slope of the tell at the edge of the settlement. Faunal data from all contexts was analysed from trenches E3 and E4. Material from trenches C4 and D4 was not included in the recorded sample.

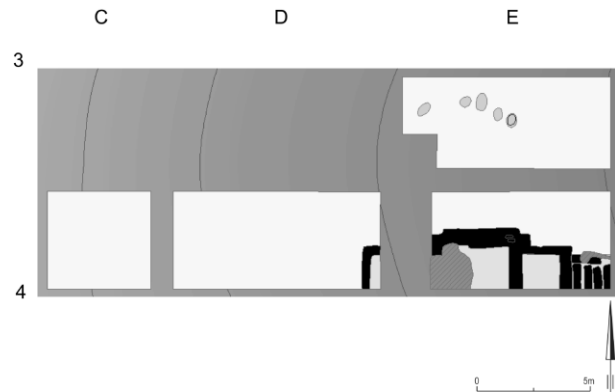


Fig 2.8: Level A10 sub-phase A

Level A9 (6675 – 6620 BC)

The excavated area covers c. 129 m² and includes trenches C4, D4, E3 and E4. This occupation phase consists of open areas with some fire pits and pits. There was one building which was disturbed by a large pit dated to level A8. Faunal data from all contexts was analysed from trenches E3 and E4. Material from trenches C4 and D4 was not included in the recorded sample.

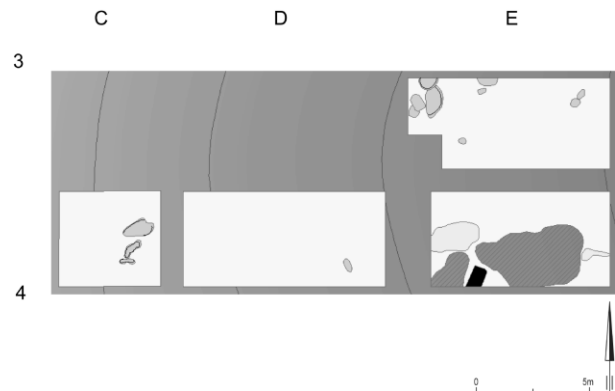


Fig 2.9: Level A9 sub-phase A

Level A8 (6630 – 6590 BC)

Trenches C4, D3, D4, E3 and E4 contained this occupation phase over an area of c. 210 m². The layout of the settlement seems to have changed in this level based on the architectural arrangement of the site, with the main occupation area shifting to the north. The southern area was deserted and large pits were dug into the levelled area (trenches C4, D4 and E4). There is a large open area between buildings with a concentration of fire-pits and/or hearths. Faunal data from all contexts was analysed from trenches E3 and E4. Material from trenches C4, D3 and D4 was not included in the recorded sample.

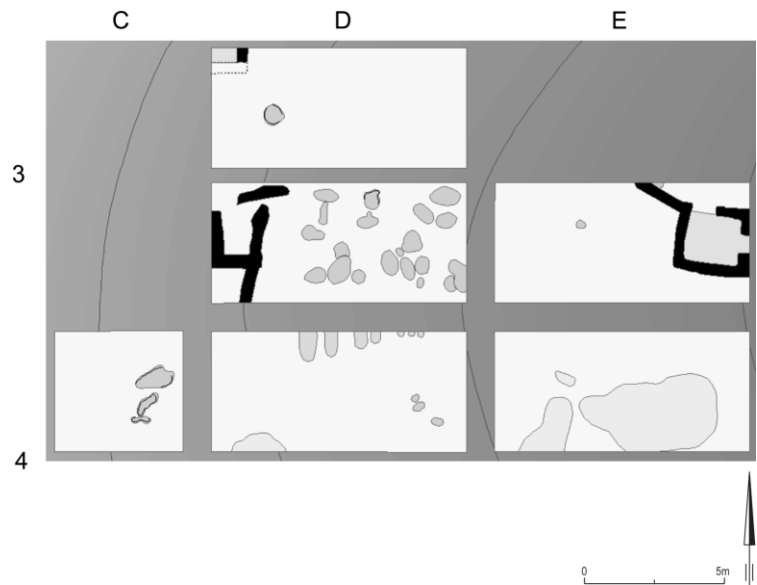


Fig 2.10: Level A8

Level A7 (6605 – 6495 BC)

Level A7 covers an area of c. 210 m² over trenches C4, D3, D4, E3 and E4. Within the area of excavation, this level contains no buildings and consists of a large open area with fire-pits and ovens. Faunal data from all contexts present was analysed from trenches E3 and E4. Material from trenches C4, D3 and D4 was not included in the recorded sample.

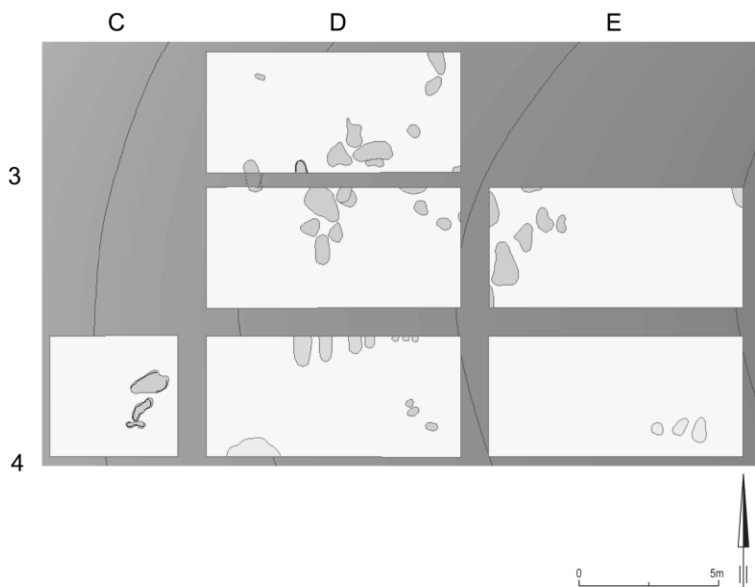


Fig 2.11: Level A7 sub-phase A

Level A6 (6505 – 6485 BC)

The excavated area is c. 249 m² in this level including trenches C4, D3, D4, E3 and E4. Extensive, multi-roomed buildings were constructed in the open area of the previous level with an open area to the south containing fire-pits. Faunal data from all contexts was analysed from trenches E3 and E4. Material from trenches C4 and D4 was not included in the recorded sample. The bones analysed were therefore derived from mostly open areas between a large building in trench D3 and a part of a building in the south-eastern corner of trench E3.

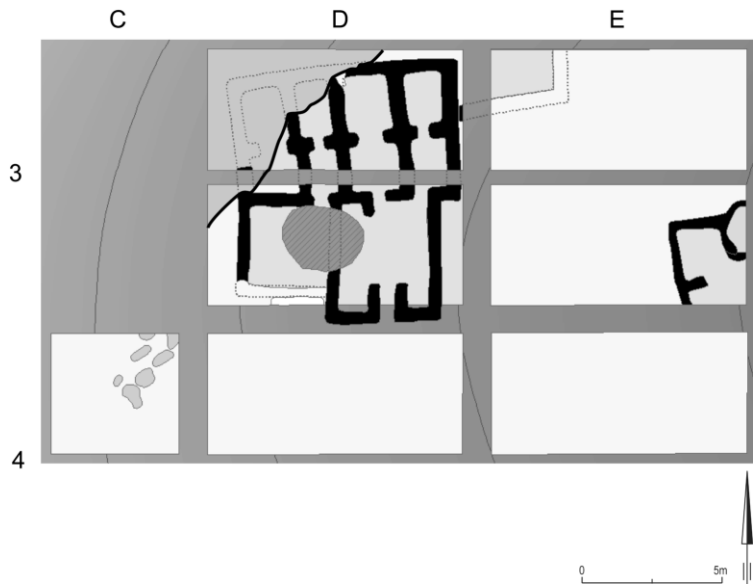


Fig 2.12: Level A6 sub-phase A

Level A5 (6495 – 6455 BC)

The excavated area containing this occupation phase is large at c. 881 m² including trenches C4, D3, D4, E3, E4, F3, F4, G3, G4, H3, H5 and I2. There is a large area containing buildings, many of which had plastered floors and some of which contained plastered bins, hearths and ovens. Faunal material was recorded and analysed from all contexts in trenches E3, E4, F4 and H5. Areas F4 and H5 consist largely of open areas while areas E3 and E4 contain buildings within the settlement.



Fig 2.13: Level A5 sub-phase A

Level A4 (6455 – 6390 BC)

Level A4 is one of the occupation phases with the largest excavated area. An area of c. 1066 m² including trenches C4, D3, D4, E3, E4, E5, F3, F4, F5, G3, G4, G5, H3, H5, I2 and I3 depending on the sub-phase. Several large buildings were present in this area, with buildings spread over the settlement, surrounded by open areas, with courtyards between some buildings. This level contains the first circular building (in trench F3). The western area (D trenches) was abandoned as a living area with buildings levelled, converting the space to an open area with large pits. Faunal material was recorded and analysed from all contexts in trenches E3, E4, F4, G5, H5 and I3. Both dense settlements areas and open areas were therefore analysed.

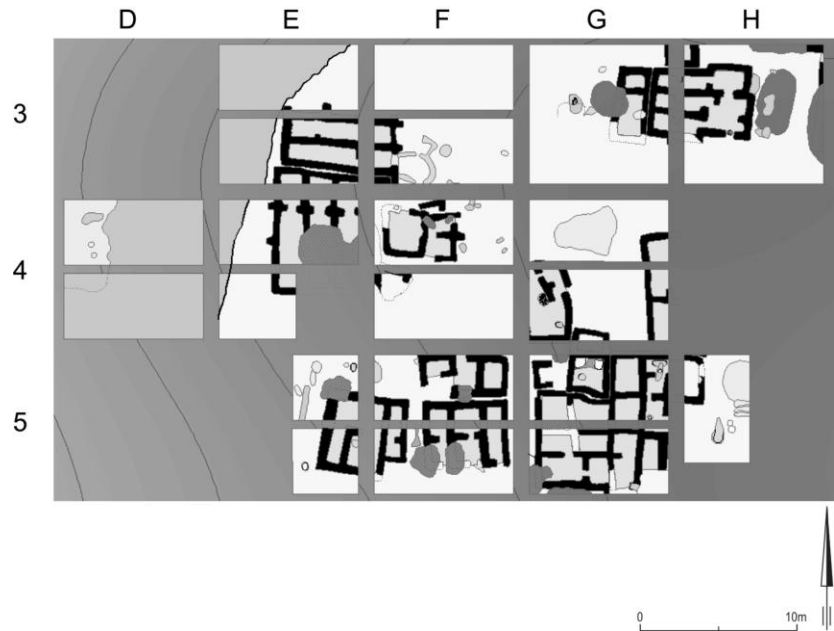


Fig 2.14: Level A4 sub-phase A

Level A3 (6395 – 6375 BC)

An area of c. 869 m² was excavated from this occupation phase but far less architecture was uncovered. The following trenches contained this level: E3, E4, E5, F3, F4, F5, G3, G4, G5, H3, H4, H5, I2, I3 and I5. The western and northern areas of the exposed settlement consist of large open areas with large pits. In contrast to previous levels, buildings were tightly clustered together in this level. All buildings seem to have been constructed at the same time. It appears as if the area surrounding these buildings was deserted. Faunal data from trenches E3, E4, F4, G5, H5 and I3 was analysed. Only trenches G5 and H5 in this sample contained buildings.

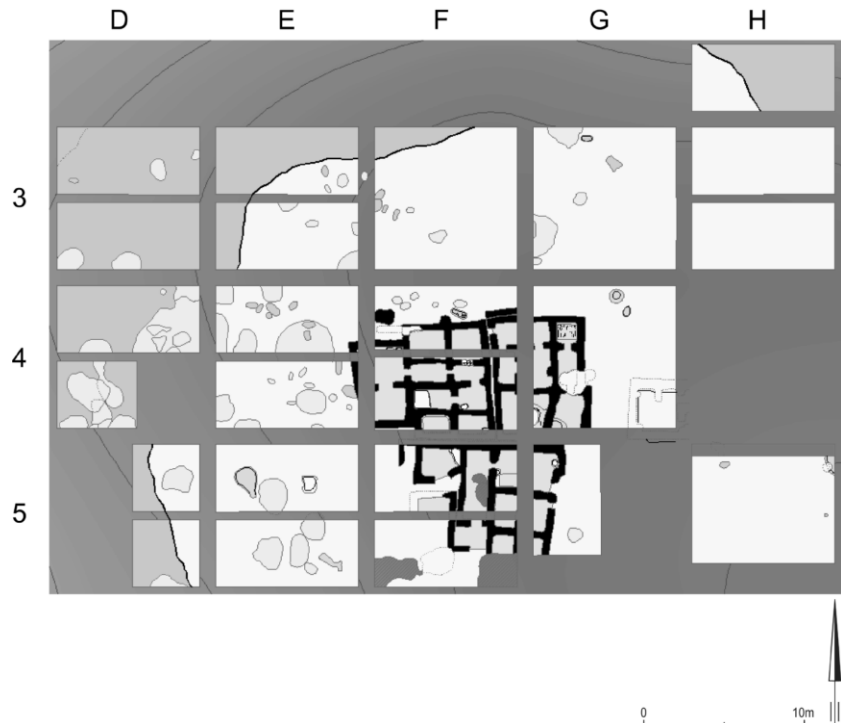


Fig 2.15: Level A3

Level A2 (6385 – 6330 BC)

An area of c. 872 m² was uncovered from this level from trenches F3, F4, G3, G4, G5, H3, H4, H5, I2, I3, I4 and I5. In comparison with the settlement structure in the previous level, the settlement seems to have been deliberately reorganised in terms of the location and type of buildings. The buildings in level A3 were levelled in order to create a new settlement with smaller and more compact buildings spread over the settlement site. Faunal data from all contexts in trenches F4, G5, H5, I3 and I4 was included in this study. Areas G5, I3 and I4 contain small buildings surrounded by open areas while the other areas sampled consist mostly of open areas.



Fig 2.16: Level A2 sub-phase A

Level A1 (6335 – 6225 BC)

This level was uncovered in trenches F3, F4, F5, G3, G4, G5, G6, H3, H4, H5, I3, I4, I5, J4 and J5. The area excavated for this level is c. 1091 m². The settlement area in this level consists of several different building types dispersed over the settlement site. In comparison to the previous levels, there is an increasing number of buildings constructed, most of them freestanding with several rooms. The settlement shifted somewhat to the east in this level, with the buildings in the west eventually being abandoned. The buildings in the east were joined by new buildings resulting in a reduction in open spaces between buildings. Faunal data was recorded and analysed from trenches F4, G5, H5, I3 and I4. I3 and I4 contain mostly open opens while the other areas sampled contain building complexes.



Fig 2.17: Level A1 sub-phase C

Level B8 (6180 – 6105 BC)

Level B8 represents the earliest occupation level with Sequence B and covers an area of c. 760 m² in trenches G5, H3, H4, H5, I3, I4, I5, I6, J4 and J5. No architectural remains were found, with the exception of large numbers of pits, fire-pits and ovens spread over an open area. It is difficult to determine where the buildings from this occupation level are located but it is speculated that they lie to the east of the excavated area. Faunal data was recorded and analysed from trenches G5, H5, I4 and J4, which, with the exception of J4, were devoid of architecture.

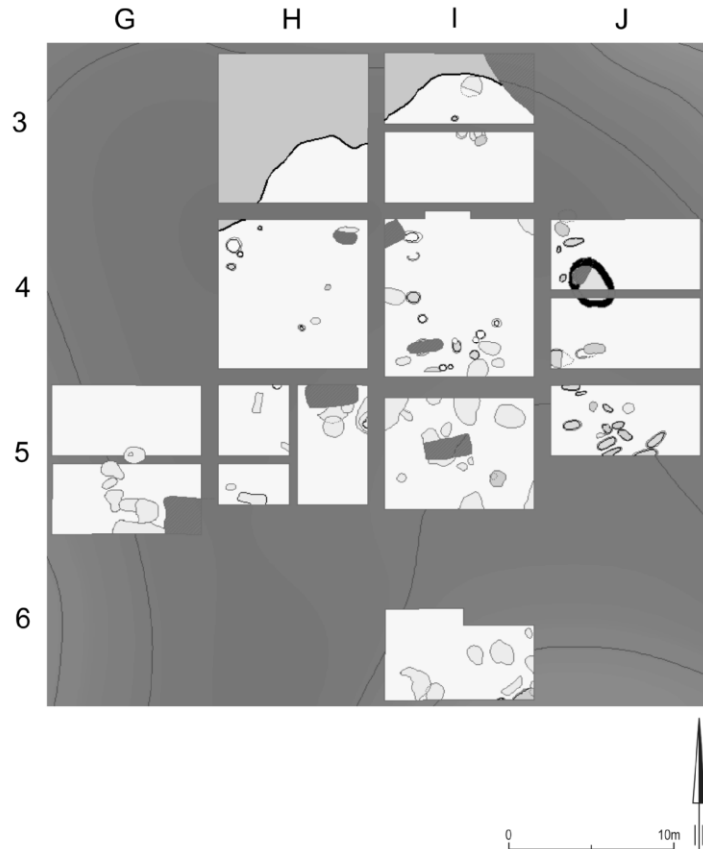


Fig 2.18: Level B8 sub-phase A

Level B7 (6125 – 6080 BC)

Level B7 is a deposit on the eastern slope of Sequence A covering c. 414 m² within trenches I3, I4, I5, J4 and J5. The settlement in this area consists of an open area on the slope of the mound with pits, fire-pits and bins. Few architectural remains were found, namely a circular building with a semi-circular extension. Faunal data was recorded and analysed from trenches I4 and J4, which mostly consist of open areas with the exception of a circular building in J4.



Fig 2.19: Level B7 sub-phase B

Level B6 (6095 – 6065 BC)

Level B6 covers an area of c. 414 m² with trenches I3, I4, I5, J4 and J5. Unlike the previous phase there is a relatively large building complex in this level. Open areas consisted of accumulated layers and ash. Faunal data was recorded and analysed from trenches I4 and J4 both of which contain open areas and building in this level.



Fig 2.20: Level B6 sub-phase A

Level B5 (6075 – 6040 BC)

Level B5 consists of an area of c. 414 m² found within trenches I3, I4, I5, J4 and J5. There were no architectural remains in this area which contained only wall debris, ash and ovens. The main settlement has presumably shifted to the east. Faunal data was recorded and analysed from trenches I4 and J4. I4 was relatively empty of features while J4 contained ovens.

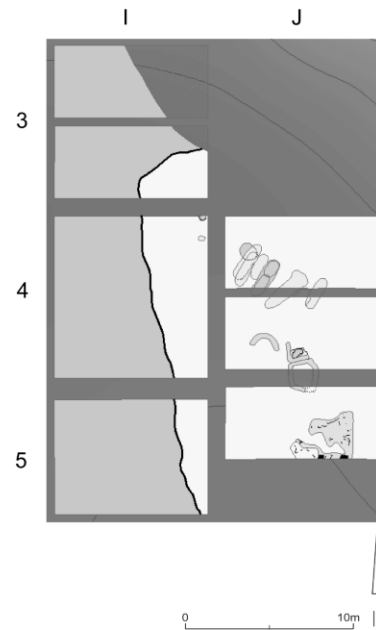


Fig 2.21: Level B5 sub-phase A

Level B4 (6050 - 6015 BC)

Level B4 relates to an area of c. 452 m² in trenches I3, I4, I5, J4, J5 and K5. There were very few architectural remains in this level, only large open areas, the remains of some walls that may have formed a kind of enclosure, and a round structure that was interpreted as a silo which was later reused as an oven. There were also several pits. This area appears to be at the western limit of the Sequence B settlement. Faunal data was recorded and analysed from squares I4 and J4 both of which were relatively devoid of features in this level.



Fig 2.22: Level B4 sub-phase A

Level B3 (6040 – 5995 BC)

This level is located at the most eastern edge of Operation III, trenches K5 and L5. An area of c. 76 m² was excavated. There is a large building located in this area with at least 11 rooms. To the west of the building is an open area containing wall debris and ash. The building in this level is abandoned and levelled before the beginning of the next level, leaving an open area dotted by pits and fire-pits. Only faunal data from trench K5 was recorded and analysed. This area was an open area west of a building complex.

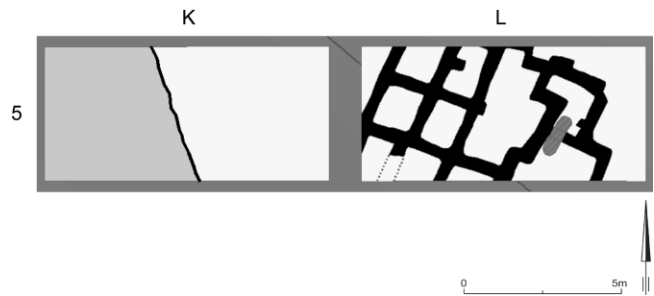


Fig 2.23: Level B3 sub-phase B

Level B2 (no radiocarbon dates)

A similar sized area was excavated in level B2 (c. 77 m²) in which a comparable building to that seen in level B3 was constructed in the same location. This is a relatively large building with many rooms and a gutter running along the western wall. On the other side of the gutter is a large open area. This area appears to be the western limit of the settlement of Sequence B with the rest of the settlement presumably extending to the east and south. Only faunal data from trench K5 was recorded and analysed. This area was mostly an open area in this level but it also contained a part of a large building found to the west.

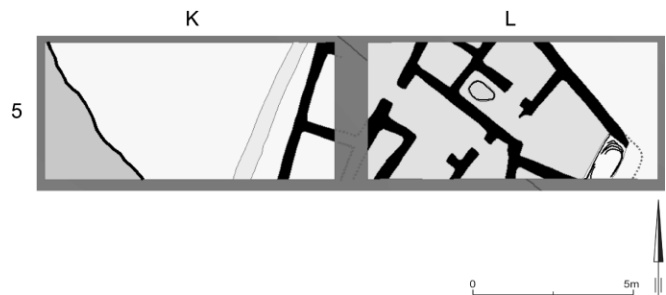


Fig 2.24: Level B2

Level B1 (no radiocarbon dates)

This small area (c. 38 m²) in trench K5 is devoid of recognisable architecture with only an oven and pits present in the north-western corner. Faunal data was recorded and analysed from trench K5.

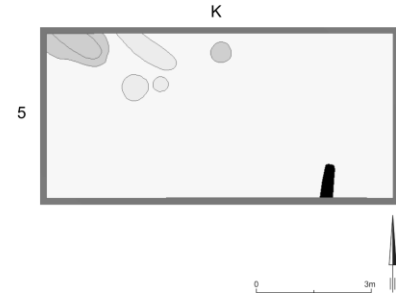


Fig 2.25: Level B1

These stratigraphic divisions were based on the building levels, regardless of cultural chronology based on material studies or radiocarbon dates. The stratigraphy reflects the occupational behaviour of the inhabitants of the village at Operation III. This settlement was founded sometime at the end of the PPNB cultural phase. The earliest levels analysed here date to 6865 BC (level A12) but stratigraphic levels older than this were discovered in the 2009 excavations (levels A13 and A14 not discussed here). The earliest occupation was located at the western portion of the Operation III area but through time the core of the settlement shifted from west to east. Within this general trend there was a great deal of internal reorganisation of the settlement. Sometimes buildings were clustered together, but they were more often dispersed within the settlement area. It is possible that these separate clusters of buildings may have represented differences in function, kinship or tradition. Although the village at Tell Sabi Abyad clearly had a year-round occupation, both the settlement and the people at Tell Sabi Abyad were apparently highly dynamic.

In levels A12-A9 buildings tend to be built in the same location as previous buildings but this changes after level A9 when the settlement shifts to the east, the architectural style however remains more or less the same. There is a change in architectural style between levels A3 and A2 with buildings becoming smaller and simpler. In general however, there was continuity in building styles and architecture in levels A12 to A2, with a more 'chaotic' settlement structure appearing in level A1 (c. 6335 – 6225 BC). This is the last level in which settlement is focused in the Operation III area, with the settlement focus moving to the east half of the mound after this time.

The settlement in the A levels at Operation III is characterised by buildings with one or two larger 'living' rooms and several smaller 'storage' rooms. In these levels households seem to be autonomous with their own storage areas contained within the house. It is hypothesised that there was little specialisation and that agricultural and pastoral activities were undertaken by each household, working together as a community. Within a generation this community structure rapidly changed, and after level A1 (after 6225 BC) a new form of settlement was present on the eastern half of the mound, an area known as Operation I. In Operation I each household no longer had its own storage facilities; instead large communal storage areas were built. It has been argued for the village located at Operation I (c. 6200 – 5700 BC) that the society was made up of two groups: the permanent residents and the mobile or transhumant component which only made use of the site for specific purposes at specific times of the year (Verhoeven, 1999: 203; Akkermans and Duistermaat, 1997: 27; Cavallo, 2000). The presence of communal storage buildings at the site are hypothesised to have served the needs of not only the settled population but also those more mobile elements. Hundreds of clay *sealings* found at the site have been argued to have facilitated the communal storage of various products and claims by a pastoral population of considerable size (Akkermans and Duistermaat, 1997). The sealings were apparently applied to small containers, such as baskets, leather bags, stone bowls and pottery, to protect their contents during storage (Akkermans, 1993: 239). Small objects known as *tokens* were also found and have been hypothesised to have been used to signify amounts and quantities of perhaps cereals or animals (Akkermans and Duistermaat, 1997; Duistermaat and Schneider, 1998). Both sealings and tokens indicate control over access to goods perhaps used by more mobile aspects of the community to secure their belongings in the communal storehouses.

at the site. These non-residential groups are thought to have been involved in a pastoral mode of subsistence in the Balikh valley and neighbouring areas (Verhoeven, 1999: 207)³. The dichotomy between nomads and residents was probably very weak, with close connections between the “mobile pastoralists” and the “sedentary agriculturalists” (Akkermans, 1993: 210; Verhoeven, 1999: 207). On the basis of ethnographic and historical evidence Akkermans and Duistermaat (1997) suggest that large sites such as Tell Sabi Abyad and Tell Mounbatah may have acted as winter camps for mobile pastoralists, providing food, shelter and security. Population estimates vary. Akkermans (1993: 166) hypothesises that the population of Tell Sabi Abyad in the Halaf period was only very small and consisted of just four or five households which together comprised a population of 30 to 50 persons. Verhoeven (1999: 212-213) suggests a larger permanent population of 60 to 120 persons, with a total community size of 460 to 790 persons including the mobile components in these Halaf levels.

There was obviously a great deal of reorganisation between Operation III and Operation I, not only in the area of settlement (a shift to the east) but also in settlement layout and structure. This change is apparently due to a major shift in the way people lived, with a move away from autonomous, equal households involved in agro-pastoralism to a differentiated community of sedentary agriculturalists who lived at the site all year round and mobile pastoralists who spent much of the year out in the landscape. This change was apparently also associated with an increase in the total number of people who made use of Tell Sabi Abyad as a base. Such a rapid change in the location and organisation of the settlement must presumably have been part of an active and conscious decision to change, perhaps in response to some external stimuli. The analysis of the faunal material from Operation III will test this hypothesis.

2.4 Contexts

Several contexts were encountered during the excavations. These include basins, bins, burials, constructions, floors, gutters, hearths, open areas, ovens, pits, platforms, room fills and vessels. A brief description of these contexts is provided below:

- Basin: a basin refers to a plastered depression, often inside structures in a floor. These could be natural in origin, due to subsidence of a floor, or may have been formed intentionally
- Bin: bins are found inside buildings and outside in open areas. They are intentionally made storage areas, some of which are plastered
- Burial: pit containing human skeletal remains
- Construction: refers to walls, foundations etc.
- Floor: the floor of a building, often plastered. Material said to come from this context was found directly on the floor
- Gutter: only one gutter was found (level B2); a long shallow ditch like feature running along side a building on a slope, perhaps acting as a drain.
- Hearth: a fireplace
- Open area: areas devoid of architecture, either between buildings or outside building areas
- Oven: a clay built structure presumably used for cooking or perhaps manufacturing artefacts
- Pit: a hole dug into the ground
- Platform: a surface constructed mostly of large mud-brick slabs often used as a foundation for a building
- Room fill: All the material found within a building, excluding material found directly on the floor surface.
- Vessel: vessels made of either ceramics, stone or white ware.

The faunal data from each of these contexts will be analysed to try to detect contextual differences in deposition and therefore intra-site differences in animal exploitation.

³ For a definition and discussion of pastoralism see chapter 3

2.5 Pottery

The ceramic analysis was carried out by Olivier Nieuwenhuyse and for a far more detailed presentation of this material I refer you to Nieuwenhuyse (in prep.). Vast quantities of pottery were recovered from the settlement area at Operation III. Very small samples of pottery sherds were recovered from the earliest A levels (A12 and A11), which represents a period at the very start of the Pottery Neolithic and represents brief stage in which very few vessels were in daily use (“Early Mineral Light Ware” and “Early Mineral Dark Ware”). Level A9 seems to be a transitional phase characterised by a rapidly increasing number of pottery vessels. Levels A12 to A10 are distinguished as a separate ceramic phase in which the pottery is very distinctive in terms of the regular shape of the vessels, their limited size, their carefully finished surfaces and decoration by slipping or painting. This phase is followed by a long period dominated by coarse, plant-tempered ceramics. Alongside this pottery a new, finely made mineral-tempered ware appears in the assemblage (“Early Fine Ware” and “Early Grey-Black Ware”). While always present in low proportions, there is a peak in levels A4 to A2. More significant is the introduction of small proportions of “Dark Faced Burnished Ware” in level A1. These wares are characteristic of the Pre-Halaf period. This form of pottery is non-local and most likely imported from Anatolia.

The pottery in levels A9 to A6 was relentlessly plain, with a proportion of “decorated” pottery of practically zero. Various decorative techniques were introduced between levels A5 to A3, but the proportion of decorated pottery as a whole remains very, very low. From level A2 this proportion gradually starts to rise. The decorative techniques attested in level A2-A1 include: painting, incising, red-slipping, appliqué, and impressing. All of these techniques are common in the Pre-Halaf levels identified at Operation I.

There are also differences in vessel shape and function through time. The earliest levels are characterised by simple shapes, without carinated profiles or clearly differentiated necks. The most characteristic vessel type throughout the A Sequence is a tall vessel with a straight, vertical wall. Complete examples of these *straight walled pots* often have two loop handles on either side of the rim. The proportion of this form of pot rapidly decreases in level A1. *Carinated bowl shapes* are present in small numbers from level A3 onwards. *S-shaped profiles* become more common towards the end of the A Sequence and eventually developed into real *jars*. From level A2 onwards the proportion of jars increases rapidly and pottery jars become firmly established. *Husking trays* are conspicuously absent for the early half of the A Sequence, only appearing in any number from level A2 onwards.

Nieuwenhuyse has shown that over time there were very clear functional changes in the various types of containers at Tell Sabi Abyad. It is clear that storage was an important consideration in pottery consumption and demand. Through time there is a long trajectory of technological innovation, leading to the development of ceramic containers for bulk storage, such as the magnificent Coarse Ware jars (fig 2.26). This appears to have been a long-term development with people intensifying their production of storage vessels around 6200 BC. In terms of food preparation there is the introduction of a new type of “cooking ware”, which raw material analyses suggest was imported from Turkey (the so-called “Dark Faced Burnished Ware”). Residue analyses suggest that at least some of these cooking pots were used for the processing of dairy products (Evershed *et al.*, 2008). As well as changes in the functional realm, there were very clear changes in the symbolic role of pottery and other types of container (Akkermans *et al.*, in press). In fact, other types of containers, made of materials such as clay, stone or plaster, largely stopped being produced. Instead the production and consumption of durable containers shifted to ceramics almost exclusively. Moreover, these gained new, symbolically charged social functions. Pots started to be decorated with abstract, geometric motifs. A variety of decorated pottery styles emerged rapidly. Some of these gained very large geographic distributions. The newly decorated pottery suggests an emphasis on display and representation, and on the collective consumption of food and drink. Pottery with figurative motifs, including representations of animals, make up a small proportions of the total ceramics (<2%).



Fig 2.26: Coarse Ware jars presumably used for storage

Briefly the following pottery phase boundaries have been suggested (for details see Nieuwenhuys, in prep.):

- Level B1: Transitional/"Proto-Halaf"
- Level B2: Transitional
- Level B3-B8: Pre-Halaf 2
- Level A2-A1: Pre-Halaf 1
- Level A5-A3: Early Pottery Neolithic 2
- Level A9-A6: Early Pottery Neolithic 1
- Level A12-A10: Initial Pottery Neolithic

The main cultural breaks in the ceramics occurred at levels A9, when the presence of pottery increases, and A1, when there are clear technological developments. These pottery phases will not frame the faunal study and are listed here for reference only. The faunal data will be analysed by level and grouped into phases based on the animal exploitation strategy to avoid bias generated by the grouping of data according to ceramic trends. Any trends seen in the faunal data will therefore be independent.

2.6 Lithics

The lithic assemblage was analysed by Laurence Astruc and is briefly summarised here (for more detail see Astruc and Russell, in press). The pattern of exploitation of lithic raw materials at Tell Sabi Abyad, Operation III, is dominated by flints with different kinds of textures from fine-grained to coarse, with obsidian present in all levels in various proportions. Small pebbles (<10 cm) found on the terraces bordering the Balikh floodplain were used in flake production, while blades were produced from fine-grained flints and bladelets from obsidians. The obsidian was imported to the village at Tell Sabi Abyad from Eastern Anatolian sources some 300 kilometres north. The main changes in the sequence concern the proportion of obsidian with a steady decrease in the proportion of obsidian in the assemblage from 37.5% in levels A9-A5 to only 11.6% in levels B3-B1 (Astruc and Russell, in press).

In the Balikh Valley, within the sequence of Operation III, the continuity in the lithic assemblage is striking but there are important temporal changes. From the earliest A levels onwards the chipped stone industry follows a general trend of technical simplification and disinvestment. The analysis at Operation III brings to light a technical disinvestment that took place from level A2 (c. 6385 – 6330 BC), reaching its optimum after 6200 BC (B levels). This disinvestment is characterised by an increase in flake production, a decrease in bipolar blades and consequently a decrease in points and arrowheads, and a decrease in obsidian imports. This disinvestment seems to be related to a decrease in the acquirement of lithic tools through networks.

In terms of lithics involved in hunting, both points and arrowheads are scarce throughout the sequence, representing less than 1.8% of the retouch blanks in all levels (Astruc and Russell, in press). Most of the points and arrowheads were manufactured on imported flint with only two obsidian fragments of points found. Typologically these tools can be assigned to the categories of 'Byblos point' or 'Amuq point'. Among the collected points and fragments, very few of them show diagnostic patterns of fracture that might be related to their use as projectiles in hunting, neither as an arrow nor a hast. On the contrary, the majority of points or fragments show clear signs of use for other technical activities suggesting that they were tools with multiple uses. The dominant use of these tools was not as arrowheads or spears but as hafted blades used and re-used for different purposes, and therefore in some cases, highly curated. This does not however completely exclude the use of these tools in hunting. Other tool types include scrapers, borers, burins, notches and sickle elements (Akkermans *et al.*, 2006).

2.7 Small finds

Many small finds were recovered from the Operation III excavations. These include stone bowls, figurines, spindle whorls, sling missiles, beads and numerous worked bone objects. Basalt, limestone, sandstone, gypsum, alabaster and marble were all used in the manufacture of a wide range of objects for the preparation of food and other domestic tasks (grinding slabs, mortars, pestles, palettes, hammers, maceheads, and chisels) (Akkermans *et al.*, 2006). The worked bones mainly consisted of awls, needles, spatulas and notched bones often referred to as 'tally sticks'. The analyses of the small finds are ongoing, but preliminary results suggest that there are important developments through time.

2.8 Settlement in the Balikh

Archaeological surveys of the Balikh Valley were carried out revealing the presence over 210 archaeological sites (Akkermans, 1993: 138). Many of these sites were very small and the ancient settlements seem to be confined to the immediate vicinity of water courses. The presence of Neolithic habitation in the Jazirah seems to be linked to the presence of water, as many settlements were founded in the Balikh area and along the wadis running into this area with few sites present further away from these channels (Akkermans, 1993: 139, Bottema, 1989). Only 49 sites in the Balikh Valley were ascribed to the Neolithic period, spanning an era of over two millennia (Akkermans, 1993: 146). Of these sites only some have levels contemporary to those uncovered at Tell Sabi Abyad, Operation III. In the Late Neolithic it is evident that the settlement pattern was a mixture between nucleated tell-type settlements and smaller dispersed hamlets or villages, with the latter predominant (Nieuwenhuyse and Wilkinson, 2008). For the Late Neolithic, the Balikh survey evidence suggests the existence of no more than a handful of villages, all situated in the northern, rain-fed, parts of the valley (Nieuwenhuyse, 2007). These settlements are in general very small, not surpassing 1.0 ha in size with the exception of Tell Sabi Abyad and Tell Mounbatah (see fig 2.27), both of which were the amalgamation of several small, frequently shifting settlements rather than a completely settled and densely occupied site (Akkermans, 1993; Nieuwenhuyse and Wilkinson, 2008).

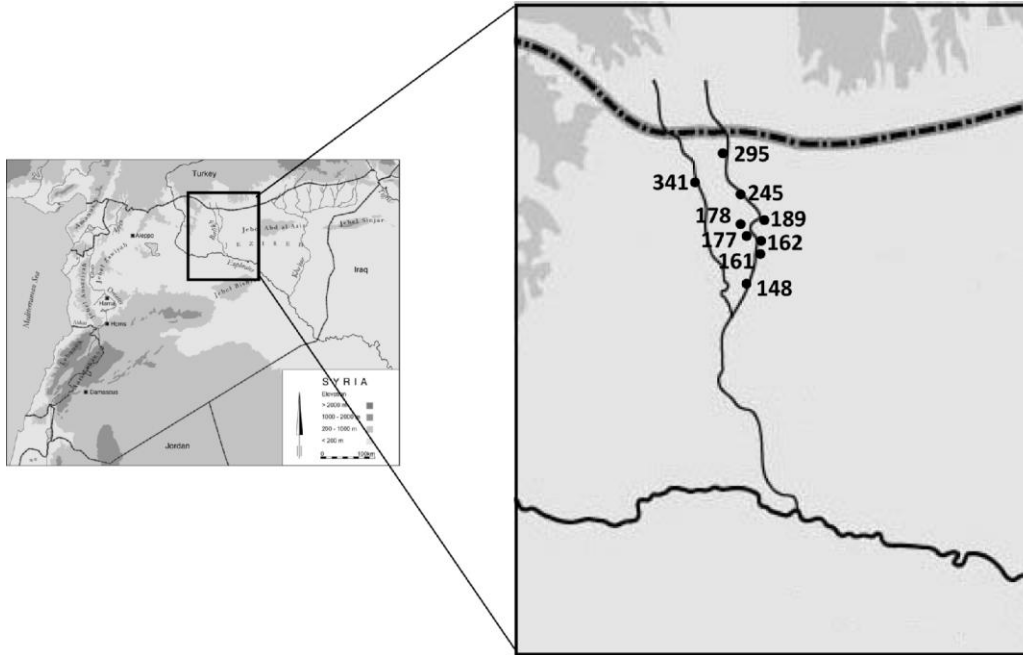


Fig 2.27: Location of survey sites in the Late Neolithic of the Balikh Valley: Site 148 (Tell Mounbatah), Site 161 (Tulul Breilat I), Site 162 (Tulul Breilat II), Site 177 (Tell Damishliyya I), Site 178 (Tell Damishliyya II), Site 189 (Tell Sabi Abyad I), Site 245 (Tell Assouad), Site 295 (un-named) and Site 341 (un-named). (Based on Akkermans, 1993: figure 5.2.)

Outside of the Balikh valley surveys have also been carried out in the areas of the Khabur headwaters (Le Mièrre, 2000; Nieuwenhuys, 2007; Nieuwenhuys and Wilkinson, 2008) and the northern Iraqi Jazirah (Campbell, 1992; Wilkinson and Tucker, 1995). Dozens of settlements have been located in surface reconnaissance's, and excavations have been initiated at places such as Tell el-Kerkh in western Syria, El Kowm in the central desert, Tell Halula on the Euphrates, Tell Boueid II on the Khabur, Chagar Bazar in the upper Khabur triangle, and of course Tell Sabi Abyad on the Balikh (Akkermans *et al.*, 2006).

Akkermans (1993: 147) characterises the Neolithic settlement of the Balikh Valley as follows:

1. A concentration of occupation in the northern, rain-fed half of the basin, and only a few sites in the south.
2. Pairing of settlements, with two or more sites appearing in small clusters.
3. Small settlement size, with the vast majority of sites being smaller than one hectare.
4. Location of settlements in a linear north-south pattern along the Balikh and its tributaries.
5. A rather small number of permanently inhabited sites per period.

Tell Sabi Abyad fits all these characteristics with the exception that it is one of the few sites that was seemingly inhabited continually over several periods. In each region there were a few permanent settlements with occupations sustained over many centuries (Akkermans *et al.*, 2006). Tell Sabi Abyad was one of these long-lived sites. The lengthy use of this site may have added to a developing sense of place and descent and this site may have been a centre of social and economic engagement, providing food, shelter, security and storage (Akkermans *et al.*, 2006). Comprising an area of about five hectares and rising up to ten metres above the surrounding plain, Tell Sabi Abyad is among the largest prehistoric sites in the region.

Throughout the Neolithic the Balikh Valley was apparently only sparsely inhabited. Evidence for a dispersed settlement system of small and often short-lived villages and seasonally occupied campsites has begun to accumulate (Akkermans *et al.*, 2006). Initial survey results suggested that the seventh

millennium BC represented a period of relatively dense occupation while from the beginning of the sixth millennium BC a considerable decline in population seems to have taken place (Akkermans, 1993: 186). This decline was apparently seen in both the number of sites and the size of sites with only a few hundred individuals inhabiting the valley on a permanent basis by 6200 BC. Akkermans (1993: 170) hypothesised that the once flourishing early Neolithic society came to an end, with the southern Balikh being abandoned (perhaps at an earlier stage) and many of the small settlements in the Northern Balikh also being deserted. More recent excavations and improvements in radiocarbon dates have since shown that this interpretation no longer holds. There was no decline, but there were several important changes in the settlement organisation that seem to have taken place in this period. Late Neolithic chronologies in Upper Mesopotamia are notorious for their terminological complexity and lack of secure dating perhaps, leading to contemporary sites in the south being missed (Nieuwenhuyse and Wilkinson, 2008). A new wave of research has shown that during the Late Neolithic the Jazirah region was far from empty, although it is clear that significant changes occurred during this period in terms of site location, density and organisation (Nieuwenhuyse and Wilkinson, 2008). All that can be said with certainty is that settlements were few and dispersed. There is also evidence that villages gained new roles from about 6200 BC onwards, with villages becoming the focal point in a social landscape that was less focused on sedentary settlement than before (Nieuwenhuyse and Wilkinson, 2008; Akkermans and Schwartz, 2003). The settlement of Operation III at Tell Sabi Abyad is one of the few settlements to continue through this period.

Chapter 3 Palaeoenvironmental and Zooarchaeological Background

3.1 Introduction

In order to try and reconstruct the environment in the past it is important to understand the current physical environment in terms of geomorphology, climate and vegetation cover. The reconstruction of past environments is the key to understanding the human populations that lived in those environments. All the world's landscapes and ecosystems are products of the natural and cultural processes that have shaped them over time (Roberts, 1998). These landscapes in turn shape human settlements in the area. Only the natural processes will be assessed in this chapter.

Research concerning late Quaternary palaeoenvironments of the Near East in relation to prehistoric activities has long attracted attention from researchers (Oguchi *et al.*, 2008). Exploration of the palaeoenvironment involves examination of ancient environmental conditions through the investigation of past ecosystems, in particular plants. Studying the vegetation of the past allow precise reconstruction of palaeoecological and palaeoclimate conditions. Research into vegetation also provides a tool for understanding the role of humans in shaping their environment. Archaeologists can contribute to palaeobotanical and palaeoenvironmental reconstructions through their research into patterns of human subsistence and the analysis of animal and plant remains, which all add to a broader understanding of palaeoenvironmental studies (Adams and Faure, 1997). The aim of this chapter is to give a broad outline of the palaeoenvironment at Tell Sabi Abyad in the Holocene and where possible, more specifically the Late Neolithic.

3.2 Geomorphology: The Balikh Valley

Only a brief summary of the geomorphology of the Balikh valley will be provided here. For a more in-depth discussion I direct you to the works of Mulders (1969), Wirth (1971) and Boerma (1988). The Near East is an indefinite geographical or regional term, usually referring to the countries of South West Asia, including Turkey, Lebanon, Syria, Iraq, Israel, Jordan, Saudi Arabia and the other nations of the Arabian Peninsula. Of particular interest to this research is the stretch of land in Northern Syria known as the Jazirah, a relatively flat area of semi-arid steppe, which lies between the Euphrates and Tigris rivers bounded to the north by the Asia Minor mountains (Akkermans and Schwartz, 2003; Wilkinson, 1990). The Jazirah plateau is approximately 300 – 450 metres above sea level and is formed mainly of Tertiary sedimentary rocks overlaid by Quaternary alluvial or gravel fans (Wilkinson, 1990). Today this area primarily consists of many thousands of square kilometres of treeless and salty steppe with seasonal water courses and brackish lakes (Oates, 1982).

Running through the Jazirah region is the River Balikh. The Balikh, a north-south tributary of the Syrian Euphrates, whose waters originate from the 'Ain al 'Arus near the Syro-Turkish border, is a small perennial river about six metres wide (Copeland, 1979; Van Zeist, 1999; Wilkinson, 1999; Mallowan, 1946). The south-facing Middle Taurus bordering northern Syria is very important as a catchment area for the run-off water supply of the Balikh, with the winter precipitation in the mountains being a major determinant of streamflow through the region's rivers (Bottema, 1989; Kay and Johnson, 1981). The Balikh valley is bordered by gravel terraces with a basin of Holocene deposits consisting of brown fluvial-aeolian loams of depths up to 10 metres. The Balikh Basin is underlain by a bedded sequence of Neogene sedimentary rocks and alluvial, proluvial or aeolian Quaternary deposits with limited areas of basalt (Mulders, 1969: 36; Boerma, 1988). The Balikh terrace is of early Holocene age and is built up of arid brown loams (pH 8-9), mixed with gravel and pebbles of limestone and flint, and intercalations of sandy loams and clay layers (Mulders, 1969: 26, 39; Van Zeist, 1988; Boerma, 1988). Formed at the start of the Pleistocene, the Balikh valley is made up of alluvial, highly calcareous, clayey deposits covered with loam (Van Zeist, 1988; Boerma, 1988). The river originally flowed west into the Euphrates valley (Mulders, 1969: 41) but towards the end of the upper Pleistocene tectonic activity diverted the Balikh to the east (Mulders, 1969: 43),

where it cut through the Euphrates deposits, creating a floodplain about one kilometre wide. The Balikh Basin is generally about four to six kilometres wide although in the region just north of Hammam et-Turkman the valley widens into a broad 12 kilometre wide plain (Van Zeist, 1999). Tell Sabi Abyad is located in the area where the valley has its greatest width (Van Zeist, 1999).

The river Balikh is a small stream, far smaller than the Euphrates, with a low average flow of approximately 6 m³/sec, increasing to a maximum of approximately 12 m³/sec after the winter rains (Mulders, 1969: 54; Copeland, 1979; Van Zeist, 1999; Boerma, 1988). The Balikh flows regularly along most of its c. 100 kilometre length, despite the fact that its course lies between isohyets of 300 mm (Tell Abyad) and 200 mm (Raqqqa) which marks the limit of reliable dry farming. It forms a narrow irrigated corridor between the Turkish border and the Euphrates (Mulders, 1969; Copeland, 1979; Wilkinson, 1998). The area around the site of Tell Sabi Abyad receives 200-250 mm of precipitation annually and has a growing period of 90 – 120 days (Ibrahim, 2002). In areas where annual precipitation is over 300 mm rain-fed agriculture can produce crops most years but a mean annual precipitation of only 250 to 300 mm is rather marginal for dry farming and crop failures are far more common (Van Zeist, 1988; Wilkinson, 1998). It is worth noting here however that it is often precipitation reliability or variability rather than simply quantity that determines the success of the harvest (Wilkinson, 1990).

The Balikh meanders across the Jazirah plains bordered by the wide floodplain of gravel and silt Pleistocene terraces (Copeland, 1979). The areas around these floodplains made excellent locations for ancient settlements; proximity to a water supply is essential in a region where practically no rain falls between March and October. Virtually all ancient settlement sites are located on the Holocene terrace (Van Zeist, 1988) and the valley formed a natural passage north-south linking up with the east-west passage between the Levant and Mesopotamia (Copeland, 1979; Wilkinson, 1998). Until fairly recently there were extensive areas of marsh in the lower reaches of the Balikh (Mallowan, 1946) but modern day demands for irrigation water have resulted in drastically lowered water tables and the modest flow of the Balikh has become almost entirely dry (Akkermans, 1993; Wilkinson, 1998; Wilkinson, 1999). In the early 1900's there were a number of small branches of the Balikh River, which ran off from the main stream before rejoining it, making a naturally irrigated area perfect for agriculture (Sykes, 1915); 70 years ago Mallowan (1946) described the abundance of wild fowl and other animals in these marshes, giving a glimpse of what must have been rich hunting ground in the Neolithic.



Fig 3.1: Balikh river today, much depleted by the use of its waters for irrigation

3.3 Palaeoclimate studies

A limited amount of palaeoclimate data, inferred from various proxy data, is often used to try to understand past climates and reconstruct the general climate (Wigley and Farmer, 1982). The value of these reconstructions is however, somewhat difficult to judge, particularly for areas like the Near East where the climate is fairly complex and our understanding of it limited (*Ibid*).

Studies of the current climate are the key to understanding past climates because the principles and rules of climate systems which apply today apply equally well to the past (Wigley and Farmer, 1982). Lying between 13 and 42°N the Near East straddles the subtropical high pressure belt making much of the area climatically arid and semi-arid (Roberts and Wright Jr., 1993). The area is influenced by middle to high latitude westerlies to the north and northwest, the mid-latitude sub-tropical high pressure systems and the monsoon climates of the Indian subcontinent and East Africa (Wigley and Farmer, 1982; De Moulins, 1997: 9; Bottema, 1989). Regional differences in the current climate are due to a combination of topographic features, prevailing winds and the distance from the sea, all of which may provide clues to similar differences in the past (van Zeist and Bottema, 1991: 16). It can be assumed that the topography of the Late Neolithic did not differ much from that of today but we can only speculate about the air circulation patterns of the past (*Ibid*). Rainfall patterns over the Near East are generally very complex with the main influence being topography, which controls the delicate balance between moisture and aridity (Wigley and Farmer, 1982; de Moulins, 1997: 8).

The present day climate of the Jazirah is strongly influenced by the regional geomorphology and the amount of precipitation, which is altitude dependent (Wiedemann *et al.*, 1999). As mentioned earlier, the climate of the area is characterised by a low annual precipitation of c. 250 mm per annum with a large variation in both the mean monthly and annual amount (Boerma, 1988). The area is home to a strong north-south precipitation gradient with areas in the southeast averaging less than 150 mm annual precipitation, while in the extreme north of the region more than 450 mm can be expected (Beaumont, 1996; Mulders, 1969: 27). This results in the southern Balikh having an arid climate while in the north it is only semi-arid (Mulders, 1969: 27). This precipitation gradient is critical from the agricultural point of view as the limit of dry farming transects the centre of the region (Beaumont, 1996). Climate plays a dominant role in determining the pattern of natural vegetation and water levels (Roberts and Wright Jr., 1993) as well as being important to soil genesis (Boerma, 1988). Although much of the Jazirah is climatically marginal for dry-land cultivation, the moister northern areas receive enough rainfall to produce crops without the need for irrigation (Wilkinson, 1990).

The Balikh valley is generally an arid⁴, steppe-like environment characterised by a low annual precipitation and very high levels of surface evaporation. The summers are generally very dry and hot and the winters are relatively cool with the rainy season lasting from the end of October until April (Mulders, 1969: 96; Wilkinson, 1990; De Moulins, 1997: 9) and the majority of precipitation coming from brief but heavy rainstorms (Boerma, 1988; De Moulins, 1997: 9). During the long summer months there is no surface water available and the high temperatures and dryness of the air create conditions of extreme desiccation (Mulders, 1969: 97) (fig 3.2). Droughts are also fairly common, occurring every six to eight years, with each drought lasting three to four years (Dahl and Hjort, 1976: 127). Dry years therefore occur in groups rather than being interspersed among average years.

⁴ The simplest classification of arid is 50 - 300 mm annual precipitation (Mulders, 1969)



Fig 3.2: Jazirah desert steppe in the dry summer season

During the Holocene the Jazirah has always been arid but it has been punctuated by brief periods of favourable precipitation as well as periods of hyper-aridity (Hole, 2007; Mulders, 1969: 28). The greater part of the Holocene though has been arid, even more arid than today (Mulders, 1969: 28). Neolithic populations living in this arid region were confronted with a range of climatic restraints and were required to adapt to highly variable conditions in order for agriculture to succeed. The Balikh valley straddles the limit of rain-fed cultivation and water supply certainly constrained settlement size in the past (Wilkinson, 1998; Boerma, 1988). In prehistory, settlements were mostly located next to perennial water sources so as to ensure access to water, with plants growing in the fertile flood basin and animals attracted to the area by the water.

It is climatic factors which largely determine the general character of the vegetation with the aridity of the climate in the summer having a particularly strong influence on plant life (Mulders, 1969: 96; De Moulins, 1997: 9). There is a delicate balance between aridity and moisture, which if upset, can have far reaching consequences that can be difficult to reverse (De Moulins, 1997: 13).

3.4 Palaeobotanical studies

The study of vegetation in the past is of considerable interest to both natural scientists and archaeologists (van Zeist and Bottema, 1991: 13). The natural environment has an important role in shaping prehistoric cultures. The interplay of topography, precipitation, temperature and soils all contribute to the distributions of plant vegetation (Henry, 1997; van Zeist and Bottema, 1991: 16) and both climate and human actions have shaped the vegetation of the Near East.

Before trying to deduce the vegetation of the past it is useful to look at patterns of modern plant cover (figure 3.1) as the existing distribution of extant vegetation can provide clues about the capacity of the land and climate to support different plant life (Miller, 1997). There are currently three main phytogeographical regions in the Near East (fig 3.3):

- The Mediterranean, characterised by a mild climate including the forests and woodlands of the Levant, Jordan valley, and coastal Anatolia to the highlands.
- The Kurdo-Zagrosian and Indo-Turanian with a more continental climate with forest to steppe and desert, which includes the northern Taurus-Zagros oak forest, southern Zagros pistachio-almond forest, the central Anatolian and Iranian steppes and northern Mesopotamian steppe.

- The Numia-Sindian, which is more tropical and includes lower Mesopotamia and the Gulf coast. The Euphrates-Balikh Basin belongs to the Indo-Turanian phytogeographic region (Mulders, 1969: 96) and consists of large, open areas of xeromorphic dwarf shrub-land and desert steppe with some river valley vegetation such as poplar, willow and tamarix (van Zeist and Bottema, 1991: 32).

There are problems which we need to consider when using modern plant distributions to infer the past environment; present-day plant formations should not, a priori, be transferred to the past (Adams and Faure, 1997; van Zeist and Bottema, 1991: 16). The natural vegetation in some areas of the world is so extremely modified or fragmented by agriculture that it is very difficult to imagine what it was like in the past (Adams and Faure, 1997). In northern Syria, human interference has made the natural steppe vegetation very rare or even absent (Bottema, 1989). Despite the possible caveats, knowledge of the modern natural environment can be indispensable in palaeobotanical reconstructions (van Zeist and Bottema, 1991: 16). Modern sources must however, be used with caution and only in conjunction with palaeobotanical data from archaeological sites. The questions of importance here are: what conditions did prehistoric farmers meet in the Jazirah and how did they exploit the area?

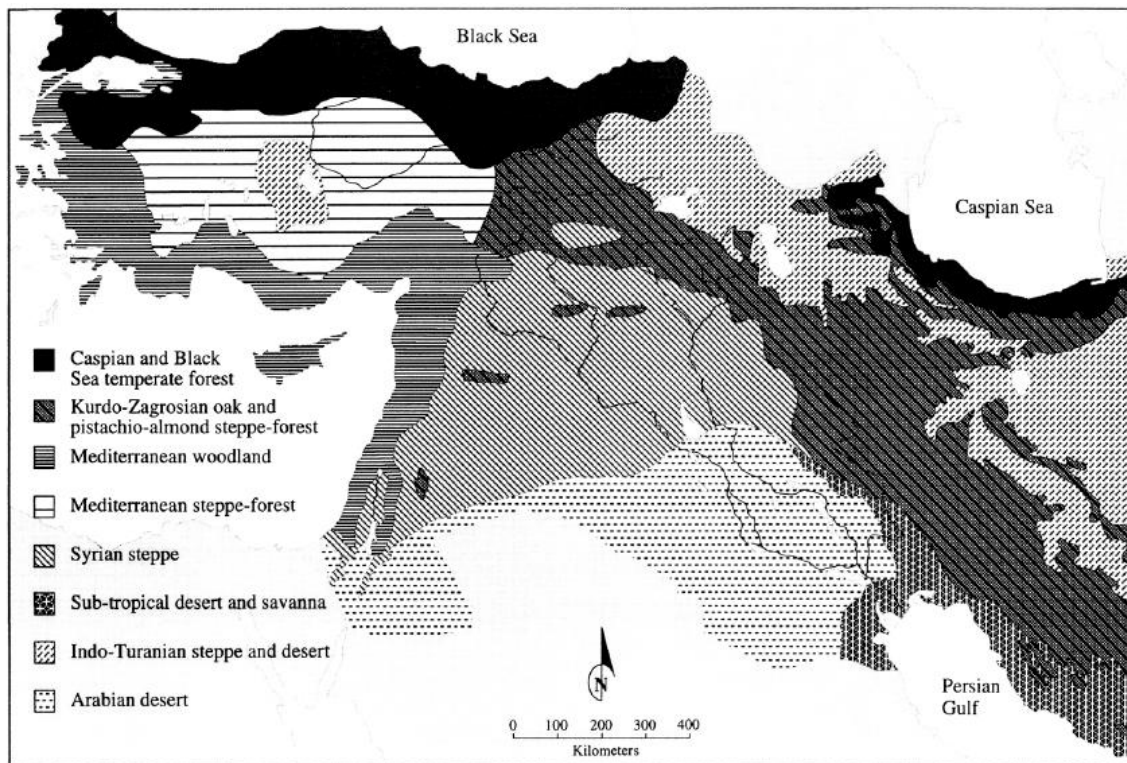


Fig 3.3: Modern vegetation zones (from Miller, 1997).

The natural vegetation of the Jazirah plateau is one of steppe, a type of ecotone that is usually dominated by shrubs and grasses and is treeless except along water courses (Roberts and Wright Jr., 1993). The vegetation of the Jazirah can be divided into two main categories: one with treeless vegetation and one where trees are present (Bottema, 1989). The latter group includes steppe forest on the Jebel Abdel-Aziz and the riverine forest along the Euphrates, Balikh and Khabour, although very few remnants of riverine forests are found nowadays (*Ibid*). At present the Jazirah steppe is dominated by dwarf shrubs such as *Artemisia* but it is thought that originally it must have been a grassier steppe on the plains with the Balikh valley being dominated by poplar, willow and tamarisk (Van Zeist, 1988; Boerma, 1988; Bottema, 1989). Grazing, subsequent overgrazing, fuel gathering and in more recent times extensive ploughing have all led to the degradation of the natural vegetation.

Tell Sabi Abyad is situated in this Syrian steppe, a very dry environment characterised by the absence of natural tree cover, where in general only low shrubs and grasses develop. A document compiled by the Syrian Ministry of Agriculture and Agrarian Reform classes the area as a 'marginal zone' with a growing period of only 90-120 days (Ibrahim, 2002). Marginality is however a rather imprecise term used ubiquitously without much explanation. Coles and Mills (1998) argue that this term only serves to disguise our ignorance of the complex environmental systems and economic choices facing both past and present human groups in these areas. Marginality suggests a situation of 'living on the edge' but what is marginal to some people may be the 'land of plenty' to others depending on their perception of the environment and on their subsistence strategies. The perception of an area as marginal depends more on social and socio-economic factors than on any inherent quality of environmental marginality (Coles and Mills, 1998).

The growing period of the many of the plants in this region is definitely a limiting factor. The main growing season in the Balikh Valley is from March to April and this relatively short period in which plants can grow gives rise to semi-desert vegetation and a generally arid appearance to the landscape (Mulders, 1969: 96). Despite this aridity the spring rains can convert the grey-brown dead surface to lush green grassland for a short time each year (Mulders, 1969: 97) (fig 3.4). Surveys of the area (Akkermans, 1993) have shown that human habitation in the Jazirah is concentrated on the rare water sources in the area. In such a generally arid area this is not surprising (Bottema, 1989). Not all these water sources could be efficiently exploited for agriculture however, and the Balikh seems to have been the most accessible (*Ibid*). The desert-steppe of the Balikh Basin can support cultivation in March-April (without irrigation) and can provide animal grazing throughout the year, although it can often be of very poor quality (Mulders, 1969: 98). The success or failure of crops is dependent on the amount of precipitation during critical stages of the growth cycle, especially at the time of sowing (Boerma, 1988). Agriculture in this area is subjected to many environmental stresses throughout the year with crops being subject to winter frosts, moisture stresses generated by hot, dry winds in the summer and inadequate water supplies during the growing season (Kay and Johnson, 1981).



Fig 3.4: Fields surrounding Tell Sabi Abyad in early spring

Although relatively arid the Jazirah region has black soils which are relatively fertile (Wilkinson, 1990) and charcoal analysis suggests that the narrow floodplain of the Balikh was once covered by riverine forest with *Populus* (poplar), *Ulmus* (elm) and *Fraxinus* (ash) (Van Zeist, 1988). Trees always require more water than the shrubs and herbs that dominate the steppe, demonstrated today by the restriction of forest cover to higher altitudes where precipitation is greater (Roberts and Wright Jr., 1993). The calcareous soils

in the area of Tell Sabi Abyad are in principle well suited to plant cultivation, which is in contrast to the nutrient poor gypsiferous plateau soils to the south (Van Zeist, 1988). The area around the upper Euphrates and Balikh is an important transitional zone for vegetation, the north being able to support relatively dense vegetation cover through precipitation alone and the south only supporting vegetation where water is available in floodplains or from ground water (Beaumont, 1996).

As described above, the climate in the Balikh area is characterised by winter rainfall and summer droughts (Roberts and Wright Jr., 1993) and the vegetation has adapted to this in two ways: deep rooted perennials and shrubs adapted to the long periods of drought, and quick growing annual grasses, legumes and other herbs capable of growing and reproducing within the period of winter rainfall and lower temperatures (Köhler-Rollefson, 1988; De Moulin, 1997: 9). Most perennial plants are shrubs growing in depressions and wadis⁵ where there is more moisture; they are specially adapted to arid conditions and have very long roots that can draw in water from considerable depth and a wide area (Mulders, 1969: 97). Today the non-arable areas are too dry to support extensive plant life, and virtually all of the arable areas have been stripped of natural cover, with the exception of a few small specimens that by chance escaped overgrazing. There are few remaining areas which still support larger areas of natural plant life, the exceptions being in the Euphrates Valley and the Oasis of Palmyra where natural groves of date palms are found, and along the coast and the fertile inland regions where grains, olives, vines, apricot trees, oaks and poplars are found, as are some reed grasses, wild flowers, trees, and shrubs, including buckthorn and tamarisk. In the Anti-Lebanon Mountains forests of pine and oak can be found.

Although these modern records tell us about the plant cover now we can not automatically equate this to the vegetation of the past. To do this we must look for evidence from archaeological sites. A continuous record of vegetation history can be derived from pollen cores, which can be used to map changes in climate and land use using regional vegetation as a proxy indicator. Unfortunately there are no pollen assemblages from the Balikh Valley that date to the late seventh and early sixth millennium period as there are no pollen bearing sediments in the steppe regions (Bottema, 1989). Reconstructions of this time period often rely upon the general picture of the Near East. Despite the general paucity of data, the data we do have indicates that during these periods the first major intensification of land use began (Miller, 1997).

The period of the eighth and seventh millennium is a particularly interesting time in terms of vegetation. This is the time when the first agricultural systems were established based on the cultivation of various wheats, barleys and pulses (Miller, 1997). Agriculture strengthened the mutual dependence between people (as farmers) and a limited range of domestic plants and animals. Cultivation of crops requires at least the partial clearance of existing vegetation cover and its replacement by field plots and gardens (Roberts, 1998: 151). This human manipulation of their surroundings brought them into conflict with other elements of nature with significant ramifications on the local ecosystem, wild animals and plant species. It has been argued (Köhler-Rollefson, 1988; Verhoeven, 2002) that humans could degrade their environments through the grazing of large herds of domestic animals, extensive woodcutting and over farming of these sensitive, marginal rain-fed areas, leading to depletion of soil nutrients, a loss of fertility and eventually a decrease in productivity of both pastoralism and cultivation. As such, the momentum of the Neolithic revolution can be seen as being precarious, and only sustained as long as the environment could cope with human manipulation.

As cereals are cultivated plants, they may reflect not only climatic fluctuations, but also the effect on water status of certain agronomic practices, such as sowing in naturally wet soils or irrigation (Ferrio *et al.*, 2005). Cereals are grasses cultivated for their edible grains. They are all annual plants and consequently produce one crop per year. Annuals were probably the most successful plants in the more unstable locations, such as between forest and steppe, because of their rapid regeneration and

⁵ Wadi is the Arabic term traditionally referring to a valley or in some cases it may refer to a dry riverbed that contains water only during times of heavy rain.

reproduction (McCorriston and Hole, 1991). The first plants to be cultivated in the Near East were emmer wheat (*Triticum turgidum* ssp. *dicoccon*), einkorn wheat (*Triticum monococcum*) and barley (*Hordeum vulgare*), followed by pulses: pea (*Pisum sativum*), lentil (*Lens culinares*), chickpea (*Cicer arietinum*), bitter vetch (*Vicia ervilla*) and flax (*Linum usitatissimum*) (Verhoeven, 2004). This group of plants were the founder crops and formed the basis of systematic agriculture. Apart from barley and flax, the wild progenitors of these annual crops have a rather limited distribution, namely the Fertile Crescent ranging from the Levant via southern Anatolia to the Zagros Mountains, bounded in the north and east by forested mountains, in the northwest by the Mediterranean, and in the south by vast steppes and deserts (*Ibid*). The shift in emphasis to the quick growing herbaceous plants, at the expense of the perennials and shrubs, would have represented a change from continuous year round cover to a seasonal flush of annuals (Köhler-Rollefson, 1988). This would result in the soil being left bare for much of the year, increasing susceptibility of the surface soil to erosion.

Climate, geomorphology, animals, humans, and existing vegetation all play a role in determining the plant cover at any one place and time. A change in any of these variables changes the competitive balance in plant communities and the composition of vegetation adjusts accordingly (McCorriston and Hole, 1991). It is apparent that determining plant cover of an area at any one time in the past is not an easy task.

Palaeobotanical studies at Tell Sabi Abyad

Several palaeobotanical studies have been undertaken at Tell Sabi Abyad Operation I, the first of which was carried out in 1989 (Van Zeist and Waterbolk-van Rooijen, 1989). Only 15 samples were recovered and analysed from Late Neolithic levels. The emphasis of the report was on the plant husbandry of the period and it was concluded that the main crop cultivated was wheat, particularly emmer but also einkorn. Hulled barley (*Hordeum vulgare* spp. *distichon*) was also cultivated, but this crop appears to have been farmed to a far lesser extent. Other plants cultivated include domestic flax and lentil although it appears these crops were of minor importance (Van Zeist and Waterbolk van Rooijen, 1996). In terms of wild plants only a few pistachio and almond nut shells were identified; the rarity of these remains could indicate that these wild fruit trees were not found in the vicinity but instead formed part of the forest-steppe in the foothills of the Taurus Mountains (*Ibid*). Wild fig appears to also have been of minor importance. A great variety of other seeds of wild grasses, wild leguminous species and dock were also recovered and probably occurred as weeds in and around the cultivated fields (*Ibid*). Charcoal samples were also analysed and identified as poplar and ash, which probably occurred naturally in the Balikh valley (*Ibid*).

René Cappers is current supervising the analysis of the Operation III botanical remains which is still ongoing. The preliminary analysis of the domestic crops has shown there to have been a wide variety of crops cultivated and exploited, including: emmer wheat, einkorn wheat, durum wheat, hulled and naked barley, flax, lentil, chickpea, grass pea, pea and bitter vetch. In essence, almost all the founder crops are present in all levels. Flax and pulses are probably underrepresented in the sample due to preservation (flax is not usefully preserved through charring because of its high oil content) and the nature of the sample (small lentil seeds for example often escape through the holes in a sieve). At this stage of the analysis it appears as if the only significant change through time is that einkorn wheat is only present up to level A1 and is not present in the B levels. Nevertheless, there is a strong continuity throughout the 1000 year stratigraphic sequence. It is thought by Cappers (*per comms*) that barley would predominantly be used as fodder crop to feed the domestic animals, notably those that would be used for heavy labour; it is particularly difficult to remove the chaff from hulled barley and, unlike wheat, it cannot be used to make bread. If this was the case, then the continued presence of barley in the assemblage suggests that perhaps some of the herd animals' diets were supplemented with fodder throughout the sequence. Nowadays, crops are sown as soon as the rains start in autumn and are harvested in April or May, and this was probably also the case in antiquity (Akkermans, 1993: 211). After the harvest the land was probably left as fallow to allow it to recover. The analysis of the wild flora is still ongoing and no results are currently available.

3.5 The Neolithic fauna

Neolithic fauna of northern Syria

Faunal assemblages can provide us with indirect data about both the environment and climate. The basis of this premise is that each wild species lives in a characteristic habitat and that habitat and species are so closely linked that in general if an animal is encountered at a prehistoric site its habitat must have existed within two days walk from the site⁶ (Bökönyi, 1982). In this way, the faunal assemblage can give us an insight into the environments exploited around the site.

As studies of modern native flora can inform us about the environment today and to some extent in the past, studies of the current fauna of the Jazirah can be useful in understanding the fauna of the Late Neolithic. Any animals found in the desert steppe must be well adapted to cope with the extreme temperatures and the exceptionally dry summers (Mulders, 1969: 104). The most noticeable species in the Balikh Basin today are the domestic ovicaprids (sheep and goats) which are herded in large numbers and are indispensable to the local nomads and villagers. Sheep are able to store food reserves in their tails during the winter and spring and are thus able to live on dry grass in the summer (*Ibid*) and goats are extremely hardy animals able to survive on a diet of browse. Wild animals such as hares, desert rats and other rodents are able to survive the hot, arid conditions by finding refuge in burrows and they can go long periods without drinking (*Ibid*). Foxes are also numerous while other carnivores such as wolves are very rarely seen today (*Ibid*). Of course reptiles and arachnids are also present and they are well able to cope with the hot conditions of summer. Fish, tortoises and frogs can be found in the Balikh River. Birds such as the partridge, pigeon, lark, stork, heron, falcon and owl can all be seen in the Balikh Basin and there are many migratory birds that pass through the area (*Ibid*). The monoculture currently practiced in many areas of the Balikh is not conducive to the presence of a diverse range of animal species. As such, a direct, linear, ancestor-descendant relationship cannot be taken for granted and it must be considered that some changes in behaviour and/or distribution of modern wild animals has occurred, particularly in light of the affect of spreading agriculture restricting the current distributions of animals (Hecker, 1975).

Before going into detail about the faunal evidence from archaeological sites it is perhaps useful to first describe the natural habits of the most common mammal species encountered in faunal assemblages from sites in the Jazirah in the Neolithic.

Goat (Capra aegagrus)

The wild ancestors of the domestic goat are a predominantly Palaeoartic group of agile, mountain-dwelling ruminants of moderate build (Harrison, 1968: 330). This species is highly sexually dimorphic, with males generally being far larger than females, weighing up to 90 kg while the females weight around 30 kg (Harrison, 1968: 336). Like sheep, they were historically distributed from Asia Minor through the upland regions of Mesopotamia and Iran (Legge and Rowley-Conwy, 2000). Goats, with their nimble climbing abilities, prefer mountainous, rocky terrain whereas sheep avoid such areas in preference of more hilly landscapes (Bökönyi, 1982; Harrison, 1968: 340). These animals can be solitary but can also be found in herds of up to 100 goats (Harrison, 1968: 339). They feed mainly on mountain grasses, shoots of small species of oak and cedar and various berries (*Ibid*); they are more browsers while sheep graze more⁷. Kidding takes place in May after a five month gestation and lactation normally lasts six months (*Ibid*). The earliest (culturally) domesticated goats in the Near East are presently known from the site of Ganj Dareh in the Zagros Mountains, approximately 10,000 years ago (Zeder and Hesse, 2000).

Sheep (Ovis orientalis/amman)

The ancestors of domestic sheep, these animals were historically distributed from Asia Minor through the upland regions of Mesopotamia and Iran (Legge and Rowley-Conwy, 2000). They are a small mountain-

⁶ Of course there are exceptions such as remains of species brought into an area through trade but these will not be considered here.

⁷ Animals that graze feed mostly on grasses while browsers feed on leaves, soft shoots and shrubs.

dwelling ruminant (weighing up to 80 kg) which favours more open, undulating highlands (Bökönyi, 1982; Harrison, 1968: 340). Unlike modern domestic sheep, these animals have a very short, coarse coat which is only about 14 mm long (Harrison, 1968: 342). Wild sheep are migratory to a certain extent; in the summer they live in mountain steppe areas where they favour meadows and grassy areas, descending to the lower foothills only in winter (*Ibid*). Mating occurs at the end of November with one to three young being born in April and May (*Ibid*). Modern flocks of domestic sheep kept in the region breed in September and October and the season for lambing in the region extends from as early as December through to February and March (Hecker, 1975, Legge and Rowley-Conwy, 2000). Like the domestication of the goat, the domestication of sheep occurred some 10,000 years ago, with evidence from several sites in the Near East (see Davis, 1993).

Cattle (Bos primigenius)

Bos primigenius otherwise known as the aurochs is thought to have favoured fairly moist areas along rivers and mainly inhabited light forest and open scrub (van Vuure, 2002; Bökönyi, 1982). These animals required more frequent watering and better graze than other mammals such as the onager and gazelle. The aurochs ate a wide variety of plant food, grazing and browsing on grasses, leaves and herbs; although essentially a grazer late medieval authors have described how in winter the aurochs fed on leaves, buds and acorns (Bökönyi, 1982). They were very large animals measuring up to 1.75 meters at the withers. Ancient Greek and Roman writers describe the aurochs as a very aggressive animal (van Vuure, 2003). Information about the metrical variation of Near Eastern *Bos primigenius* is somewhat scarce but these animals appear to have been relatively small in comparison to their European relatives, which greatly increases the problem of differentiation between bones from wild and domestic specimens (Becker, 1991). The aurochs is the ancestor of domestic cattle. Present evidence for cattle domestication suggests that morphological domestication occurred first in the northern Levant approximately 9000 years ago (Peters *et al.* 1999).

Wild boar (Sus scrofa)

Sus scrofa are a very robust race of wild boar and the males can weigh up to 250 kg (Harrison, 1968: 372). The wild boar, a dweller of the river edge, is a social animal that lives in groups of c. 20 individuals. These groups are matriarchal and consist of two or three mature females and their recent litters of young. Adult males are usually solitary outside of the mating season. In Turkey wild sows are receptive in December and January and give birth to one litter a year, usually in April and May (*Ibid*). The natural habitat of the wild boar is woodland and they happily live in the bushes along rivers and brooks but they are not adapted to arid environments such as desert steppe (Brentjes, 1973). They need vegetation cover and in the Near East their typical habitat is the gallery forest from where they can make short excursions into the steppe, but they can't survive long in this arid environment (Bökönyi, 1982; Harrison, 1968: 375). The range of temperatures and humidity these animals can endure is quite narrow and in arid environments they can compete with humans for food (Haber and Dayan, 2004). The omnivorous diet of the wild boar is diverse and varied, and includes rhizomes of aquatic and marsh plants, cereals, nuts, berries, insects, larvae, small vertebrates, refuse and carrion (Harrison, 1968: 376). These animals are the ancestors of domestic pig. Çayönü Tepesi in South-eastern Turkey provides evidence for the early domestication of wild boars approximately 9000 years ago (Ervynck *et al.*, 2001).

Gazelle

One of the main sources of meat for Epipalaeolithic and Early Neolithic communities was the gazelle (Bar-Yosef and Belfer-Cohen, 1989). There are two main species of gazelle that existed in the Near East. *Gazella gazella* is basically a sedentary antelope with a home range of between 1km² in the Mediterranean belt and 5km² in more arid areas such as the southern Negev (Bar-Yosef and Belfer-Cohen, 1992). Females and fawns are quite sedentary in comparison to the herds of males. Where water availability is good, gazelles reproduce all year round but drier conditions lead to seasonality in the timing of birth, in general from March to July (Bar-Yosef and Belfer-Cohen, 1989; Harrison, 1968: 359). *Gazella subgutturosa* is the species commonly found in the Syro-Arabian desert mainly in western and northern Iran and in Mesopotamia (Becker, 1991). Unfortunately, no behavioural studies are available but they are

thought to have a similar pattern of behaviour to *Gazella gazelle*, only with a larger territory (Bar-Yosef and Belfer-Cohen, 1989). *Gazella subgutturosa* is a large species of gazelle with a relatively heavy, thick-set build (Harrison, 1968: 359). Gazelles prefer arid environments such as the desert or grassy steppes, gravel plains and rocky plateaux (Bökönyi, 1982). They exist on the steppe by feeding on the perennial dwarf shrubs supplemented by the abundant grasses following the winter rains (Harrison, 1968: 364). In the Syrian desert the *Gazella subgutturosa* are thought to have migrated south to central Arabia in the autumn and back north in the spring (Rosen and Perevolotsky, 1998). During migrations the gazelle congregated into large groups of 50 to several hundred animals (*Ibid*).

Equid species

The identification of Western Asian equids from archaeological sites remains a contentious issue and identifying equid remains in south-west Asia to subgenus level is not an easy task. Species of small equid are often identified as either the onager (*Equus hemionus*) or as a species of wild ass (*Equus asinus* or *Equus africanus*) (Legge and Rowley-Conwy, 2000). Both *Equus hemionus* and *Equus africanus* have been identified in Holocene archaeological material from the area resulting in a debate as to whether two species of wild ass could have coexisted in the Middle East (Groves, 1986: 38). Traditionally, wild asses have been thought of as African and onagers as Asian in distribution (Groves, 1986: 40; Uerpmann, 1986: 247). This assumption was so ingrained in the psyche of zooarchaeologists that the identification of equid species was often based on geography alone (Uerpmann, 1986: 247). There is however no reason why wild asses and onagers could not coexist and wild asses have been identified from Neolithic sites in Northern Syria (Ducos, 1986; Uerpmann, 1986).

We know almost nothing of the recent distribution of equids of Syria (Ducos, 1986: 238). The now extinct subspecies of onager found in Syria in sub-recent times was the *Equus hemionus hemippus*, the smallest of all the onagers measuring only one metre at the withers (Groves, 1986: 24; Uerpmann, 1986: 247). It has become clear from zooarchaeological studies of early Holocene equids in Northern Syria (see for example Mureybet: Ducos, 1986) that these equids do not fit in the size range of 'hemippus', being much larger in size. It may be that the last remains of a Mesopotamian population of onagers may have been altered and dwarfed under the influence of isolation and ecological deterioration brought about by human settlement and agriculture in more recent times, before they finally became extinct during the first third of this century (Uerpmann, 1982; Uerpmann, 1986: 247). The alternative hypothesis is that these larger early Holocene equids are in fact wild asses. The former existence of wild ass in the Near East has been discussed among zooarchaeologists for several years and is still not readily accepted (Uerpmann, 1991: 12). This reluctance has had to diminish with increasingly convincing finds of wild ass in the area.

Identification of these subspecies relies on bone measurements and the folding patterns of tooth enamel (Davis, 1980) but morphological distinction of bones of onagers and wild asses is still a serious problem (Uerpmann, 1986: 247). Equids from most sites in the area of analysis appear to derive from *Equus hemionus*, more commonly known as the onager. The onager is an animal of the treeless steppe and is usually found in arid environments from Syria to Mongolia (Davis, 1980). It is a relatively large and slow maturing animal with the young remaining dependent on their mothers for a prolonged period (Legge and Rowley-Conwy, 2000). The onager was a migratory species.

Fallow deer (Dama mesopotamica), roe deer (Capreolus capreolus) and red deer (Cervus elaphus)

Deer are very river focussed animals, preferring wetter regions, and are particularly attracted to clearings and forest edges where seasonal growth is most abundant (McCorriston and Hole, 1991). These animals tend to prefer forested areas along rivers and flood plains with enough woody vegetation to provide shelter. Red deer, the largest of these deer species, are inhabitants of open deciduous or mixed woodland and forest with rich undergrowth (Bökönyi, 1982). They prefer woodland areas that have many open glades and clearings where they can find enough food to feed on. In summer time they can foray on to grassy steppe areas but they draw back in the winter (*Ibid*). Fallow deer are a medium sized deer with males measuring 950 to 1050 mm at the shoulder. They also prefer areas of open woodland, mixed forest or forest steppe (*Ibid*) and are thought to have occupied much of south-west Asia in prehistory, although

today they have a very limited distribution in western Iran. They browse on the young shoots of poplar bushes (Harrison, 1968: 368). They have one or two young which are born between April and May (*Ibid*). Roe deer are the smallest cervid species of the Near East and are an animal of the ecotone between forest and grassland, being most often seen in open deciduous or mixed forests with little undergrowth, along woodland edges and in areas of scrub (Bökönyi, 1982; Harrison, 1968: 369, 371). They feed on a variety of shoots and leaves as well as berries, forest fruits and grasses (Harrison, 1968: 371). Mating lasts from July to September and one or two young are produced in May.

The 'Neolithic revolution' and animal domestication

There is now a large body of literature devoted to the subject of domestication and as such it is not felt to be worthwhile to cover this issue in depth again, instead I direct you to the following literature for example, Clutton-Brock (1989); Helmer (1992); Garrard *et al.* (1999); Bar-Yosef (2000); Russell (2002); Davis (2005); Zeder (2006) and Zeder *et al.* (2006). Instead I will focus my attention here on identifying the process of domestication and the presence of domestic animals archaeologically, and on the ongoing role of domestication in the Late Neolithic.

The term 'domesticate' is usually used to describe a species bred in captivity and modified from its wild ancestors so as to make it more useful to humans who control its reproduction and food supply (Diamond, 2002). Domesticates are not simply tamed wild animals. Very few wild species have actually been domesticated; in fact only 14 of the 148 large terrestrial mammals have been domesticated (*Ibid*). One of the commonly acknowledged signs that an animal has been domesticated is decreasing bone size (Terrell *et al.*, 2003). Such readily identifiable morphological changes are however, less common than they should be and it can be difficult to document the history of such signs as it takes time for morphological changes to become apparent in the archaeological record (*Ibid*). In zooarchaeology the focus is on the methodological criteria for recognising domesticates, the process of domestication and the diffusion of domesticated animals. Identifying the process of domestication in the archaeological record is not easy. It requires the combined use of several criteria and also depends on the exact definition of domestication one subscribes to (Haber and Dayan, 2004). The dictionary definition of domestication is not easily applied to animals exploited by people in the Neolithic. Domestication is a process that began in the Neolithic (with the exception of the domestic dog) and that continued throughout prehistoric and historic times. There is no dichotomy between a domestic and a wild animal, instead domestication should be viewed as a process which includes a developmental continuum of different and slowly changing human-animal interactions with varying steps along the way (Haber and Dayan, 2004; Hecker, 1975). It can be difficult to define what a domestic animal is, but in general we think of the biological process which starts when a small number of animals are separated from the wild population and become used to humans. It is these biological changes that we look for in the zooarchaeological record. The criteria for recognising domestic animals in the archaeological record are well established and involve observing the following:

1. Changes in the spectrum of taxa through time and relative species abundances.
2. Changes in animal morphology, or size, through time.
3. Changes in mortality profiles and cull patterns.
4. Increases in the incidence of pathologies
5. Zoogeographical changes.
6. Pathologies

(Martin, 1999; Haber and Dayan, 2004).

These different criteria can be considered as indicative of different stages of domestication and the relative timing of these changes can be as revealing as the changes themselves (Haber and Dayan, 2004). Unfortunately there are many problems in testing zooarchaeological remains against these criteria. For example, studies of size change in fauna from the southern Levant illustrate a large range of size variation in the wild populations and domestication is not the only cause of size diminution as natural climate and geography can both be factors (Martin, 1999).

The terms "wild" and "domestic" represent two extremes on a spectrum of human control of animals. It is perhaps the intermediate steps in the development of a fully domestic animal which are most interesting

to the zooarchaeologist studying animal domestication. We are interested in this trajectory from wild to behaviourally and morphologically domestic. Several terms are used to describe animals on this trajectory including “culturally controlled” and/or “proto-domestic”. These terms are often interchanged and refer to animals that, although still morphologically wild, are showing signs of human control. This human control usually manifests itself in the culling profiles and sex ratios of the animals which no longer reflect the natural ratios of a hunted population but instead suggest a selective culling strategy. It has been suggested that there can be a significant time-lag between incipient domestication and morphologically wild animals (Arbuckle and Makarewicz, 2009). This means that relying on one line of evidence alone would not necessarily detect the first domesticates. All the available zooarchaeological evidence should be used in conjunction in order to build as strong a case as possible for the presence (or absence) of domesticates in an assemblage.

What is often neglected is the cultural aspect of domestication. This cultural process affects both humans and the animals being domesticated and starts with the concept of ownership. For an animal to be domestic it must be integrated into the social structure of human society where it becomes an object of ownership, purchase and exchange. As already mentioned one of the problems with detecting domestic animals in the archaeological record is the definition of domestication itself. Some researchers prefer the term ‘cultural control’ as this puts emphasis on the human-animal relationship itself, rather than on the effects on the animal population (Hecker, 1975). Rather than concentrating on the presence or absence of morphological change alone, the focus should perhaps also be brought on to considering how human populations interacted with the animals, how much control they exerted and what changes occurred in these human-animal interactions.

So what bearing does domestication have in terms of the people of the Late Neolithic? By this period sheep and goats had already been domesticated for several millennia in some areas, with the Zagros Mountains hypothesised to be one of the centres of origin (Zeder and Hesse, 2000; Davis 1993). The domestication status of cattle and pigs at this time remains unclear. At some sites in the Near East these animals are thought to be at least proto-domestic and under human control while at other sites they are apparently still wild (see section 3.6). What is clear, despite our imperfect understanding of the timing and tempo of this process, is that by the end of the Late Neolithic the domestication of these basic herd animals was well underway. One of the key questions to answer in this study is: what is the domestic status of the cattle and pigs in the Late Neolithic levels at Tell Sabi Abyad and does this change through time? In terms of the domestic sheep and goat herds of the Late Neolithic it is important to consider their management and the development of management strategies through time.

There is no argument that domestication of herd animals was a pivotal transformation in the development of the Near East (Abdi, 2003). One step further from domestication is the development of pastoralism. Pastoralism is a rather ill-defined and loosely applied term referring to an economy in which the bulk of the food supply is derived from the herding of species such as sheep, goats and cattle. The term ‘pastoralism’ is used variably in archaeological and ethnographical literature. In a broad sense it refers to any dependence on domestic herd animals and more specifically it refers to particular types of herd management (Martin, 1999). Pastoralism is a mode of production concerned with the exploitation of domestic animals, in the case of the Near East ovicaprids (sheep and goat), that occurs in a continuum from fully sedentary (village-based herding) to fully mobile (nomadic) pastoralism (Abdi, 2003). The composition of the herds, the management practices, the social organisation and all other aspects of pastoralism vary between areas and between social groups. Usually pastoralism involves the production of secondary (antemortem) products such as milk, yoghurt, cheese, and blood (see discussion of secondary product production below).

Abdi (2003) describes several broad forms of pastoralism:

1. Village-based herding: Perhaps the most basic form of pastoralism; this is still practised in many rural areas today. Village based herding can be further subdivided into “proximate” and “distant” forms on the basis on the distances travelled by herds and herders. Proximate village-based

- herding involves the herds returning to the settlement on a daily basis, being grazed in the fallow fields and pasture around a settlement in the summer and being kept in pens and fed with fodder in the winter months. This form of pastoralism is closely associated with agriculture and herd size is often small. The management of these herds is usually performed by those not required for more important agricultural activities, i.e. younger members of the household. Distant village-based herding involves taking herds to graze outside the agricultural areas and involves at least one day's travel. Herds are left to pasture for a few days before returning to the village, perhaps for milking. The herd is usually entrusted to one or two young adults who are capable of looking after themselves and the herds while the rest of the community is based at the village and involved in agriculture.
2. Transhumant pastoralism: Transhumance is a specialised form of pastoralism that makes use of seasonal variations in the availability of pasture, usually involving movements between summer pastures in the highlands and winter pastures in the lowlands.
 3. Semi-nomadic pastoralism: This form of pastoralism marks a move away from an economy focused on agriculture to one based primarily on pastoralism. It is characterised by extensive herding and a periodic change of pastures during the year. Either the entire group can be involved in both pastoralism and agriculture or there can be separate groups, those primarily involved in pastoralism and those primarily involved in agriculture.
 4. Nomadic pastoralism: This strategy is characterised by high mobility and an almost complete absence of agriculture. The whole group will cover considerable distances with their herds.

Nomadism and semi-nomadism refer to communal mobility while pastoralism, transhumance and herding are principally subsistence activities (Wossink, 2009: 101)

Sedentary pastoralism ranges in scale from the keeping of a small herd to ranching hundreds of stock over a very large area. Some pastoralist communities are nomadic and can be highly mobile. Mobile pastoralism as a way of life and as a subsistence economy is assumed to have developed parallel to the domestication of sheep and goats in southwest Asia (Alizadeh, 2008: 78). It is one of the mainstays of the economy of people who use the lands of the Syrian steppe, but herders rarely rely exclusively on pastoralism as a means of support, instead they are often involved in a mix of subsistence strategies (Betts and Russell, 2000: 24).

Pastoralism did not necessarily immediately precede animal domestication. It is important to note that there was perhaps a considerable amount of time preceding true herding, which can be defined as a perception of an animal as a person's property and the genetic manipulation of the animals (Horwitz, 1997). Pastoralism, in its various forms, has however played an important and diverse social and economic role in the Near East since the domestication of the primary herd animals - sheep and goats - in the Neolithic period (Abdi, 2003). Pastoralism, as a means of production and a mode of subsistence, has always been an integral part of Near Eastern society and economy (*Ibid*).

The nature of sedentism and the development of pastoralism in the Neolithic are important questions to tackle in archaeology. In recent decades there has been a move away from the concept of sedentary Neolithic societies towards one of a more mobile population, but demonstrating sedentism or mobility in the past is very difficult (Milner, 2005: 32). A growing body of evidence indicates that traditional conceptualisations of 'mobile pastoralist' and 'sedentary agricultural' residence and production systems are inadequate (Van der Kooij, 2002: 30). People in the Neolithic may have been more mobile than previously envisioned. Traditional conceptualisations of mobile pastoralism versus sedentary agriculture can no longer be considered adequate or accurate. Instead, sedentism and nomadism should be considered to represent competing forces on a continuum along which populations in marginal areas shift. Under the erratic environmental conditions of the Syrian steppe, mobility is an important factor in herd management with herds needing access to both grazing and water, which do not always occur together (Betts and Russell, 2000: 30-31). Restricted mobility can restrict both the scale of herding possible and the quality of the graze available (Halstead, 1996). Sedentary villages may have served as symbolic tethers for mobile people who herded their animals around the local landscape (Milner, 2005:

32). Ethnographic studies have shown that there are often important linkages between pastoral and agricultural economies, and that pastoral producers are often bound into sedentary and agricultural economies (Van der Kooij, 2002: 30). Sedentary settlements should be viewed as places where at least part of the population remains at the site all year round. This does not preclude mobility and some elements of the group may have been very mobile, perhaps being involved in the trading of goods or transhumance (Milner, 2005: 33).

One of the most distinct cultural developments in the past was nomadic pastoralism (Roberts, 1998: 177). This extensive form of production is thought to be an adaptation to arid or rugged terrain and it involves a distinctive set of ecological relationships between human groups and their environments (*Ibid*). The long distances travelled by many nomadic people today are impressive but the adaptation of nomadic pastoralism does not necessarily require substantial migrations (Gilbert, 1975). Pastoral nomads been shown to have a distinctive relationship with settled societies throughout the later Holocene (Roberts, 1998: 178), and this was likely also the case at the onset of this specialised form of subsistence. The distances may be long or short, the important thing is the move from areas of low grazing potential to areas of higher potential (Gilbert, 1975).

Ethnographic evidence from recent pastoralists indicates that killing for meat is rare and that, instead, milk products were developed for food (Ryder, 1981: 182). While we are discussing pastoralism it is therefore important to consider the possibility of 'secondary' product production in the Late Neolithic. It is also important to outline what these products are and how we go about detecting them in the archaeological record.

Secondary products are those for which animals may be utilised repeatedly over the course of their lifetimes and as such, they can also be considered antemortem products (Greenfield *et al.*, 1988; Arbuckle *et al.*, 2009). Secondary products include milk, fibres such as hair and wool, and traction. The term 'secondary products' was first coined by Sherratt (1981) based on the assumption that these products were not initially used when animals were first domesticated. It was originally thought that secondary products were only exploited to any extent in the fourth millennium BC, based on epigraphic and artifactual sources (Greenfield *et al.*, 1988). When, where and why this shift to an emphasis on secondary products took place however remained uncertain. New evidence, both biomolecular and demographic, has put the first exploitation of secondary products a few millennia earlier than the extensive production seen in the Bronze age, with clear evidence for milk exploitation in the Neolithic (Vigne and Helmer, 2007; Greenfield, 2005). Biomolecular and demographic data from traditional zooarchaeological analyses now indicate that dairying practices were in use from at least 6500 BC in northwest Anatolia and northern Syria, and may have emerged as early as the Middle PPNB in the northern Levant (Evershed *et al.*, 2008; Vigne and Helmer, 2007; Makarewicz, 2009). It is now clear that the origins of the exploitation of domestic animals for their secondary products lie much deeper than the third millennium historic civilisations, although perhaps not as deep as the origins of domestic animals themselves (Greenfield, 2005).

Careful stock management is necessary for the exploitation of milk products (Outram and Mulville, 2005). There is of course a need to not only balance milk production against the need for primary products such as meat, but also to balance the needs of offspring against those of the human population. At some point in time in the Neolithic pastoralists began to exploit milk as a dietary resource. Their success in exploiting milk and its use as a food source depended on their ability to manage their livestock (Tani, 2005).

Bones can be used to monitor changes in animal usage since they are more directly related to the reconstruction of prehistoric herding patterns than other types of archaeological data (Greenfield, 2005). The only way to detect secondary product production using archaeological faunal material alone is to look at the mortality profiles and sex ratios for animals for which such products are a possibility. These mortality profiles are then compared to a range of models of idealised meat, milk and wool or traction profiles. Perhaps the most widely used of these models (based on ovicaprids) was devised by Payne

(1973). His meat model predicted that most males would be culled when they reached the age of prime meat production, i.e. when they reached an optimum point in weight gain between 18 and 30 months of age. Payne's age model for fibre production predicts that most animals (both male and female) will survive well into adulthood. Finally the milk model suggests that most males will be slaughtered at a very young age with the survival of females well into adulthood. This third model is perhaps the most contentious; based on the specialised and intensive production of milk (such as that seen in modern dairy herds) it is very unlikely to be mirrored in the early domestic types of sheep, goats or cattle and care should be taken when extrapolating modern patterns of animal husbandry on to the past (Halstead, 1996).

It has been noted that primitive breeds of domestic sheep, goats and cattle will not release milk without the presence of their offspring and that it is necessary to keep the young alive (McCormick, 1992). The selective killing of very young males in archaeological samples is therefore unlikely to suggest a dairying economy (*Ibid*). The young males would instead be culled when lactation ended, from around nine months of age onwards (Balasse and Tresser, 2002). This delayed slaughter then starts to reflect the meat production model making the early, non-intensive production of herds for milk in addition to meat indistinguishable from the range of variation expected within the meat model (Arbuckle *et al.*, 2009). To complicate issues further, herders rarely focus on a single product. In the Near East mixed profiles are the norm (Helmer *et al.*, 2007) and herders must balance between conflicting requirements represented by management for multiple products, as well as in response to social and environmental factors (Arbuckle *et al.*, 2009). A new set of models was developed by Vigne and Helmer (2007) which included the addition of a "type B milk" model. The "type B milk" model is mostly characterised by the presence of a few lambs (2 to 6 months of age) with a high quantity of yearlings killed for meat throughout the year and with some older females being killed when their lamb or milk production decreased (Vigne and Helmer, 2007). This model is characterised by the fact that the un-weaned lambs are kept alive, as is still widespread in traditional Near Eastern herding today (Helmer *et al.*, 2007). Payne's (1973) milk model is termed "type A milk" in this new scheme and is characteristic of seeking a surplus for trade or commerce. The "meat type B" model of Vigne and Helmer (2007) corresponds to obtaining animals whose flesh is still tender but at their maximum weight, by preserving lambs and fattening them, thereby increasing the profitability of meat production, while the "meat type A" model corresponds more to the consumption of very young animals (Helmer *et al.*, 2007). These models are summarised in figure 3.5. This new range of models takes a much more holistic approach to animal husbandry which is thought here to be far more appropriate for use in understanding Neolithic animal exploitation strategies based on the age and sex of animals.

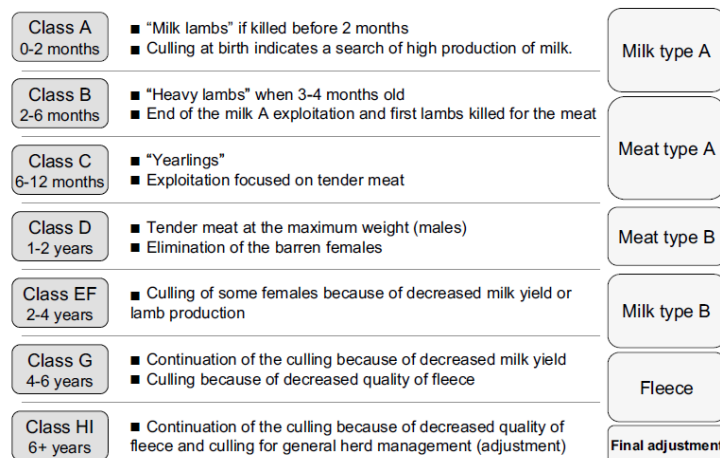


Fig 3.5: Secondary product model taken from Helmer *et al*, 2007

The carbohydrate in milk is lactose, which not everyone is able to digest (McCracken, 1971). All mammal infants possess the ability to metabolise milk but lactase production rapidly declines after infancy (*Ibid*).

Only humans consume milk as adults and it is assumed that the ability to produce lactase as an adult was an adaptation linked to survival (*Ibid*). Lactose tolerance (i.e. the ability to produce lactase) is a genetic adaptation which seems to have first occurred in the Neolithic (Outram and Mulville, 2005) pointing to the first adult consumption of milk products sometime in this period. Populations with prior histories of diets containing milk and milk products frequently exhibit the persistence of intestinal lactase into adulthood, including most Northern Europeans and Arab populations (Russell, 1988: 30). The most common practice to negate the effects of lactose intolerance is to process the milk, which breaks down the lactose by bacterial action, producing fermented products such as soured milk, yogurt, buttermilk and various cheeses (Outram and Mulville, 2005; Russell, 1988: 31). The curdling of milk is likely to have been discovered as soon as milk began to be exploited (Ryder, 1981: 195). Curd can be made into cheese, a highly nutritious food source containing 25% protein compared to 20% in meat, and 35% fat compared to 30% in meat (*Ibid*). While the processing of dairy products increases the labour costs and reduces the caloric returns, it has the added benefit of reducing lactose levels to a point where dairy products can be more easily digested by lactase-deficient adults (Betts and Russell, 2000: 28).

Although milk is perishable when fresh it can be stored for short periods through processing. Presumably, the Neolithic pastoralists, like their modern descendents, would have preserved their milk resources, perhaps in the form of cheeses, so that it could be stored for winter. A food store of this type is a considerable buffer against famine and stored fats are both highly palatable and nutritious (Legge, 2005). Such food stores are potentially a powerful social lubricant as items of gift and exchange (*Ibid*).

The development of domesticates had a huge impact on human life. Domestic livestock not only provide food but also milk, blood, skins, fibre, bones for tools and transport. The domestication of animals and plants had a significant effect on humans; it meant that human biology had to change to cope with the new novel dietary requirements, such as adult lactose absorption, and human social institutions had to undergo a revolution to cope with the increased population densities (Richerson and Boyd, 2000). The food surplus that early farmers were able to generate made possible the establishment of a 'non-food-producing' sector for the first time in human history (Weisdorf, 2005). The economic advantages of dairy production over meat production are many and the judicious use of animals for their secondary products can last throughout much of the animal's lifespan without serious damage to the animal or the generation of the product (Greenfield, 2005).

3.6 Zooarchaeological literature review

There are very few contemporary sites within the vicinity of Tell Sabi Abyad. The quality of the zooarchaeological reports also varies greatly and there is often only very basic information available. All radiocarbon dates were calibrated using the Groningen program WinCal25. Contemporary sites located within a few kilometres of Tell Sabi Abyad are shown in figure 2.26. These sites include Tell Mounbatah and Tulul Breilat and several un-named and un-excavated sites which were discovered through archaeological survey, for which no zooarchaeological data is available. The very nearby site of Tell Damishliyya was analysed by the author (see Russell and Buitenhuis, 2008). Tell Assouad is located a few kilometres upstream of Tell Sabi Abyad. In the broader landscape are the sites of Tell Halula in the Euphrates Valley and Tell Seker al-Aheimar in the upper Khabur basin, and to the south is the site of Tell Bouqras (see figure 1.1).

Table 3.1: Table of sites reviewed including approximate occupation dates (shaded areas⁸)

Date cal. BC	Period	Tell Sabi Abyad I Op I	Tell Sabi Abyad I Op III	Tell Sabi Abyad II	Tell Damishliyya	Tell Assouad	Tell Halula	Tell Seker al-Aheimar	Tell Bouqras
5700	Middle Halaf								
5800	Early Halaf								
5900									
6000	Transitional								
6100	Pre-Halaf								
6200									
6300	Early Pottery Neolithic								
6400									
6500									
6600									
6700									
6800	Initial PN								
6900									
7000	Late PPNB								
7100									

3.6.1 The Balikh

Over the past few decades, Syria has become one of the prime focuses of Near Eastern fieldwork, with the pace of Syrian archaeological research accelerating annually (Weiss, 1994). This region has an incredibly rich cultural heritage and is more far more accessible than other countries in the area such as Iran and Iraq (Akkermans and Schwartz, 2003: 2). The archaeology of this region provides information on a vast array of human societal changes such as the Neolithic revolution and the emergence of urban societies. For the Neolithic period, Syria provides some of the earliest evidence in the world for the onset of sedentary and agricultural life (*Ibid*).

Until recently the Balikh Valley received little attention from archaeologists who were preoccupied with sites in Mesopotamia and salvage projects along the Tigris and Euphrates rivers (Wilkinson, 1998). Although the Balikh lacks sites of the same magnitude as sites in other areas of the Near East, it is remarkably rich in Neolithic and Halaf occupation, often buried deep under multicomponent Tell sites (*Ibid*). The importance of the Balikh Valley to prehistory lies in its position between the Levant and Mesopotamia, where it acts as a link between these important areas (Copeland, 1979). Compared to the wealth of information on the southern Levantine Pre-Pottery Neolithic, especially in the seventh millennium BC, and the Chalcolithic cultures of the fourth millennium BC, there are very few syntheses of the Pottery Neolithic of the sixth and fifth millennium BC (Gopher and Gophna, 1993). In the Northern Levant this period requires analysis at a more advanced level as many complex events occurred at this time including the 8.2k BP climate event (see chapter 4).

A survey undertaken in 1983 gave ample evidence of a large number of prehistoric sites in the Balikh valley which suggested a continuous occupation of the area at least from the late eighth and early seventh millennium BC onwards (Akkermans, 1993). Unfortunately very few of these sites have been comprehensively excavated and, as such, there are not many comparable sites to Tell Sabi Abyad in the area of the same period, and even fewer with comprehensive faunal analyses available. There is unfortunately a general dearth of published evidence for subsistence for much of the known Late Neolithic, with many reports concentrating on settlement archaeology, pottery and flint.

⁸ The end of occupation at Tell Bouqras is usually set at about 6800 BC but ceramic analyses indicate that abandonment took place at a much later date (c. 6300 – 6200 BC). See Le Mièrre, 1986 and Campbell, 1992.

Previous studies at Tell Sabi Abyad

Several previous studies have been undertaken on the faunal material at Tell Sabi Abyad. In 1989 a study of 2344 bone fragments was undertaken by Van Wijngaarden-Bakker. This study was based on seven phases of Late Neolithic and early Halaf (c. 6100 and 5800 BC) material from Operation I, square P14. Fragmentation of this material was high with only c. 36% identified to species level. Ovicaprids dominate the assemblage representing c. 60 to 70% of the domestic animal remains. No specific husbandry strategy was uncovered due to a “generalised mortality profile” (Van Wijngaarden-Bakker, 1989). From biometrical analysis it was concluded that the sheep, goats, cattle and pigs were all domesticated at the site during this period. Through the phases the importance of pigs apparently increased to the detriment of cattle. It was speculated that this may have been due to a decrease in the amount of good grazing available. Wild animals were rare with very few specimens recovered; gazelle was only represented by one or two fragments in each of the phases for example.

In 2000 a study on the Late Neolithic levels at Tell Sabi Abyad was published based on the occupation levels dated from c. 6500 to 5800 BC (Cavallo, 2000). This study was based on faunal material from squares P13, P14, P15, Q14, Q15, and R13, an area known as Operation I, excavated during 1986, 1988 and 1991. More than 35,000 fragments were analysed producing a sample of c. 6900 bone fragments that could be identified to species and assigned to a specific phase. The bones were highly fragmented producing a high percentage of unidentifiable bones (c. 75%). The data was grouped into three broad phases: Pre-Halaf, Transitional and Early Halaf. The dominant species of ovicaprid represents c. 70% of the identified animals. Ovicaprids appear to have been exploited for meat in the earlier phases moving towards the development of secondary products (*Ibid*). This is accompanied by an increase in the number of goats, which are far better milk producers than sheep. It is hypothesised by Cavallo (2000: 114) that there was a move to pastoral nomadism in the Early Halaf. The next most common species were cattle and pigs. Analysis of the faunal remains showed that animal exploitation was based on these four domestic species i.e. sheep, goat, cattle and pig. While the ovicaprids remain dominant throughout the course of time their importance did decrease somewhat, especially after the pre-Halaf period. The importance of cattle also decreases with pigs in contrast continually increasing their importance, outnumbering cattle in the Early Halaf phase (Cavallo, 2000). Wild animals played only a very minor role in the subsistence economy of the settlement; species exploited include equids (probably *Equus hemionus*), aurochs, gazelle (probably *Gazella subgutturosa*), fallow deer, red deer, brown bear, fox, hare and striped hyaena.

Tell Sabi Abyad II

Tell Sabi Abyad II is another of the mounds that make up Khirbet Sabi Abyad. It is a small site which has been dated to between c. 7200 and 6700 BC (Verhoeven and Akkermans, 2000). During the 1993 season of excavation 2885 animal bone fragments were recovered from the PPNB period (Van Wijngaarden-Bakker and Maliepaard, 2000). Due to high levels of fragmentation approximately 60% of the animal remains could not be identified to species level. At Tell Sabi Abyad II the practice of animal husbandry focussed on the herding of sheep and to a much lesser extent, goats; loose control over the herd was argued based on broad age profiles and variable size (*Ibid*). Measurements indicate that the ovicaprids were fairly large, larger than those from the Pottery Neolithic at Tell Sabi Abyad I, with considerable variation in size. It is likely that the ovicaprids were domesticated but that hunting of wild sheep also occurred at low levels. Age profiles suggest a fairly even distribution in the kill off pattern for different age groups (*Ibid*). Cattle and pigs are only present in low percentages. Cattle bones were particularly fragmented which made separation of wild and domestic forms very difficult (*Ibid*). The cattle were predominantly adult and were large with all measurements falling into the upper range of cattle bones from Tell Sabi Abyad. Van Wijngaarden-Bakker and Maliepaard (2000) believe that these animals were probably within the very early stages of incipient domestication. The pig remains were in general from large individuals, but whether they were wild or domestic could not be determined. Other species present at very low proportions are gazelle, fox, badger, and a small number of bird remains.

Tell Sabi Abyad III

Excavations at the mound of Tell Sabi Abyad III revealed levels dated from c. 7000 – 6700 BC. The faunal remains from this site have unfortunately not been studied.

Tell Damishliyya

Tell Damishliyya is a small mound situated on the west bank of the river Balikh, opposite the modern village of Damishliyya. A small scale rescue excavation was undertaken in 1984 when it was discovered that building work was to occur at the site. Excavations revealed both seventh and sixth millennium levels, with three radiocarbon dates placing the late Neolithic strata to c. 6600 – 6400 BC. A total of 1567 animal bone fragments were recorded, all of which were hand collected (Russell and Buitenhuis, 2008). Due to high levels of fragmentation 57% of the bones could not be identified to species level. Species present include sheep, goat, pig, cattle, gazelle, fallow deer, equid, canid, hare and tortoise. The assemblage was dominated by ovicaprids with pigs the next most common species. The economy in the seventh millennium appears to have been based predominately on mixed herds of domestic sheep and goats, with sheep primarily exploited for meat and goats possibly also exploited for milk production (*Ibid*). Wild animals such as onager and gazelle were present only in very low numbers. The domestication status of the cattle and pigs could not be determined due to the small sample size.

Tell Assouad

Tell Assouad is a site situated approximately 20 kilometres from the Turkish border. It dates to around the same period as Tell Sabi Abyad and is therefore directly comparable. Only 815 bone fragments were identified from the 1969 sondage undertaken by J. Cauvin (Helmer, 1985). Excavations revealed a sequence of settlement layers but no architecture. The faunal assemblage at Tell Assouad is dominated by ovicaprids, with both sheep and goats thought to be domesticated. Pigs were also present and show signs of proto-domestication. Other animals present were aurochs, gazelle, and equid. Gazelles were present in high numbers at this site.

3.6.2 Beyond the Balikh Valley

Tell Halula

Tell Halula is situated on the right banks of the river Euphrates in the north of Syria in an area where precipitation varies between 250 – 350 mm annually. Material from this site dates from the PPNB, pre-Halaf, Halaf and Ubaid phases. Excavations at this site began in 1991 and have revealed a sequence of archaeological levels dating from 6,900 – 4,700 BC (Seguí, 1999: 70). Analysis of faunal data from the levels dated to 6800 – 5800 BC revealed an early phase relying on goat husbandry (c. 30% of the assemblage) together with a significant reliance on wild animal exploitation including aurochs, deer, equid, wild boar and gazelle (Seguí, 2000). The husbandry practices focussed on the breeding of goats for meat and possibly milk. Towards the end of the PPNB domestic sheep were introduced to the site and these animals were integrated into the economy. Cattle and pig domestication followed shortly after, with domestic cattle present by c. 6900 BC, based on biometric data (*Ibid*). By the beginning of the Pottery Neolithic the people of Tell Halula relied almost entirely on domestic animals.

Tell Seker al-Aheimar

Tell Seker al-Aheimar is a Neolithic mound found in the upper Khabur basin in north-eastern Syria about 45 kilometres north-west of Hassake. The mound first came to light in a 1991 French-Japanese survey and in 2000 became the focus of yearly excavations. At least five Neolithic phases have been defined including three PPNB and two PN phases (Nishiaki and Le Mièrre, 2005). The faunal analysis is currently being undertaken by Lionel Gourichon and preliminary findings reveal that domestic sheep and goat were the dominant species but that wild gazelle also formed a significant part of the assemblage (Gourichon, *per comms*). Cattle and pigs were also present but it remains unclear as to whether these were wild or domestic. Sheep and goat age profiles indicate that meat production was the main aim of the husbandry

of these animals in the PPNB but by the PN a more mixed pattern exploitation of these animals was indicated, with both meat and milk and perhaps also fibre production being important.

Tell Bouqras

Tell Bouqras is located on the west edge of the Euphrates Valley on a remnant of a Pleistocene river terrace c. 30 kilometres downstream from modern town of Deir ez-Zor (Akkermans *et al.*, 1981). The tell site measures approximately 2.74 ha in size. Excavations at the site took place in the late 1970's and they revealed ten building levels dated to c. 7200 – 6700 BC. This site is located in a desert-steppe environment with a modern annual rainfall of c. 125 mm. It is suggested by Akkermans *et al.* (1981) that animals formed the basis of the food supply rather than agriculture. Both herding and hunting were practised. Ovicaprids and cattle are the most common species present in all levels. The ovicaprids were apparently domestic and managed for their meat with no evidence of secondary product production (Buitenhuis, 1988). Although the cattle were of a similar size to the wild cattle found at Mureybet, it is stated that cattle were probably domestic at Bouqras and managed for their meat (*Ibid*). Sus, whether wild or domestic is unclear, were found in only very low numbers at the site. Wild fauna were also present and included gazelle, wild goat, aurochs, equid, wild boar and some birds. Fish and shell remains were also present but they were very rare.

3.6.3 General Trends

Faunal reports from the Balikh show that animal husbandry in this area focused intensively on domestic ovicaprids, particularly sheep, and the production of meat although some sites displayed signs that secondary products were also important. Pigs are generally the next most common species and often show at least signs of proto-domestication or cultural control. The domestication status of the cattle at these sites remains contentious until the Halaf period where evidence of the presence of domestic cattle is more concrete. All other animals exploited appear to be wild in origin and they generally make up a small proportion of the assemblages. As you move further a field into other areas of Northern Syria, ovicaprids, and again in particular sheep, remain the most important species with meat production the primary aim. Both pigs and cattle are also important, though to a lesser extent. Pigs show definite signs of domestication whereas cattle appear to be present in both the wild and domestic form at this time.

This review of zooarchaeological literature has made it apparent that each of the areas reviewed comes with its own particular ecological, geographical and cultural conditions which must be taken into consideration. Although broad trends are visible we see a lot of inter-site variability and regional variations. This is true of not only the animal and plant resources exploited but also the scale of the sites, and the different architectural and cultural attributes (Kansa *et al.*, 2009b). Despite these differences, it is evident that domestic ovicaprids were the most important species at the vast majority of sites, with the husbandry of these animals concentrating on meat production with secondary products perhaps also coming into play. Although the domestication and animal husbandry of ovicaprids is quite well developed at all sites the domestication status of both pigs and cattle varies from site to site. At most sites pigs appear to be at least proto-domestic or culturally controlled, if not fully domesticated at some sites. The picture for cattle is somewhat cloudier although it seems that the process of domestication had started at least at some sites. Despite the presence of apparently advanced forms of herding and animal husbandry at some of the sites reviewed, other sites of the same period remained heavily dependent on wild species. This highlights the amount of inter-site variation occurring at this pivotal period of time. Many of these settlements are located in very marginal areas where both plant cultivation and animal husbandry would have been a risky enterprise. It is clear that although there are signs of exchange of ideas and material culture, sites maintained a sense of autonomy and individuality particularly in their subsistence strategies.

3.7 Summary

It is clear from this broad review of palaeoenvironmental data that there is still much that we do not know about the Late Neolithic environment. In order to look at environmental changes it is imperative that environmental reconstructions can be produced not only for the Late Neolithic but for difference periods

within this broad time frame. In addition there is a lack of comprehensively analysed data available for this period. This is true both in terms of the animals and plants present, and broadly encompasses the whole of the Near East. The reasons behind this lacuna of information are related both to taphonomy and opportunity. There are so few Late Neolithic sites that have been uncovered in upper Mesopotamia and even fewer that have been comprehensively excavated and analysed with all the rigour of a modern scientific investigation. Those sites that have been excavated often have very little palaeobotanical data available either due to poor preservation of the organic remains or due to the excavation methods; sieving and flotation is rarely undertaken in any all-inclusive or uniform fashion and without such practices these minute remains will rarely be recovered in any number. In the case of animal bones the main problem lies in a lack of prioritisation of these remains for extensive analysis. This is particularly the case for older excavations which concentrate on architecture, flint and pottery.

Chapter 4 Climate Change and Changing Cultures

“...to ignore climate change as a potential element in affecting social behaviour is to refute not just the growing number of regional and global palaeoclimate reconstructions which show that Holocene climate varied across a wide frequency range, but also the equally strong archaeological/anthropological evidence for climate being implicated in social change and even collapse on all the continents... especially in marginal agricultural environments.”

(Dearing 2006)

4.1 Introduction

Over the last few decades the discussion concerning worldwide climate change, and its possible impact on the global environment, has escaped the narrow field of scientific investigation and has become a general topic of concern (Jansen *et al.*, 2007; McIntosh *et al.*, 2000; Issar and Zohar, 2004: 14). Fear about the rate and magnitude of future climate change has made understanding the underlying mechanisms of past climate changes increasingly important (Clarke *et al.*, 2003). The historical relationship of humanity to climate is a story that for the most part remains substantially untold (McIntosh *et al.*, 2000). The extent of climate variability during the present interglacial period, the Holocene, is currently a hot topic of debate with many studies dealing with abrupt climate oscillations being initiated (Rohling and Pälike, 2005; Hoek and Bos, 2007). The study of periods of climate instability during the Holocene has important implications for the modelling of anthropogenic effects on modern climates (Stager and Mayewski, 1997). Popular and political preoccupation with present human-induced climate change has led to a plethora of research not only into the climate in the past, but also into the effects changes in the climate had on human evolution and ancient human societies (Weiss, 2000; Weiss and Bradley, 2001; Berglund, 2003; Claussen *et al.*, 1999; Foley, 1994; Sherratt, 1997; to name but a few). This research has led to the realisation that many changes in ancient cultures can at least in part be linked to contemporaneous climate change. Some of the main questions posed are:

- When did these climate changes occur and how long did they last?
- What were the effects of such changes on different environments?
- How did they impact humans?

Of course, one does not wish to be a climate determinist as many other factors can come into play. Societies are not simply monolithic bodies that roll and flow with environmental tides (Rosen, 2007: 4). The problem with linking environmental and cultural change is demonstrating causality. Just because these changes take place at the same time does not mean that one caused the other. In order to establish a link it must be demonstrated that the environmental change was the critical factor (Coombes and Barber, 2005, Rosen 2007). This involves carefully dated environmental and cultural changes, the use of models and the consideration of all other factors. This is one of the aims of the current research at Tell Sabi Abyad.

4.2 What is climate change?

Before launching into a discussion about climate change, it is important to understand what climate is and what is meant by abrupt climate change. Climate can be defined as the meteorological conditions, including temperature, precipitation, and wind, that prevail in a particular region. As such climate is not the same as weather; weather events occur on a daily scale while climate variability occurs on many time scales ranging from decades to millions of years (Peixoto and Oort, 1984). Although weather is a fairly chaotic non-linear dynamic system, climate is fairly stable and predictable. Climate change is the long-term change in the average weather conditions including changes to global temperatures and precipitation. It becomes apparent as a change in annual, seasonal or monthly means and is superimposed upon the natural variability of climate both temporally and spatially. Abrupt climate change refers to an event where large and widespread climate change occurs within a short period of time, perhaps as short as a decade.

Although the climate of the Holocene is thought to be very stable compared to previous epochs, recent research has not only provided evidence suggesting that climate shifts occurred, but also that they occurred more rapidly than had previously been thought possible. In fact, fossil records show that natural climate shifts can occur in as short a time as a few decades (Hoek and Bos, 2007). The discovery of these warming and cooling cycles has drawn attention to historic events such as the 'Little Ice Age' and other climate downturns that have been significant enough to disrupt human cultures (Peiser, 2003). The exact timing of the events largely depends on accurate dating (Hoek and Bos, 2007).

Arguably some of the best proxy data for climate change comes from ice-core records where both a large time span and good time resolution is available. A more or less continuous fine-grained palaeoclimate record has been obtained from Greenland ice cores, which show annual deposition allowing independent dating in 'ice-core years' (Dansgaard *et al.*, 1993). The Greenland ice sheets provide high resolution and a continuous times series of climate related parameters providing an insight into changes in climate and atmospheric chemistry throughout the last glacial to interglacial cycle (Johnsen *et al.*, 1992; Peel, 1995; Alley, 2000). The well dated, high-resolution Greenland Ice Sheet Project Two (GISP2), the European Greenland ice core Project (GRIP) and NorthGRIP provide some of the best proxy data of Holocene climate change. Ice core records show that changes in the climate of the past have been broad, rapid, and synchronous over large areas (Alley, 2000; Alley *et al.*, 2003; Johnsen *et al.*, 2001).

Evidence from North Atlantic deep sea cores also reveal abrupt shifts in the climate of the 'relatively stable' Holocene with events occurring with a cyclicity close to 1470 ± 500 years with peaks at about 550 AD, 1850 BC, 2250 BC, 3950 BC, 6150 BC, 7450 BC, 8350 BC and 9050 BC possibly due to "ice-rafted debris" (IRD) events (Bond *et al.*, 1997). All these events represented a cooling episode. Multi-proxy records from a bog in eastern Newfoundland revealed evidence of 14 events occurring at 6320 BC, 5550 BC, 4850 BC, 3750 BC, 3250 BC, 2950 BC, 2450 BC, 2050 BC, 1150 BC, 550 BC, 100 BC, 250 AD, 1350 BC and 1750 BC (Hughes *et al.*, 2006). It is apparent that the exact timings of events vary by proxy record perhaps due to uncertainties in the age control. Examination of c. 50 globally distributed palaeoclimate records revealed as many as six periods of significant rapid climate change during the time periods 7050–6050 BC, 4050–3050 BC, 2250–1850 BC, 1550–550 BC, 750–950 AD, and 1350–1800 AD, with most of these climate change events being characterized by polar cooling, tropical aridity, and major atmospheric circulation changes (Mayewski *et al.*, 2004). In general, the Holocene climate change events occur at intervals of approximately 1500 years (*Ibid*). Most of these cooling events lasted around 100-200 years with a modest change in temperature of approximately 0.5–1°C, with the exception of the event occurring approximately 8200 cal BP for which temperature reductions of between 5°C (Nordic Sea) and 0.5°C (subtropical North Atlantic) have been reconstructed based on proxy-data and climate models (Wiersma and Renssen, 2006). These high frequency changes, several of some magnitude, would have occurred very suddenly and would have been important in stressing human populations in marginal situations, with different local expressions depending on specific thresholds of climatic and biological change (Sherratt, 1997). These abrupt climate change events of the Holocene radically altered precipitation, fundamental for cereal agriculture, across the expanse of late prehistoric and early historic cultures known from the archaeological record in Near-Eastern regions (Staubwasser and Weiss, 2006). Social adaptations in both dry-farming and irrigation agricultural regions are visible in the archaeological record during many of these abrupt climate change events in West Asia (*Ibid*).

It is now clear that the Holocene climate was not as stable as once thought and was in-fact plagued by events that were often abrupt in their beginnings but lasted for decades or even centuries (Weiss and Bradley, 2001; De Menocal, 2001). It is important to understand the aetiology of these climate anomalies and the underlying mechanisms. There is increasing evidence for a solar component to climate variability in the Holocene⁹, together with perturbations in the THC (thermohaline circulation) resulting from sudden freshwater releases into the oceans (Barber *et al.*, 1999; Bauer *et al.*, 2004; Klitgaard-Kristensen *et al.*,

⁹ Although the exact mechanisms involved still need to be determined

1998; Renssen *et al.*, 2002; Teller *et al.*, 2002; Wiersma and Renssen, 2006; Van Geel *et al.*, 1999; Bond *et al.*, 2001). The consequences of such climate changes on agricultural production, as well as many other variables, would be immense. The aspects of climate change with the most impact are rainfall, soil moisture, storminess and dustiness (Broecker, 1999). It is important to note however that there is a strong regional component in Holocene climate changes, making studies in climate-archaeology complicated as observations made in one region are not necessarily valid for the next (Weninger *et al.*, 2009).

4.3 Climate change in archaeology

Archaeological research can provide a unique and effective means of following changes in the demography and social organisation of human societies through long periods of time (Wossink, 2009: 4). Unfavourable environmental change has been one of the most popular prime movers in archaeological explanation, probably due to its undeniable role as a source of stress to a society (Rosen, 1995). There is a widespread tendency to ascribe a causal role to environmental change in the explanation of many of the major processes in human prehistory (Wakins, 2008). It is however arguably far easier to write about new, fast-developing areas of research such as climate change than it is to explore the implications of this research on a relatively mature discipline such as archaeology (Burroughs, 2005). In addition, there are considerable limitations in archaeological data when it comes to attempting to infer associations with climatic conditions (Oates, 1982). So how do we relate climate change data to human experience? Of course we can never truly experience anything that happened in the past, we can only extrapolate hypotheses from archaeological data. What we can do is study past climate change events and archaeological data from these periods to try to see what the possible effects of these events were, if there were any effects at all. This is the most important issue faced by archaeologists in terms of climate change. In this task, accurately calibrated radiocarbon dates of archaeological levels and palaeoclimate data are essential. During the last decade, large scale dating programs have become available using AMS (Accelerator Mass Spectrometry); the dating precision of large datasets can also be improved by advanced statistical treatment (Bayliss *et al.*, 2004; Bronk Ramsey, 2008). Precision is key and an assessment of the role of small scale climatic fluctuations as a forcing factor of population dynamics requires the availability of fine resolution environmental data (Kay and Johnson, 1981).

Archaeologists are interested less in the climatological aspects and more on the social-cultural dimensions. How did climate change affect cultures in the past? How did people cope and adapt? Was there any cultural response at all? Or was there in fact a complete collapse? We want to know how past cultures interacted with their environment and how changes in climate affected them. The only way to do this is to place the archaeological record of cultural change within the context of detailed, and most importantly well dated, palaeoclimate records (De Menocal, 2001). Synchronisation of archaeological chronologies with palaeoclimate histories is essential for those wishing to evaluate the impact of climate on past populations, as this is the only way potential links between climate and cultural changes can possibly be alleged (Wossink, 2009: 4). Even with this information, there is a problem with linking environmental and cultural change and demonstrating causality. Just because these changes take place at the same time does not mean that one caused the other. It must be demonstrated that the environmental change was the critical factor. This involves carefully dated environmental and cultural changes, the use of models and the consideration of all other factors. It is particularly important to consider the complex interactions between humans and their environment, as to ignore the agency of humans can lead to a climate/environmental determinist interpretation.

Archaeological investigations have revealed evidence for prehistoric societal collapses, which occurred quite suddenly and frequently involved regional abandonment and replacement of one subsistence base by another, such as agriculture by pastoralism (Berglund, 2003; Brooks, 2006; Catto and Catto, 2004; Clare *et al.*, 2008; Weninger *et al.*, 2006; Weiss and Bradley, 2001). The cause of these collapses was thought to be a combination of social, political and economic factors, but increasingly palaeoclimatic data points to the possibility of another cause. Abrupt climate change could have brought new conditions that were

unfamiliar to the inhabitants of the time and which lasted for decades or even centuries (Weiss and Bradley, 2001). The collapse of a number of ancient civilisations has, at least in part, now been blamed on climate change including the downfall of the Akkadian civilisation (Weiss *et al.*, 1993), Norse settlements in Greenland (Barlow *et al.*, 1997) and the ancient Mayans (Peiser, 2003). The archaeological record is replete with evidence for the 'collapse' of cultures (Berglund, 2003; Brooks, 2006; Catto and Catto, 2004; Clare *et al.*, 2008; Weninger *et al.*, 2006; Weiss and Bradley, 2001) and the Neolithic in the Near East is no exception. We cannot assume however that the collapse of a social system is an automatic and unavoidable response to climate change and environmental degradation (Rosen, 1995). Many of the climatic explanations for the collapse of societies have been criticised for being overly simplistic (*Ibid*). Nevertheless, climatic explanations persist.

Despite the possible negative affects of climate change some periods of extraordinary environmental change may have provided the optimum conditions for short-term diversification of socio-economic systems; the emergence of the Holocene environments and subsequent cultural diversification is a worldwide example of this (Prentiss and Chatters, 2003). Severe, abrupt changes in climate are often associated with the collapse of civilisations but there is increasing evidence that global climate change and the process of environmental desiccation is accompanied by increasing levels of social complexity, stimulating societies to become more complex and organised as they responded to these changes (Brooks, 2006). Given our extraordinary adaptability and variability, environmental transformations that might be catastrophic for some may present significant opportunities for others (McIntosh *et al.*, 2000). As often as climate changes cause collapse, they may stimulate increased complexity or provide opportunities to explore altered environments (*Ibid*). The continuation of these environmental changes can however lead to decimation of human cultures (Prentiss and Chatters, 2003). This decimation of culture is often associated with incompatibilities between human behaviour and ecological conditions and/or intensely competitive relationships between human populations (*Ibid*). Environmental change may reduce landscape productivity and increase demographic stress and the intensity of intersystem competition (*Ibid*). Populations dependent on hunting and foraging without significant investment in storage of food would have experienced severe hardship in times of environmental stress (*Ibid*).

It is clear that societies do display some adjustments to the Earth's various climates (Kay and Johnson, 1981). A full understanding of the cause of societal change at this time can only be achieved through a rigorous reconstruction of climate, human activities and earth processes, and most importantly, their interactions (Dearing, 2006). Human activities and environmental change work together. Climatic impact on human societies can be analysed through several aspects of human cultural evolution: the choice and management of animal subsistence resources is the aspect explored in this research.

4.4 Climate Change at Tell Sabi Abyad

There is a growing consensus among scholars that climatic and environmental changes were often the root of a chain reaction leading to economic recession and resource depletion that could ultimately have been responsible for the decline and collapse of some Near Eastern civilisations (Weiss, 2002; Weiss and Bradley, 2001; Weiss *et al.*, 1993; Issar and Zohar, 2004: 38). The 8.2k cal BP climate event has been connected with culture change and a restructuring of prehistoric communities in the Near East, notably the Levant and northern Mesopotamia (Weiss and Bradley, 2001; Staubwasser and Weiss, 2006; Weninger *et al.*, 2006; Weninger *et al.*, 2009). Tell Sabi Abyad is one of the few sites that appears to have had continued occupation throughout the so-called 8.2k event, and as such is a very important and interesting site, the analysis of which will give a much needed insight into this important period of human history. Recent research has shown that arid events affecting the Near East occurred several times in the Holocene with evidence coming from the Dead Sea in Jordan and Soreq cave in Israel (Migowski *et al.*, 2006; Enzel *et al.*, 2006; Bar-Matthews *et al.*, 1999). The Dead Sea can be viewed as a large rain gauge for the Levant region and the recent achievement of both high resolution and well dated sedimentary records have allowed the reassessment of climate-culture interactions in the Holocene (Migowski *et al.*, 2006; Enzel *et al.*, 2006). Through the analysis of these sediments major wet and dry, arid periods have been

documented, many of which had already been noted in proxy records from the Northern hemisphere. In particular it is the arid periods that have the most detrimental effects. Not only is there building evidence for the existence of these arid inducing climate events but they also seem to coincide with major breaks in the Near East cultural evolution (Migowski *et al.*, 2006). It has been put forward that a general drying process, which began around the end of the seventh millennium BC marked a crisis that saw the disintegration of cultures along the desert margins (Issar and Zohar, 2004: 68). Data from marine cores, Dead Sea sedimentology, and the palynology of the Houleh and Ghab indicate a period between 6050 and 5650 BC when winters were colder and the climate was generally drier (Sanlaville, 1996). Until recently this period of distinct change was widely overlooked in Near Eastern archaeology, mostly due to a lack of sites. Previous research at Tell Sabi Abyad has indicated substantial cultural change around 8200 years ago with strong evidence of a fundamental, rapid transformation of society at this time, including changes in the arrangement of settlement, architecture, social organisation and material culture. A recent study by Weninger *et al.* (2006) tied the desertion of Çatalhöyük-East, as well as other sites in Anatolia and the Eastern Mediterranean, and the spread of early farmers out of the Near East into Europe to the influence of the 8.2k cold and dry event. Investigating the possible effects of climate change obviously requires a detailed insight into the development of society before, during and after the event. The occupation of Tell Sabi Abyad spans the event and provides the perfect opportunity for archaeologists to do just that, making Tell Sabi Abyad a good candidate for research into the reactions of the prehistoric communities that weathered the climate change. This is exactly the purpose of this research project and it is hoped that it will help to shed further light on this climate phenomenon, with particular attention paid to changes in the animal based subsistence economy.

The 8.2k event is a widespread, synchronous climate event that is thought to have punctuated a broader underlying deterioration in climate that started 8600 years ago and lasted 400 to 600 years (Rohling and Pälike, 2005), which may have been caused by a period of decreased solar forcing although this remains a contentious issue (Rohling and Pälike, 2005; Muscheler *et al.*, 2004; Van Geel *et al.*, 1999). Evidence from a North Atlantic deep-sea sediment core suggests that this broad climate anomaly was marked by two distinct cooling events at 8490 and 8290 years ago (Ellison *et al.*, 2006), while GRIP and North-GRIP Greenland ice cores place the peak of the event at 8.15 to 8.05k cal BP (6200 – 6100 BC). The 8.2k event was not an isolated event but the culmination of change that started several hundred years earlier (*Ibid*). This event is thought to have brought about generally cold and dry conditions causing a drought in arid areas (Rohling and Pälike, 2005; Alley and Ágústsdóttir, 2005; Weiss and Bradley, 2001; Hoek and Bos, 2007). This is the event used by Pentagon officials as a 'worse case' scenario for future climate change (Schwartz and Randall, 2003). The effects of the 8.2k cooling episode are identified in Greenland, the North Atlantic, Europe, North America, North Africa and the Venezuelan Cariaco Basin (Baldini *et al.* 2002) with ties between cold temperature in the North Atlantic and drought in Asian and African monsoonal regions (Alley and Ágústsdóttir, 2005). Oxygen records from Greenland ice-cores have provided convincing evidence for this abrupt cold event with an estimated cooling of $6 \pm 2^\circ\text{C}$ over Greenland (Alley *et al.*, 1997), with these changes in temperature contributing to a major displacement of vegetative patterns (Alley and Ágústsdóttir, 2005). This event was not restricted to the Northern Hemisphere with evidence for a sudden and marked reduction in precipitation in Africa, the Near East and Asia at this time (Renssen *et al.*, 2002; Gasse, 2000; Bar Matthews *et al.*, 1999; Migowski *et al.*, 2006; Enzel *et al.*, 2006).

Over the last few years it has become clear that global weather conditions are an expression of the relationships between the atmosphere and the world's oceans, their currents and counter-currents (Issar and Zohar, 2004: 15). The generally accepted explanation for the 8.2k event is a slowing down of the ocean THC as a result of freshwater perturbation, following the drainage of the huge proglacial Laurentide Lakes (Lake Agassiz and Ojibway) in front of the Laurentide Ice Sheet (Barber *et al.*, 1999; Bauer *et al.*, 2004; Klitgaard-Kristensen *et al.*, 1998; Renssen *et al.*, 2002; Teller *et al.*, 2002; Wiersma and Renssen, 2006) (figure 4.1). Geological evidence shows that these lakes drained catastrophically around 8400 years ago, which resulted in an anomalous climate pattern that developed across much of the Northern Hemisphere (Alley and Ágústsdóttir, 2005; Barber *et al.*, 1999). Ocean circulation in the North Atlantic is driven by a sensitive density balance, between salinity and temperature, which would respond

immediately to such a large outburst of freshwater (Klitgaard-Kristensen *et al* 1998). The result would be a slowing of the THC and a decrease in northward heat transport by the North Atlantic Ocean, leading to pronounced cooling (Wiersma and Renssen, 2006).

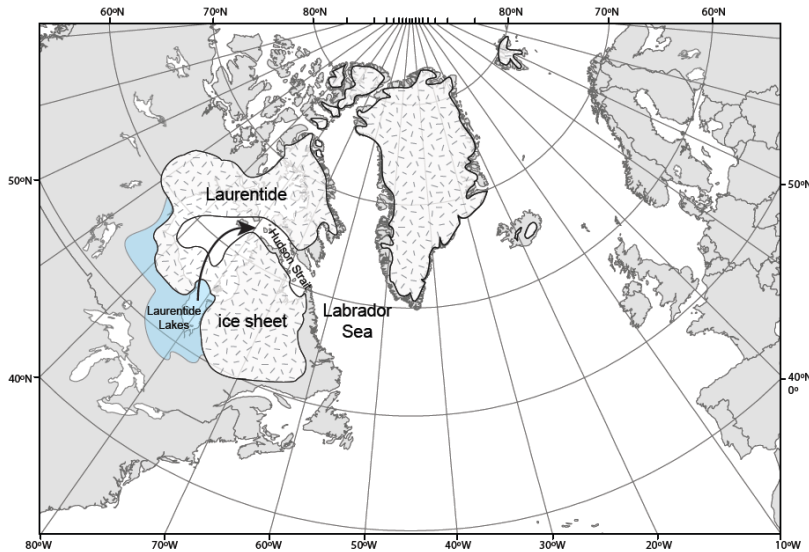


Fig 4.1: Map to show the configuration of the Laurentide Lakes and the Laurentide ice sheet, just before the lakes drained with the arrow showing the direction of drainage (taken from Wiersma, 2008)

Investigations into current climate change are based on direct data, such as air and sea temperatures, atmospheric pressures, wind directions and velocities. In order to explore climate change in the past however, we rely on proxy data derived from geology (the nature and distribution of sediments), geochemistry (chemical and isotope composition), biology (botanical and faunal assemblages, tree rings) and other sources such as archaeology. Although the past few decades have witnessed a refinement in palaeoclimate proxy records, one of the main problems with investigating any climate event by collecting published proxy records remains the uncertainty related to the chronology (Wiersma, 2008; Wiersma and Renssen, 2006). There is an offset of around 200 years in the terrestrial dates for the Agassiz drainage and the ice core chronologies, which while within error bars, is still quite significant (Schmidt and Jansen, 2006). There is often uncertainty in the radiocarbon dates, with marine or lacustrine dates having the added complication of the reservoir effect and correction to consider, assumptions are often made about sedimentation rate, and to make matters worse there is a plateau in the calibration curve around 8.2k cal BP (Wiersma, 2008; Wiersma and Renssen, 2006). Differences in climate from region to region and differences in the sensitivity of climate proxies from different records means that not every rapid climate change will necessarily be captured by every record (Mayewski *et al.*, 2004). Proxy records with a low resolution may easily miss abrupt and short-term climate changes. All these factors taken together can lead to uncertainties in the timing of signals in proxy data of up to several centuries. Pin-pointing an abrupt climate anomaly such as the 8.2k event can therefore be very difficult, with the climate signal perhaps not occurring synchronously in different records (Wiersma, 2008). This is well illustrated in figure 4.2. It is important to consider the response time of a proxy record to changes in the climate (Kay and Johnson, 1981), and in order to integrate the time-scales of different palaeoclimate records it is necessary that the chronologies for each record are determined with sufficient precision and accuracy (Bronk Ramsey, 2008).

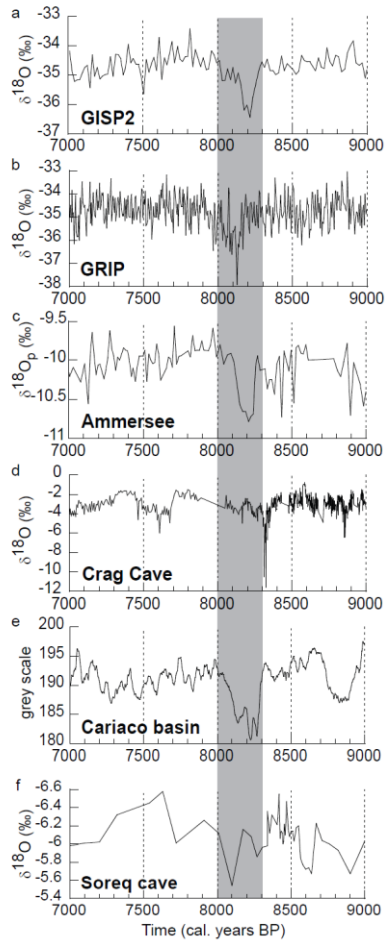


Fig 4.2: High-resolution sites that record the 8.2k event. a) GISP2 (Greenland), b) GRIP (Greenland), c) Ammersee (Germany), d) Crag Cave (Ireland), e) Cariaco Basin (Venezuela), f) Soreq Cave (Israel) (taken from Wiersma, 2008)

These are examples of well-dated records from different latitudes which have a relatively high sampling resolution and a clear climate signal (Wiersma, 2008). For the Northern hemisphere evidence for the 8.2k climate change has been provided by temperature records derived from Greenland Ice cores (NorthGRIP, GRIP and GISP2), with decreased snow accumulation rates, lower levels of atmospheric methane, and increased atmospheric dust and sea-salt loading indicating widespread dry conditions (Baldini *et al* 2002). Major ice-rafting and strengthened atmospheric circulation also point to cooling over much of the Northern Hemisphere (Mayewski *et al.*, 2004). The extent, character and magnitude of the climate change associated with the 8.2k event outside the North Atlantic remain insufficiently constrained however, and there is a lack of high-resolution proxy records from the low to middle latitudes (Rohling and Pälike, 2005; Schmidt and Jansen, 2006). There is some strong evidence from other regions however. Tree ring records from Germany and the European Alps show decreasing tree-ring width presumably caused by lower summer temperatures, shorter growing periods or lack of moisture (Klitgaard-Kristensen *et al.*, 1998; Spurk *et al.*, 2002; Nicolussi *et al.*, 2009) indicating that the effects of the 8.2k event were felt in Europe. Evidence that the effects were also felt further south is evidenced through massive perturbations in terrestrial ecosystems and temperature reductions of $>4^{\circ}\text{C}$ in the Eastern Mediterranean region occurring shortly after 8.2k BP (Pross *et al.*, 2009). There was a reduction in the percentage of broad-leaved tree pollen from 87% to 53% indicating deforestation related to a reduction in temperature. Unfortunately proxy data of this kind for the Near East are scarce; one study in existence is that of core samples from sediments at the bottom of the Persian Gulf taken by the research ship *Meteor*, which indicate a very dry

climate from c. 6500 BC to 5500 BC (Issar and Zohar, 2004: 65). There is also proxy data from Soreq cave in Israel (Bar Matthews *et al.*, 1999). The Soreq Cave signal is not straightforward because of its lower resolution, but a marked period of aridity is detected between 8.5 and 7k cal BP (*Ibid*). The Dead Sea is viewed as a large rain gauge for the Near East and therefore a sensitive recorder of Near East climate variability. Proxy data from the Dead Sea in Jordan indicates that the effects of the 8.2k event reached the Near East, with a rapid drop in lake level around 8.6k BP, followed by a further drastic decrease c. 8.1k cal BP (Migowski *et al.*, 2006), and that it brought generally cool and arid conditions (Migowski *et al.*, 2006; Enzel *et al.*, 2006). Climate modelling has also indicated that this event would have increased aridity in the Near East (Wiersma, 2008). These palaeoclimate records, although useful, are unlikely to pick up any subtle changes occurring in the micro-climate of the Balikh Valley. What these proxy records show is that although the effects of the 8.2k event are detected, there is a great deal of regional variation in the effects of this climate anomaly.

In general the 8.2k event apparently brought about a reduction in atmospheric moisture content and possibly inhibited the development of rain bearing convection currents, these changes would have significantly altered both the oceanic and atmospheric circulation (Brooks, 2006). These factors are thought to have contributed to a reduction in rainfall over regions such as northern Africa and the Near East, which appear to have experienced a period of aridity around this time (Brook, 2006; Weiss and Bradley, 2001). This aridity is assumed to have also effected the upper Balikh Valley and therefore the Late Neolithic inhabitants of Tell Sabi Abyad. It is water availability that is the key climatic determinant for people existing in semi-arid areas such as the Near East (De Menocal, 2001) and an increase in aridity can be fatal. Tell Sabi Abyad is situated between isohyets of 300 mm (Tell Abyad) and 200 mm (Raqqqa) making the area rather marginal for dry farming and crop failures common (Van Zeist, 1988; Wilkinson, 1998). Even small changes in the amount of annual precipitation can have drastic results with long term droughts of a few centuries being easier to adapt to than short term droughts of a few years which can bring swift disaster to agricultural communities (Mulder, 1969: 29).

Palaeo-studies of environmental proxy indicators such as peat, lake sediments, fluvial sediment, estuarine sediments and tree rings, have provided a comprehensive list of environmental conditions, which leave us with little doubt that there was indeed a significant climate change at around 8.2k cal BP. Although there are now a number of palaeoclimatic records from across the hemisphere, which show a large and abrupt climate change around this time, the exact timing, the duration and general character of the event remains ambiguous. A survey of published literature on the chronology of the event point to it peaking c. 6225 BC (Alley *et al.*, 1997; Barber *et al.*, 1999; Kleiven *et al.*, 2008; Thomas *et al.*, 2007; Spurk *et al.*, 2002; Nicolussi *et al.*, 2009). The duration of the event appears to be different at different locations, probably owing to the difficulties of age uncertainties in all palaeoclimate records, continuity and regional climatic influences (Kobashi *et al.*, 2007). Although evidence from Greenland indicates that the event started at around 8175 ± 30 years BP and lasted roughly 150 years (*Ibid*), while others dare to be even more precise stating the cold event lasted 160 years with the peak of the event lasting 60 to 70 years (Schmidt and Jansen, 2006; Thomas *et al.*, 2007), other sources state that it lasted as long as 300 years (Wiersma and Renssen, 2006), or even 400 years (Weiss, 2000). The big question is how sensitive or resilient were past socio-economic systems to increased stress from climate change? Social adaptations to the abruptness of the 8.2k climate change are likely to be very varied and complex based on the differences in the flexibility of systems in the area. Systems that functioned adequately in the normal course of short-term drought may not have been able to cope with long-term trends towards a drier climatic regime.

The scarcity of high resolution terrestrial climate proxies from the Near East make connecting culture change to climate change, and proving causal relationships very difficult. Pross *et al.* (2009) suggest that the climate forcing during the 8.2k event in the north-eastern Mediterranean region was strong enough to have a massive effect on socioeconomic structures. Migowski *et al.* (2006) suggest that the arid events in the Dead Sea appear to coincide with major breaks in the Near East cultural evolution and suggest a parallelism between climate and Near East cultural development. Weninger *et al.* (2006) propose that rapid population movements and the transient abandonment of settlements in central Anatolia caused by

particularly dry conditions around 8.2k cal BP lead to the propagation of Neolithisation in south-eastern Europe. It is also suggested that the event caused social change and triggered abandonment at Çatalhöyük in Anatolia (Weninger *et al.*, 2006; Weninger *et al.*, 2009). Rollefson and Köhler-Rollefson (1992) suggest a “collapse” in the Levant with large villages probably becoming small hamlets as the amount of water necessary for agriculture became unavailable. The abandonment of Cyprus is also connected to the event (Weninger *et al.*, 2006). Complex cultures and societies are readily able to adapt to variations in weather and climate but persistent droughts are a challenge that require developed coping strategies (De Menocal, 2001). From the archaeological viewpoint, uncertainty about the causal linkages between abrupt climate change and social collapse derives from chronological imprecision and the uncertain ability of societies to adapt to the abruptness, magnitude and duration of environmental change brought about by the 8.2k event (Weiss and Bradley, 2001). It is clear that not all sites responded synchronously or equally during the 8.2k event, despite its apparent global extent, emphasising the complexity of the Holocene climate and further highlighting the importance of having widely distributed site-specific palaeoclimate data (Mayweski *et al.*, 2004). It is important not to use data from one area to extrapolate to another. Chronological refinement, in both the palaeoclimate and archaeological records, and transfer functions for precipitation and both agricultural and pastoral production are needed to understand and substantiate any suggestions of causality (Staubwasser and Weiss, 2006).

4.5 Climate change, subsistence and culture

The process of increasing social complexity, often associated with the development of agriculture and large settled communities, was made possible by the relatively benign climate of the Holocene (Brooks, 2006). All agricultural societies, past and present, rely on the constancy of climatic conditions (Peiser, 2003); any abrupt changes to the Holocene climate would have had serious repercussions on early agricultural communities, particularly those in marginal areas like Tell Sabi Abyad. One theory is that climate change can bring about an uncertainty in the availability of foods, which may lead to people trying to control access to food resources as reliable food supplies can no longer be assured (Richards, 2002).

Archaeological research has unearthed empirical evidence for the inherent vulnerability of agricultural societies to climate change (Peiser, 2003). The Neolithic system of mixed cereal cultivation and livestock husbandry would have been no exception (Bonsall *et al.*, 2002). These early systems were probably especially sensitive to even small changes in precipitation or temperature, either due to the limitations of early farming technology or because pioneer farmers were less able to deal with periods of environmental stress (*Ibid*). Changes in subsistence strategies have previously been linked to both social mutation and climate changes (Jousse, 2006). It is hypothesised that since agricultural production relies on factors such as soil fertility and precipitation, prolonged climate downturns such as droughts, would have regularly led to migration and resettlement. It is important to bear in mind however, that the relocation of a society does not necessarily mean the unmitigated ‘collapse’ of a society (Peiser, 2003).

Culture and climate change

Humans have developed a remarkable range of cultural mechanisms to buffer against variability and we use culture to respond to changes in our environment (Halstead and O’Shea, 1989; Naylor, 1996). Environmental variability is a fact of life and it is culture that acts as a mitigating factor, allowing humans to respond to problems which may otherwise affect their survival (Halstead and O’Shea, 1989; Naylor, 1996). Success is based on the ability to cope with extreme variations in environmental conditions. No culture is immune to change and all cultures change for a wide variety of reasons. In the context of adapting to environmental change a culture must be flexible, adaptable, and open to change itself. There must be some provision within a culture to cope with the natural fluxes in both natural and sociocultural environments and these coping mechanisms and strategies must match both the scale and capacity of the variability it has to contend with (Naylor, 1996; Halstead and O’Shea, 1989). It can be argued that the susceptibility of a human population to environmental change is primarily a social condition: humans are not inherently susceptible to climate change except under very specific local environmental and socio-cultural circumstances (Wossink, 2009: 5).

Before going into more detail about culture change it is perhaps logical to first define culture. This however is easier said than done. Even among the specialists of culture, the anthropologists, there is often disagreement over what culture truly is. For some it is customs and traditions, for others heritage, a way of life or a material legacy (Naylor, 1996: 16). These difficulties in defining culture arise because culture is purely a mental construct with behaviour and material objects little more than an outward manifestation of something that exists only in the mind (Naylor, 1996: 17). For some there is an equation for culture: culture = belief + behaviour + products: these three interrelated factors combined make up the sociocultural environment and a change in one can potentially mean a change in all three (*Ibid*). Such a change can be an addition, subtraction, alteration or modification. Where other animals are forced to adapt physiologically to survive, humans use culture. Humans can't prevent environmental perturbations, but they can adapt to them with culture.

In examining the role of environmental change as a source of external stress to a social system it is useful to borrow a paradigm from cultural ecology (Rosen, 1995): societies as equilibrium systems generally have built in social, economic and technological mechanisms to deal with external stresses which dampen their overall negative effect. Culture can be thought of as a buffer evolved to lessen the effects of variability. Food is one of the most basic requirements of life, yet it is also one of the least reliable (Halsead and O'Shea, 1989). Variability of such essential resources can be measured along numerous axes which reflect differences in resource abundance, predictability, duration and extent of fluctuations relative to alternative resources and the coping capabilities of the group (Minc and Smith, 1989). How societies cope with the consequences of subsistence shortages can have far-reaching implications in terms of cultural behaviour, and variability in food supplies can be a powerful selective pressure. In general there are four ways a culture can respond to variations in food supply (Halstead and O'Shea, 1989; McIntosh *et al.*, 2000):

1. Mobility – spatial variability
2. Diversification – exploiting heterogeneous resources
3. Physical Storage – temporal variability
4. Exchange – temporal variability and 'social' storage

As general coping strategies these responses can operate over a broad range of spatial and temporal scales but are only effective if they transcend the adverse conditions (Minc and Smith, 1989). Cultures evolve around resource fluctuation and subsistence based societies are accustomed to adapting to seasonal, interannual and even long-term variations in resources. In-grained in cultures are the abilities to cope with such fluctuations and it is only when these variations exceed the threshold level of adaptability possessed by a culture that problems start to occur. In general, stable social systems should be able to execute adaptive changes that ensure the maintenance of the community at large (Rosen, 1995).

Mobility is a strategy for redistributing people in the environment which may facilitate procurement and communication and helps to avoid risks and reduce stress (Jochim, 1981: 148). In times of trouble mobility may increase, as ethnographic studies have shown it does in subsistence systems today (Morton, 2007). Diversification in agricultural economies may involve the use of a mixture of domesticated plants and livestock, and in some cases may involve the use of non-domesticated secondary or fall-back resources (O'Shea, 1989). The linking of subsistence farming and animal husbandry produces a strong synergistic relationship: they are mutually stabilising with complementary patterns of interannual variability (*Ibid*). Resource storage is, by contrast, a relatively short-term anticipatory strategy. Storage of dried and smoked meat and the stockpiling of grains represents a security strategy aimed at providing sufficient resources for anticipated lean seasons (Jochim, 1981: 176). Storage implies significant seasonal variability in resource availability and sufficient seasonal regularity that lean seasons can be anticipated (*Ibid*). There is a very strong seasonality in Syria which people have been coping with for millennia. Seasonal variation has the most immediate effect on farming communities and if a farming community is to be successful it must have the means to provision itself through non-productive periods (O'Shea, 1989). Season variability is predictable and can usually be anticipated and accommodated and the value or necessity of buffering mechanisms is constantly reinforced until they become part of the 'normal' programme of activities (*Ibid*).

It is interannual variation that is most unpredictable. Climate change and the associated environmental variability may make seasonal shortages unpredictable and therefore difficult to anticipate.

Several of these coping mechanisms could have been put into action in order to survive the 'normal' years of drought as well as the 'abnormal' successive years of drought brought on as a result of climate change. Long term droughts of a few centuries which progress very gradually are easier to adapt to than short term droughts of a few years which start abruptly bringing swift disaster to agricultural communities (Mulder, 1969: 29). The 8.2k event is thought to have brought about just such a rapid reduction in precipitation followed by many years of drought. All the procedures involved in the selection and performance of coping behaviour may be termed "coping" or "management" strategies and involve:

1. recognition of the problem;
2. selection and execution of the response.

(Jochim, 1981: 205-206)

Activities will vary with the particular adaptive situation of the group (Binford, 1978: 3). If existing anticipatory strategies have not or cannot be initiated, or are inadequate, then some immediate responses to resource stress are necessary to correct the human-resource imbalance (Jochim, 1981: 185). These responses can take one of two general forms: redistribution of resources or the redistribution of people. The more extreme or persistent the period of environmental stress the more costly or disruptive the adaptive mechanisms adopted will be (Halstead and O'Shea, 1989: 5).

Many of these coping strategies are recognisable archaeologically. The diversification of crops and herd animals can be identified through systematic zooarchaeological and palaeobotanical studies. Storage is manifested archaeologically by domestic and public storage facilities and the presence of storage vessels. The extension of social networks, and therefore social storage, can perhaps be identified archaeologically by cautiously tracing the dispersal of ethnically distinct artefacts (Rosen, 1995). Nevertheless, a major element of any human response to climate or other environmental change is behaviour that is intangible, such as changes in some social networks, in relationships of reciprocity, or in the cosmology that defines the place of humanity in nature (McIntosh *et al.*, 2000).

When the buffering mechanisms of a culture fail it is necessary for the culture to undergo change in order to adapt. Environmental adaptations include measures such as technological innovations, changes in land-use practices, and economic diversification that reduce the impact of the environmental changes (Batterbury and Forsyth, 1999). Long-term adaptive processes at work in societies should not be viewed in mechanical, evolutionary terms but as organised and considered responses to local problems (*Ibid*). As is generally the case with evolutionary processes, new things are not invented, but existing features are modified step by step, or recombined in new ways (Watkins, 2008). Social memory can be seen as a means for societies to reinvent responses to the environment in the face of environmental change (McIntosh *et al.*, 2000). In order to identify such adaptations it is necessary to identify the critical point on an evolutionary gradient (Watkins, 2008).

Any group's social organisation and its dynamics interact with the dynamics of the environment, natural and cultural (Van der Leeuw, 2000). There have been many models generated to explain culture change and the mechanisms involved; some deal with broad sweeps of human history, others are focused on more specific changes within groups. In terms of change due to environmental pressures a very simple model can be used (fig 4.3).

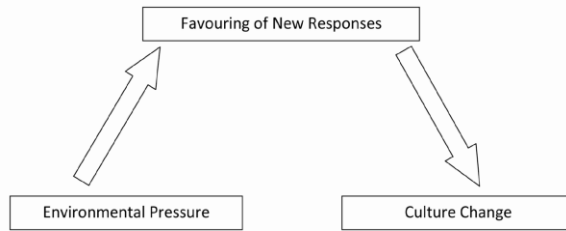


Fig 4.3: Simple model of culture change as a result of environmental pressure

These changes can either be initiated by people within a culture coming up with the response themselves or it can be introduced from outside (Naylor, 1996: 48). Of course this depends on who in society records climate data and who may access those data to mobilise the appropriate response (McIntosh *et al.*, 2000). In other words social memory is key and human-environment interactions are shaped by past experiences (*Ibid*). Social memory is defined by McIntosh *et al.* (2000) as the long term (greater than three-generation) communal understanding of landscape and biocultural dynamics that provides for the curation of pertinent experience and its intergenerational transmission. The extent of a group's collective memory is of vital importance to its survival, if it is diverse and encompassing, the society has a better chance of finding a solution to any problem they encounter (Van der Leeuw, 2000). The challenge (an impossible one archaeologically) is documenting how social memory is activated under stresses of different degrees. An ethnographic example of social memory can be sourced from the traditional West African communities; at the beginning of the Sahel drought in 1968 effective responses to environmental degradation could be mobilised because the village elders recalled similar conditions in the early decades of the 20th century (McIntosh *et al.*, 2000). Whether any change is fully accepted will depend on its ability to fit into the existing culture values, social forms, economics, politics and technological capabilities (Naylor, 1996: 58). Whether changes are adopted also depends on several "arbiters of change", including the knowledge of the people, the biophysical environment and the availability of labour (Batterbury and Forsyth, 1999). Of course not all human responses in the past will have been based on an objective assessment of climate variability (McIntosh *et al.*, 2000).

Much of the behaviour involved in interactions with the environment is learned behaviour that has become part of the repertoire of responses of a particular human group; it is in other words, cultural behaviour (Vayda, 1969: xi). Some aspects of culture are more directly related to the natural environment than others: the technology and economy of a society are more directly related to the environment (Jochim, 1981: 7). The environment does not simply set vague limits but rather is intimately related to aspects of culture (*Ibid*). It has been argued in the past that a large part of cultural traditions are formed by the experiences the members of a culture have accumulated in a dialogue with the ecology of their environment, i.e. that culture is an extrasomatic means of adaptation to the environment as proposed by Binford (1972: 136 referencing White, 1959: 8). It has also been said that culture acts as a code system conveying this experience, symbolically expressing the less visible interaction of economy, demography and ecology (Dahl and Hjort, 1976: 128-129). I do not necessarily subscribe to this notion of human culture but I think it would be foolish to assume that human culture is not at some level affected by the natural environment; human culture is not above climate. Vayda (1969: xi) suggest that there are two main ways of relating cultural behaviour to environmental phenomena: showing that parts of cultural behaviour function as part of systems that also include environmental phenomena, or showing that environmental phenomena are responsible in some way for the origin or development of cultural behaviour. The idea that cultural behaviour is determined by the degree that it enhances biological survival is today quite unpopular with archaeologists, being thought of as "functionalist" or "determinist". This idea is however perhaps more strongly adhered to by biologists. The behavioural model recognises that behaviour is the dynamics of adaptation; people draw upon a repertoire of cultural background and

experience to meet changing or variable conditions in their environment, both social and physical (Binford, 1978: 3).

Adaptation is a strategy adopted to reduce the impacts of environmental or social change on local resources (Batterbury and Forsyth, 1999). Adaptation is far more than simply adjusting technology and resource extraction strategies. Adaptive and maladaptive responses are intimately related to social institutions such as social structure, belief systems and human perception of the environment (Rosen, 1995). Some adaptations may only protect certain resources or benefit only some members of the community and it is important to examine how adaptations come about and why they succeed or fail (Batterbury and Forsyth, 1999). Social memory may allow the community to designate those of its members who have the authority to act in times of stress (McInosh *et al.*, 2000). Both societies and environments have fundamentally different internal dynamics that impinge on one another under certain circumstances (Van der Leeuw, 2000). The relationship between climate change and the social response is by no means a direct association, but neither can we consider nature and culture as separate subsystems as these two spheres are in fact inextricably linked (*Ibid*). There is a need for a framework for the study of human-environment relationships that allows the recognition and inclusion of multiple causes and causalities (Wossink, 2009: 5). It is important to recognise that neither nature, the environment, nor culture is the only determining factor in these relationships. Nevertheless, it is difficult to refute the negative impact an extended period of drought would have on a Neolithic agro-pastoralist based society.

Climate determinism

Climate-human interactions are often approached either from the side of humans affecting the environment or the environment affecting human societies. The latter has the rather hefty label of climate determinism.

Although the idea of environmental determinism, and as such climate determinism, comes from the discipline of geography the idea was borrowed from biology (Peet, 1985). Environmental determinism was one of the leading paradigms of the late nineteenth and early twentieth century and was founded on ideas taken from Social Darwinism (*Ibid*). The American geographer Ellsworth Huntington (1926) promoted in his textbooks the idea that major cultural changes were strongly influenced by climate change. The general idea was that physical environments could affect or even control cultural development (Coombes and Barber, 2005). In the development of these ideas there were not the constraints of a closely controlled prehistoric chronology, let alone any independent palaeoclimatic data (Wright Jr., 1993). By the second half of the twentieth century environmental determinism was discredited, heavily critiqued and shunned by many researchers (Coombes and Barber, 2005; Nunn, 2003). It can be argued that researchers then went to the opposite extreme, portraying the environment as an unchanging backdrop to human culture and societal change (Nunn, 2003). This dichotomy is not constructive. The environment obviously plays a role in human societies, as it does even today, and environmental change should be viewed together with human activities as a co-evolutionary and adaptive process (Dearing, 2006). Although crude determinism is now discredited, and arguably rightly so, the interaction of the environment and human groups through time should still be discussed, particularly in regard to human groups perceived by archaeologists as living in 'marginal situations' (Coles and Mills, 1998).

The bringing together of detailed palaeoenvironmental research with archaeological studies showing strong correlations between climate change and cultural collapses in the archaeological record, has caused somewhat of a revival of what would traditionally have been labelled 'environmentally deterministic' ideas. The admittance that environmental influences may play a role in past cultural change has led to a form of 'soft' determinism which, while stressing the inseparable nature of environmental and cultural influences, views the physical environment as "a delimiter of action rather than a prescriptive agency" (Coombes and Barber, 2005). In such environmental models of marginality the effects of a climate change on the human group are determined by the scarcity or absence of certain critical resources necessary for their survival (Coles and Mills, 1998). The effect of climate change on humans

is mediated through society (Peet, 1985) and causal relationships between complex culture-environment interactions are less straightforward than they at first appear (Coombes and Barber, 2005). Explaining broad cultural changes will always be problematic, but the increasing evidence for temporal correlations in climate and culture change and the emergence of viable hypotheses to support the premise of 'cause and effect' make completely dismissing environmentally deterministic ideas more difficult (Wright Jr., 1993). Nevertheless, these hypotheses should still be treated with caution as coincidence in time by itself should never be used as proof of cause and effect. Instead it should provide an incentive to look beyond purely social factors (*Ibid*).

The possible effects of climate change on subsistence

The dietary customs of Neolithic populations partially reflect their cultural response to their environmental surroundings and include a balance of resources including fishing, hunting and animal husbandry (Jousse, 2006). Given the importance of physical environment in determining the suite of available livelihood options for prehistoric societies, it would be incredible if changes in climate had not influenced the development of societies (Brooks, 2006). In the early Holocene, areas that today are arid deserts were wetter and well vegetated which could support significant faunal and human populations (*Ibid*). This warm humid period was interrupted by a number of cold episodes associated with enhanced aridity in the tropics and sub-tropics (*Ibid*). The question we need to ask is: how strong was the impact of these events? To answer this question far more research into the events themselves and the human groups living during these events needs to be carried out.

As outlined in chapter 3, the upper Balikh Valley area in Northern Syria can be considered marginal in terms of rainfall. Environmental deterioration would severely affect people living in such a marginal situation (Watkins, 2008). Farmers in this region have learned to expect great fluctuations in precipitation, streamflow and crop yields from year to year (Rosen, 1995). Farmers have a sense of the causes of crop failures and food shortages, and of how frequently different sources of failure may occur (O'Shea, 1989). Even without climate change events, droughts would have occurred regularly in this area. Droughts occur at regular intervals in the area today, with a cycle of six to eight years, with each drought lasting three to four years (Dahl and Hjort, 1976: 127). These droughts can destroy harvests and decimate domestic herds. If drought was brought on by climate change in the Neolithic this would surely have had serious ramifications on agriculture and animal husbandry. In terms of hunter-gatherer communities, climatic pressure can reduce the natural stock of food on which they subsist because plant and animal populations respond quickly to climatic change by dramatically shifting their ranges (Weisdorf, 2005; Richerson *et al.*, 2001). Mobile populations can respond to such changes by habitat tracking. Vegetation responds to environmental changes in a somewhat predictable manner; in general a colder climate with decreased rainfall will result in a reduction in both the vertical and horizontal diversity in vegetation (McCorrison and Hole, 1991). The effects of climate change on sedentary agro-pastoralists are more difficult to ascertain. Based on ethnographic studies of the impact of climate change on subsistence agriculture and pastoralism in marginal areas, it is clear that people practicing these subsistence systems face substantial risk (Fafchamps *et al.*, 1998). Herding and farming are both constrained by the distribution of moisture and the principle effect of drought is crop failure and livestock loss leading to a reduction in the food supply (Campbell, 1984; Morton, 2007; Mace, 1993). With the decline in livestock and crop productivity comes food stress with the possibility that people lose weight and become weak (Mace, 1993). Ethnographic evidence has also shown that periods of climate change and/or drought can lead to a general feeling of unease and social disturbance among communities (Campbell, 1984).

Subsistence systems, especially those located in marginal environments, are often characterised by livelihood strategies that have evolved to reduce vulnerability to climate changes ("adaptive strategies") and to manage their impacts ("coping strategies") (Morton, 2007). Coping strategies for extreme climatic events such as drought typically involve changes in the relative importance of crops, livestock species and the interactions between them (*Ibid*). These mechanisms for reducing the impact of drought are usually integrated within the socioeconomic framework of the society, with strategies for alleviating the effects of seasonal and interannual variability in rainfall permeating many aspects of economic and social

organisation, with their importance increasing once climate change and/or drought threatens the system (Legge, 1989; Campbell, 1984). Responses to individual years of drought are often an extension of the responses to the more predictable seasonal cycle of aridity, but more severe cycles of drought can radically disrupt behaviour (Legge, 1989).

Ethnographic studies of preindustrial farmers in marginal areas have shown that those who live under the threat of unpredictable crop yields develop predictable measures for buffering the effects of dry years and the resulting low crop yields and diminished herds (Rosen, 1995). The Maasai of Africa, for example, keep a variety of livestock - cattle, sheep and goats – as these animals respond differently to the impact of drought and a diverse herd is one way of reducing the risk of total loss of livestock (Campbell, 1984; Legge, 1989). This is also the case with the Wodaabe of Niger (Legge, 1989). This is a classic strategy of pastoralists in order to take advantage of different ecological niches and the labour of men, women and children (Morton, 2007). They also split up herds and disperse them throughout the area in order to exploit a wider resource base (Campbell, 1984). Mobility remains the most important pastoralist adaption to spatial and temporal variations in rainfall, and in drought years many communities make use of fall-back grazing areas unused in “normal” dry seasons because of distance or conflict (Morton, 2007). Traditional knowledge often includes an understanding of crop and livestock diversification, along with shorter term possibilities offered by mobility (Batterbury and Forsyth, 1999). Movement is often used to offset difficulties such as disease and drought, to maximise the effective use of limited resources and to avoid overgrazing (Legge, 1989). This movement is usually highly informed and flexible. “Herd accumulation” is also practiced as a form of storage and insurance against drought (Morton, 2007; Legge, 1989), with livestock being kept by predominantly agricultural communities as a buffer to insulate against fluctuations in harvest (Fafchamps *et al.*, 1998). Herd size is increased beyond the needs of normal subsistence as a response to interannual variability and as a safeguard against drought or disease, with any stock that survives the crisis being used to rebuild the herd (Legge, 1989). There are of course inevitable constraints on herd size, such as the availability of pasture, water and labour (*Ibid*). Cereals are a crucial food component particularly as a source of storable winter food and animal fodder, which would have been a major limiting factor in the number of animals that could be kept (Bonsall *et al.* 2002). During drought a mixed economy is more resilient than either ones dominated by livestock or agriculture (Campbell, 1984; Batterbury and Forsyth, 1999; O’Shea, 1989). For dryland communities diversification is the most common response to drought (Batterbury and Forsyth, 1999).

One of the aims of this research project is to assess the possible effects of climate change on the animal based subsistence system using zooarchaeological data. To what extent can animals be used to detect climate change in the archaeological record? Animals are influenced by many factors including their external environment but they are also adapted to cope with certain changes in their environments either through behaviour or their physiology (Tchernov, 1982). Traditionally factors such as growth, secondary product production and reproduction have been used to measure an animal’s response to environmental factors (Da Silva, 1993). Unfortunately, accurately measuring these factors in a fragmented archaeological sample of faunal bones is not an easy task. There are, broadly speaking, four types of response to environmental changes (Tchernov, 1982):

1. Abrupt climate induced ecosystem deterioration can cause the mass elimination of species.
2. Moderate fluctuations can affect the internal structure of animal communities i.e. changing the relative frequency of species.
3. Moderate fluctuations can also cause changes in the physiological tolerance i.e. change in body size over generations.
4. Gentle climatic alterations can lead to animals retreating to refugia where, eventually, speciation may occur.

Climate can affect animal production in four main ways (Valtorta, 2002); the first is that a change in climate can impact both the availability and cost of animal feed. In Neolithic communities this cost may come in the form of domestic animals competing with the humans for food. Changing environmental conditions can also impact on the availability of good pasture for the animals, putting even more pressure

on the humans to provide food for them from their stored grain. The distribution of diseases and pests are also affected by changes in environmental conditions, which can mean that climate changes can cause the spread of disease into new areas. The direct effects of weather and extreme events also affect animal health, growth and reproduction. Different species of animals react differently to environmental changes. Each species of animal has an individual physiological response, to heat for example, due to morphological characteristics of the skin and hair coat, which allow the animal to exchange heat with the environment (Da Silva, 1993). Some species, such as the pig, are particularly ill-equipped to cope with dry, arid conditions. Arguably the most problematic aspect of climate change faced by farmers is the uncertainty and unpredictability.

The study of such matters is known as 'Agricultural Biometeorology' (Bourke, 1963) or 'Agrometeorology'. Concern with the sustainability of agriculture, particularly in light of possible future climate change, has led to an increase in agrometeorological studies. Climate is often the most critical factor in the sustainability of agriculture and there are major interactions between climate and biological diversity (Sivakumar *et al.*, 2000). In light of the increasing interest in past, present and possible future environmental change zooarchaeologists are now being invited to contribute to discussions about long-term sustainable development of resources (Amorosi *et al.*, 1996). Being asked to contribute to such important research is of course flattering, but can how can zooarchaeological data be used in such studies, and used appropriately? All zooarchaeologists understand the fragility of their data with the effects of different taphonomic processes, depositional contexts, excavation and recovery methods, and recording methods all greatly affecting the sample (Ibid). Despite these caveats zooarchaeology has a lot to add to this research as it is the only way to systematically interpret the use of animals in prehistoric times.

In order to assess to what extent any changes seen in the subsistence economy can be attributed to the result of a climate induced deterioration of the environment, it is important to first understand how such a climate change could affect the animals exploited. Environmental stress can have direct economic effects leading to the marginalisation of an area, taking the form of vulnerability to resource failure, inability to generate surplus and a difficulty in meeting subsistence needs over an extended period (Armit, 1998). The long term effects of a climate 'disaster' such as an aridification of the environment are little understood. Clearly a deterioration of the environment due to drought will at least limit the economic options open to human societies. There is a tendency for drought to occur at intervals, with a cycle of six to eight years suggested for the Near East with each drought lasting three to four years (Dahl and Hjort, 1976: 127). The recent affects of a four year drought in Syria have been shown to be dramatic with many crops failing and the loss of large herds of sheep and goat (Akkad, 2009). Severe droughts or cold events seem to occur around every thirty years or so in Syria with a severe drought occurring in 1958-1961 and a cold period in 1931-1933 destroying harvests, causing water shortages and food deficiencies and devastating herds of sheep and goats (Akkermans, 1993: 207). Less severe droughts occur more regularly with crop failures in rain-fed agriculture occurring every few years. Water is most essential in the early stages of plant growth and seeds must be planted in wet soil, i.e. after the first autumn rains. If the rains are late, or do not come at all, then crop planting can be severely delayed or is unable take place at all. Plants are also very fragile when immature so a water shortage in the first few months of growth could result in crop failure. As apparent in modern and historical droughts in this area, it is not only crop production that is seriously affected by drought conditions. Climate models have revealed that droughts in marginal areas can cause a dramatic reduction in livestock numbers and that the length of the drought period influences the subsequent rate of reproduction and regeneration (Dahl and Hjort, 1979: 12). In short, the longer the drought the longer it takes herds to recover. Even hardy populations of sheep and goats are not immune and drought conditions can lead to heavy reductions in herd size; droughts reducing the sheep and goat populations to half its size are likely to occur at least once every decade in the Near East (Dahl and Hjort, 1976: 116). Sheep, which require frequent watering and constant access to grass become very weak in comparison to goats which are browsers and need less water (Dahl and Hjort, 1979: 234; Russell, 1988: 57). Cattle and sheep predominantly graze on herbaceous species, while goats are less selective. These feeding patterns are very significant when considering

relative susceptibility of these species to disastrous herd losses due to drought. Marked seasonal variations occur in the availability of forage from herbaceous herbs and grasses as opposed to woody shrubs and trees (Russell, 1988: 58). In dry seasons and drought years herbaceous production is minimal or even nonexistent, with the quality of the forage also declining rapidly after the rains cease, while woody forage maintains biomass much longer into dry seasons (Russell, 1988: 59). This makes goats the most well adapted to drought, followed by sheep and cattle with pigs being the least well adapted.

A drought is also likely to affect the more susceptible younger members of the herd first with older animals being more robust in the face of difficult conditions. If drought conditions did cause the loss of many heads of cattle this would take several good years to recover from. Sheep and goats have a rather more rapid rate of reproduction and such catastrophic losses could be recovered more quickly. Cattle generally do not start to breed until their third to fifth year while ovicaprids can generally bear their first offspring by the time they are two years of age (Russell, 1988: 61). In addition to an increased mortality in the younger elements of the herd, variations in the potential milk production can also be expected (Dahl and Hjort, 1979: 15, 16). These effects are not just felt during the drought itself: during the drought milk production will be reduced due to a scarcity of (high quality) fodder, but when the rains return milk production does not start up straight away but is delayed until the next offspring is born (Dahl and Hjort, 1979: 16).

Baring these factors in mind it is easy to see that the consequences of a drought for a pastoral economy would be severe and complex. Not only are herd numbers reduced, so is herd security and the amount of meat and milk that can be produced. Pastoralists live under constant threats to their daily supply of food. Reducing potential loss, insurance and security are central themes in modern East African pastoral societies (Dahl and Hjort, 1979: 18) and this is likely to also have been the case for the earliest pastoral economies of the Near East in the Neolithic.

Summary

The impact of drought is as much related to social, economic and political factors as to climatological ones (Campbell, 1984). The projection of climate change impacts on agro-pastoralists is in fact very complex and often location-specific (Morton, 2007). Subsistence systems in marginal areas such as the Near East are already characterised by constant adaptation to climate variability, which makes observing or predicting impacts of climate change within this process of adaptation very difficult (*Ibid*). An understanding of decision-making in human groups is imperative in order to understand and anticipate responses to environmental change (Mace, 1993).

Climate and weather variation would have made the evolution of methods of intensive exploitation of plants and animals very difficult and extreme years would have caused notable famines (Richerson *et al.*, 2001). On the whole, climate change is a highly disruptive force, which puts incredible stress on populations (Weiss and Bradley, 2001). In the north of Syria, where farmers relied on rain-fed cultivation, a decrease in rainfall would have had serious consequences. Even small changes in the amount of annual precipitation can have drastic results as seen in the recent three year drought that has hit Syria causing both crop failure and livestock loss.

4.7 Summary

Climate is a global phenomenon in which changes occur periodically with even slight changes impacting on the sustainability of agriculture in the Fertile Crescent (Hole, 2007). There is little doubt now that the 8.2k event occurred and was characterised by a generally cool, dry and windy climate accompanied by a period of aridification in low latitudes in the mid Holocene. This event is thought to have essentially established locally the general nature of the modern climate and vegetation (Hunt *et al.*, 2006). To ignore climate change as a potential factor affecting social behaviour in the Holocene one would have to disregard an increasing number of regional and global palaeoclimate reconstructions and ever-increasing archaeological evidence. Despite the apparent importance of the 8.2k event no comprehensive study had

been undertaken to identify the potential effects of this considerable climate induced environmental degradation on the people of the time, until now. The site of Tell Sabi Abyad provides the perfect opportunity to correct this oversight, as it represents a site that continuously inhabited throughout the seventh millennium BC.

It is becoming increasingly clear that it is necessary to include studies of palaeoecology and palaeoclimate to fully understand the behaviour and movements of people in the past (Adams and Faure, 1997). The problem for archaeologists looking for evidence of past climate change is that sources of climatic information can only rarely be directly tied to cultural evidence. Since archaeological data rarely inform directly on climate, we instead rely on the pattern of cultural activities aligned chronologically with known climate events (Hole, 2007). Climatic factors play a key role in agricultural communities and mechanisms for coping with changes brought about by climate change, such as scarcity of resources, play a pivotal role in the maintenance and transformations of human societies (Halstead and O'Shea, 1989; Forbes, 1989). Risk-buffering behaviour tends to have ramifications throughout the cultural system and changes in these activities are likely to trigger a chain reaction affecting many other aspects of society (O'Shea and Halstead, 1989). In short, the connection between climate change and settlement cycles is undeniable even if specific evidence for this relationship is still a subject of research (Hole, 2007).

Rosen (1995) states that we must attempt to view the role of climate from the anthropological perspectives of adaptation and maladaptation to a dynamic environmental system, social and economic strategies of risk-taking and risk-buffering, resilience in the acceptance of new technologies, and the elusive but important factor of the perception of catastrophe and the social formulas for response. Communities do not simply react to climate change, they actively sort through information about past climate and about how successful or unsuccessful their responses were (McIntosh *et al.*, 2000).

In order to assess the possible affects of the 8.2k climate event on the animal based subsistence economy it is imperative that the affects of this event in Northern Syria and in particular the Balikh valley are understood. This is where we face difficulties as there are no high resolution climate proxy records available from Northern Syria with the nearest records coming from the Soreq Cave speleothems (Bar-Matthews *et al.*, 1999) and the Red Sea in Israel (Migowski *et al.*, 2006; Enzel *et al.*, 2006), the Dead Sea in Jordan (Migowski *et al.*, 2006) to the South-West, and from the Eastern Mediterranean (Pross, 2008). These palaeoclimate records, although useful, are unlikely to pick up any subtle changes occurring in the micro-climate of the Balikh Valley. What these proxy records show is that although the affects of the 8.2k event are detected, there is a great deal of regional variation in the effects of this climate anomaly. There is also the added complication that the 8.2k event apparently punctuated a broader event starting around 8600 years ago; the magnitude and sequence of changes surrounding the 8.2k event are not straightforward to decipher (Rohling and Pälike, 2005). The only material from Tell Sabi Abyad that can be used as a proxy record is the botanical data, in which there is considerable dating uncertainty. Only macro-fossil remains are available and many of these are derived from storage areas and are domestic crops. This makes the analysis of these remains more complicated as anthropogenic based changes must be extricated from environmental based changes. Models of the effects of the 8.2k event on Northern Syria suggest that this event led to cooler and dryer conditions with perhaps a reduction of the effective precipitation by up to 20%, i.e. >25-50mm less average precipitation in the Balikh Valley (Renssen *per comm*s; Renssen in press; Wiersma, 2008). This reduction in precipitation, occurring in an area already at the limit of dry farming, could have had dramatic implications for crop production and animal husbandry.

Chapter 5 Methodology

5.1 Introduction

In the following chapter the methodologies utilised in this research will be outlined in full. In addition, information on important considerations to the data analysis will be outlined (i.e. taphonomy).

5.2 Recovery methods

All the bone material recovered from Tell Sabi Abyad was excavated by hand (no sieving was undertaken) and is termed 'hand collected' in this report. As a consequence, retrieval will have generally favoured the larger anatomical elements and bone fragments from the larger species. A number of small mammal and bird bones were recovered suggesting that excavators were not missing these bones entirely. Once excavated, the bones were cleaned and packed into boxes until they were recorded by the author. All data was recorded in the field.

5.3 Recording system

Vertebrate material was recorded directly into a computerised database using Microsoft Access software. The database consists of a series of interlinked forms and tables built for the recording of faunal assemblages. All data regarding species, skeletal element, zone present (see Identification and Quantification sections below), measurements, ageing and sexing information, taphonomic information and context information were recorded into this database.

5.4 Preservation and fragmentation

Every fragment was recorded with the following variables in mind: levels of surface preservation, levels of fragmentation, whether new breaks were present, and the presence of gnawing, burning and root etching were noted.

5.5 Identification

Identification of the material was carried without the use of a vertebrate skeleton reference collection as none was available. It can be very difficult to distinguish some closely related taxa and for this study the following elements were used for separation as they are thought to have the most reliable criteria. For caprines the lower deciduous 3rd and 4th premolars (Payne, 1985), distal humerus, distal metapodials, astragalus and calcaneum (Boessneck, 1969) and distal tibia (Kratochvil, 1969) were used. The techniques used to distinguish between sheep/goat of Hylke Buitenhuis (in press) were also used to help differentiate between sheep and goat. For equids the shape of the enamel folds were used to differentiate species (Davis, 1980). Small mammals were identified based on morphological differences in teeth. Bird bones and small mammal bones were brought back to Leiden University to be identified with the aid of a reference collection. Those species that could not be identified to taxa were split in size groups of large mammal (cattle, red deer, equid sized mammal), medium ungulate (goat, sheep, gazelle, roe deer), medium mammal (pig, dog, sheep, goat sized mammal), or medium to small mammal (fox, hare sized mammal).

5.6 Quantification

The bone material was recorded using the zoning method of Cohen and Serjeantson (1996) and Serjeantson (1996). Briefly, this method involves the use of zones; each bone is arbitrarily split into clearly defined and numbered segments normally giving eight zones. When recording a complete bone the zones present are listed as 12345678. A zone is only recorded as present if >50% of the zone is present. This

method allows the quick and uniform recording of bone fragments. All bone fragments from the analysed contexts were recorded including those that could not be identified to species. All calculations will be based on the number of specimens identified to species (NISP). Minimum Number of individuals (MNI) will not be calculated. The MNI was not calculated because quantification using this method is preservationally biased and subjective, and can lead to over-representation of rarer species. There are also biases with the NISP method, such as the presence of complete skeletons artificially inflating bone counts from that species, and the problems associated with different number of skeletal elements of each species and fragmentation. It is assumed however that there is a great deal of independence between fragments which justifies the use of NISP for quantification. This is confirmed by the general lack of articulated bones in the assemblage. The NISP is also the most commonly used method of quantification and analysis especially in faunal studies of the Near East. Using NISP in this study therefore makes site comparisons easier and more effective. The MNI will only be calculated in order to analyse body part proportions eliminating any bias generated by the NISP. All bone fragments were also weighed to the nearest gram to give an idea of the overall mass of bone present. Weighing bones provides a quantitative result more directly related to meat weight than can be obtained by counting the bones (Uerpmann, 1973).

5.7 Bone modification and pathology

Information on the presence of gnawing and burning, and details of pathology and butchery were recorded for each bone. The animal responsible for the gnawing was recorded where possible for example canid, felid or rodent. Burnt bones were graded as charred, burnt black, or calcined which can indicate the temperature and intensity of the fire responsible (see below). Butchery marks were described by type (i.e. chop, cut, sawing). Pathologies were categorised and described where appropriate.

5.8 Ageing and sexing

Sexing using morphological characteristics was attempted for all species where possible. The shape of the pig canines (and their alveoli) were used to differentiate boars from sows. The presence of canines in equids was used to identify males. The presence of the dog baculum was used to identify male dogs. Cattle and sheep/goat pelvises were used to distinguish males and females where possible.

Information on the state of epiphysial fusion was collected for all long bones and was recorded using a number of categories: fused, fusing (fusion line still visible), ossified, porous, and unfused (Silver, 1969). In addition, the presence of juvenile and neonatal bones was noted. Analysis of fusion data was undertaken using the categories of O'Connor (1989).

Mandibular tooth wear stages were recorded from the dP4, P4, M1, M2, and M3, for both loose teeth and those in mandibles. Cattle and pig teeth were recorded using the system of Grant (1982), while for caprine teeth the criteria for Payne (1973, 1987) were followed.

5.9 Biometry

Measurements mostly follow Von den Driesch (1976), with the exceptions noted below. Measurements of cattle and caprine teeth were the maximum length and width of the given tooth. Measurements of equid cheek teeth follow Davis (1987). Pig tooth measurements follow Payne and Bull (1988). Once data are divided up between different species, phases of occupation, body parts and types of measurements only very small samples may be available. One way to overcome this problem is to merge different measurements of bones of the same species on the same scale (widths, lengths and breadths) (Albarella, 2002). The log ratio technique first introduced to zooarchaeology by Meadow (1981) is the most commonly used of these scaling techniques and will be the method used here. This method uses the decimal log ratio between the 'standard' and the actual measurement (Albarella 2002). The main criticism of this technique is that it assumes that all measurements vary proportionally with the size of the animal

(Russell and Martin, 2005). Proportions do of course vary according to sex, breed and age so while this method is not perfect it does provide a graphic means of comparing measurements from different skeletal elements, scaling all measurements to a common reference (Haber and Dayan, 2004).

5.10 Taphonomic considerations

Introduction

As understanding the taphonomic factors and formation processes involved in forming a faunal assemblage is so important they will be briefly described here and revisited in the discussion.

In order to understand the potential of faunal data, it is important to recognise just what the sample of animal remains represents (Meadow, 1980). In recent years site formation processes have been highlighted as a fundamental part of the patterning observed on archaeological sites and as such taphonomic studies have become increasingly important (Roberts *et al.*, 2002). It is arguably very naive to assume that the recovered fraction of bones from an archaeological site accurately represents the deposited fraction or that the deposited fraction directly reflects the entire picture of human exploitation of animals at that site (Meadow, 1980). Archaeological assemblages are in reality created by a plethora of complicated processes that can cause a huge amount of variability in the composition of an assemblage, both between sites and within a site. Once an animal dies or is slaughtered, various factors of disposal, deposition and preservation act to modify the potential contribution of the skeleton to the zooarchaeological record (*Ibid*). The complexities of how a bone assemblage was formed cannot be ignored and a valid interpretation of archaeological remains depends on understanding how animal remains came to their final resting place (Maltby, 1985; Roberts *et al.*, 2002). One of the tasks faced by archaeologists is to distinguish between the 'natural' and 'cultural' origins of a bone assemblage and this is where the field of zooarchaeology comes into play (Denys, 2002).

Zooarchaeologists are faced the enormous problem of trying to recognise the various taphonomic processes that could have affected their material and one of the major challenges faced by archaeologists is understanding how such processes affect quantitative measures of faunal remains (Lyman, 1994; Maltby, 1985). Most bone populations studied can be said to have undergone a series of transformations which were summarised by Maltby (1985) as follows:

- Cultural practices (including such activities as trade, redistribution, butchery, bone working and ritual).
- Disposal strategies
- Post-depositional taphonomic processes (such as chemical actions in the soils, weathering, and scavenging).
- Archaeological sampling (the choice of sites, parts of sites, or types of contexts within sites, for excavation).
- Recovery procedures (whether sieving was carried out and what type).
- Methods of Analysis (the type and detail of the information recorded etc.).

Putting together the 'jigsaw puzzle' of taphonomy is no easy task as each of these stages is complex and the scope for variation is enormous. Compounding this problem is the lack of a general methodological framework to isolate the consequences of each transformation process and studies assessing the effect of sampling procedures and analytical methods used (Maltby, 1985; Costamagno, 2002). In addition each site has its own taphonomic history with its own specific processual sequence with the development of the site being both multifaceted and very often multiphasic with re-elaboration, mixing and reworking all taking place (Denys, 2002). Admixing of bones and biases created by other sources of sample variation can also make interpretation more difficult.

Taphonomic processes are an important consideration because they affect quantitative measures such as taxonomic abundances, meat weights, and frequencies of particular skeletal elements (Lyman, 1994). In

order to make any meaningful comparisons between samples it is essential to know how well an assemblage has been preserved. In terms of osteological studies, this ultimately requires more rigorous and detailed recording of fragmentation, gnawing marks, and the surface condition of the bones (Maltby, 1985). The differential preservation of mammalian bones on archaeological sites can point to the natural or cultural origin of assemblages, and in particular, human consumption or use (Denys, 2002). Bone density is an important taphonomic factor and density models (built up on rank order patterns of bone density values) have been shown to be a promising way of investigating taphonomic loss in zooarchaeological assemblages (Lyman, 1994; Ioannidou, 2003). Skeletal elements have different survival patterns, both between the different elements and between species (Nicholson, 1996); teeth, for example, are the densest elements of the skeleton and can be expected to survive where other parts of the skeleton may have been destroyed by various agents of attrition (Maltby, 1985). Factors such as age, sex, genetics and nutritional state all affect levels of calcium, protein and fat in bone (Nicholson, 1996). Preservation is particularly age related with juvenile bones, which are less mineralised than adult bones, being more susceptible to fragmentation, diagenesis and degradation.

Carcase utilisation and disposal strategies should also be considered. Different parts of any carcase can be used for a variety of uses and it is logical to assume that butchery activities would leave distinct patterns in the faunal record (Maltby, 1985). The problem with the interpretation of faunal remains is that we have insufficient knowledge of the expected nature of assemblages created by archaeological activities. Butchery often leads to marks on the bone surfaces, but butchery activities also lead to spatial patterns of distribution and fragmentation of bones which can provide us with a means of interpreting human strategies of consumption and the type of site (Denys, 2002). There are also three broad classes of disposal and deposition defined by Meadow (1980): primary disposal which involves waste deposition at the locus of its creation resulting in undisturbed living or activity surfaces, secondary disposal which involves the removal of contemporary waste from its locus of origin to dumping areas which can cause the mixing of refuse resulting from discrete activities, and finally tertiary deposition which is defined as the redeposition of waste in a different spatial and temporal context of previously deposited remains.

One of the main problems with taphonomy is the reduction of sample size. Any assemblage excavated on an archaeological site is in fact a sample of a sample of a sample. Consequently zooarchaeologists work in steps, beginning with questions about the agencies involved in bone collection, modification and destruction (Stiner, 2002). Only once any biases introduced by non-human processes can be excluded or at least taken into consideration can zooarchaeologists begin to take on questions about human behaviour.

In general, there is a division between pre- and post- burial conditions and between chemical and biological taphonomic factors (Lotan, 2000). Some of these issues will now be discussed in more detail.

Diagenesis

Bones recovered from archaeological sites are undoubtedly altered over time, with alteration occurring on all scales (Nielsen-Marsh and Hedges, 2000). Diagenesis is the process of chemical and physical change in bones in the ground which greatly affects their preservation (Von Endt and Ortner, 1984). The major components of bone are protein (primarily collagen) and mineral (primarily hydroxyapatite). Live bone tissue is active, very strong and able to adapt to withstand a variety of stresses but this property is lost to some extent in diagenesis (Stiner *et al.*, 1995). After death the bone tissue does however continue to react to its environment as both the organic and inorganic components break down. On the molecular level there is the uptake of cations (positively charged atoms), the exchange of ions, and the circulation of organic compounds to consider (Hedges, 2002). The bone also undergoes a leaching of collagen, an alteration to the mineral matrix and microbiological attack (*Ibid*). One of the main factors in bone diagenesis is microbiological attack (generally complete within less than 500 years) as this is the main cause of collagen loss which in turn leads to histological destruction within the bone (Hedges and Millard, 1995; Hedges, 2002). These changes are all part of the process of diagenesis and the response of the bone

to its environment. These diagenetic changes have important implications for dating and other analytical procedures involving bone (Von Endt and Ortner, 1984).

As discussed above, conclusions drawn from faunal analysis in terms of the relative significance of an animal to the economy of a given society can also be affected by a differential preservation of bones of different species (Von Endt and Ortner, 1984). An important part of understanding the preservation of archaeological bones is understanding diagenesis and the aspects of the environment that can affect the course of diagenesis (Nielsen-Marsh and Hedges, 2000).

Different climates can influence both weathering and diagenesis, and environmental factors can contribute towards the state of bone preservation or destruction. Every site has its own microclimate which affects the bone preservation and the local environment surrounding the bone may accelerate certain reactions while inhibiting others (Lotan, 2000; Von Endt and Ortner, 1984). The degree with which bones are found in the archaeological record is decided by these factors. Between death and burial, animal bones go through a number of fairly extreme environments, which can include cooking, defleshing and exposure (Hedges, 2002). What concerns the archaeologist is whether these factors affect subsequent diagenesis.

Cooked bone

When analysing animal bones from a human settlement one of the main stages in the taphonomic history will be food preparation and consumption (Roberts *et al.*, 2002). One of the main issues with animal bones is whether they have been cooked or not and how this could effect bone preservation and bone element representation. Cooking is perhaps the most common pre-burial treatment of animal bones but it is one of the least understood taphonomic transformations (*Ibid*).

Faunal specimens may to some extent preserve evidence of cooking and the ability to detect cooked bone remains a desirable objective within zooarchaeology. With cooked bone there are three practices to consider (Roberts *et al.*, 2002):

1. Burning, where the bone is in direct contact with fire or a substantial heat source.
2. Roasting/baking, where the flesh on the bone insulates the bone from the heat source
3. Boiling, where the bone and flesh are heated in a liquid

Of these three practices the first, burning, is most clearly evident macroscopically on the bones. This process is unfortunately the process least associated with cooking and is more often associated with rubbish disposal. Roasting can be indicated by burning on just the articular ends of the bone and not the shaft as it protected by the meat. Boiling produces no macroscopic signs on the bone but it does accelerate diagenesis and bone that has been extensively boiled is unlikely to survive due to high porosity and reduced mechanical strength (Roberts *et al.*, 2002; Nicholson, 1996). This preferential loss of cooked bones has important consequences to the zooarchaeological record.

Burning

Burnt bone is commonly recovered from archaeological sites, where it can represent several processes including the remains of consumed animals. Bone can be burned *in situ* during cooking or later when rubbish was perhaps put on the fire (Nicholson, 1993); bones can also be used as fuel. There may be several reasons for the presence of burned bone material (Costamagno, 2002):

1. Accidental: natural fires, or when bones are near to a hearth
2. Utilitarian: cooking (see above), waste disposal in fires, bones used as fuel
3. Ritual

The question of what burned bones reveal about prehistoric human behaviour is a complex one, requiring accurate identification of burning on archaeological materials together with a reliable assessment of the context of these finds (Stiner *et al.*, 1995).

There are three changes that occur in bone as a result of burning (Stiner *et al.*, 1995):

1. Visible changes in bone colour
2. Changes in bone mineral and matrix composition
3. Alterations in the mechanical properties of bone that promote fragmentation.

The colour and condition of burnt bone depends on the temperature of the fire and the position of the bone in relation to the fire. Fires attain different maximum temperatures according to the fuel used and fire construction (Nicholson, 1993). Other factors such as the duration of the fire and the amount of fat on the bone also play a role (*Ibid*). Bones usually show gradual progression through brown (scorched c. 400°C), black (carbonised c. 525°C) and grey to white (calcined c. 645°C) with heating but the colour of bone only gives a very general idea of the temperature a bone reached. It is also worth noting that other factors such as soil conditions after burial can affect the colour of a bone (Nicholson, 1993). Bones heated to very high temperatures, i.e. calcined bones, are likely to have been deliberately burnt as rubbish or perhaps cremated, while charred bones are more likely to be cooking waste (*Ibid*). Analysis of an assemblage of burnt bones from a context can give information on the intensity and size of a fire and the position of animal bones within it. It is important to note that bones buried in sediments prior to a fire being lit can be burned by the fire (Stiner *et al.*, 1995). This potentially means that bone deposition and bone burning represent two unrelated events archaeologically.

There is a relationship between bone fragment length and the incidence of burning. Burning causes significant rearrangements in the crystal lattice of bone which greatly affects its potential resistance to pressure and makes burnt bones more likely to crumble than fresh bone (*Ibid*). Burnt animal bone fragments are generally smaller than un-burnt bone with both heat and pressure (trampling) causing this increased fragmentation (Stiner *et al.*, 1995; Costamagno, 2002). The intensity of combustion plays a role in the differential preservation of bone, with calcined bones less likely to survive than carbonised bones because of their fragility (Costamagno, 2002). The high fragmentation of burned bones has a direct impact on the study of archaeological bones limiting their ability to be identified to element or species.

Zooarchaeologists are ultimately concerned with how burnt bone became part of the archaeological record, the spatial associations between the live fire and the bones and the affect of the fire on bone preservation (Stiner *et al.*, 1995).

Fragmentation

The problems associated with the study of fragmentary bones have long been recognised. As already mentioned above, burning can cause an increase in bone fragmentation, but what are the other factors of concern here? Relationships between long bone breakage and past behaviours have often been expressed as a one-to-one relationship between bone breakage and the intensity of processing, i.e. the greater the fragmentation the greater the intensity of processing (Todd and Rapson, 1988). This is however, probably not entirely the case. Both pre-dispositional and post-depositional processes can result in the differential destruction of bone elements (*Ibid*). Studies by Binford (1978) implied that the numbers of articular ends and long bone splinters or shaft fragments related to the manner in which the bones were broken. Although this is may be in part true, in many archaeological faunal assemblages much of the breakage recorded is likely to result from a variety of processes in addition to human processing. Breakage of bones can occur during excavation, handling, and storage. Bones hit by a pick axe will often shatter, bones will break being removed from the earth, and if they are exposed to direct sunlight they will crack, spilt and eventually disintegrate (Meadow, 1980). These destructive forces affect different kinds of bones and different elements differently but systematically with long bones, particularly of larger animals the most likely to be fragmented.

Marrow and grease exploitation

Marrow extraction has been an important component of hominid butchery for over two million years (Pickering and Egeland, 2006) and fat procurement played an extremely important role in many past societies (Outram, 2001). Fat contains far more calories than protein or carbohydrate and is a much needed resource for subsistence populations. The skeleton is one of best sources of fat within an animal,

with medullary cavities filled with marrow fat or bone grease, and it is expected that bone marrow and fat extraction will leave signs in the fragmentation patterns of bones. If the bone has not been exploited for bone marrow or fat it is expected that the only damage inflicted on the bones by humans will be the result of killing the animal, butchery and possibly tool production, resulting in these bones being largely deposited whole with limited damage (Outram, 2001). If marrow has also been exploited evidence of deliberate long bone shaft fractures is expected (*Ibid*). Marrow is extracted by breaking open the bone and the grease is rendered by boiling the small bone fragments for an extended period of time and skimming off the fat as it comes to the surface of the water (Church and Lyman, 2003). The bone fragments from such 'soup kitchens' tend to be very small due to heavy fragmentation.

The problem is that fragmentation can occur for many other reasons. There are two theoretical scenarios outlined by Outram (2001):

1. A set of bones deposited on the ground, begin to dry out. They are subsequently trampled and fragmented
2. Fresh bones are fractured for bone fat extraction and deposited. Further disruption causes further fragmentation.

It can however, be difficult to distinguish between these two scenarios, particularly where modern breaks are also present. Other causes of fracture include animal gnawing, butchery and craftwork, which can all be recorded.

Other taphonomic factors: gnawing, weathering and trampling.

Scavenger gnawing is characterised by the presence of multiple parallel striations on the bone surface, and often by the removal of the articular surface. It can often lead to the complete destruction of bone, especially of smaller elements, and many mammals are also known to collect skeletal elements leading to the loss of elements from the assemblage (Denys, 2002). Weathering results in progressive cracking, spitting and exfoliation and can also lead to complete bone destruction (*Ibid*). Bones left on the surface for a long period of time can also be trampled by cattle or other large mammals resulting in breakage and burial of the bone fragments (*Ibid*). In general, better preservation is related to rapid burial.

Chapter Six The Fauna

6.1 Introduction

Over 170 kilograms of material was analysed (table 6.1), comprising in total 48,802 bone fragments (table 6.2). Faunal material was recorded from the following squares: E3, E4, F4, G5, H5, I3, I4, J4 and K5 excavated variously in seasons 2003, 2004, 2005 and 2007 (for more details see Chapter 2). The bone material was all hand collected and then bagged by square, locus and lot in the field. The material was later cleaned by gently brushing off the soil, put back into the labelled bags and stored in large cardboard boxes until it was recorded. As described in chapter 2 there are, broadly speaking, three periods of tell formation. These are known as Sequence A (c. 6865 – 6225 BC), B (c. 6180 – 5900 BC) and C (c. 5900 – 5500 BC). Within Sequence A and B 20 levels of occupation were identified (Kaneda, in prep). The stratigraphic analysis of the C Sequence is ongoing. The faunal data will be analysed first by sequence (A, B and C), then by level, and finally for the more in-depth analyses the levels are grouped into phases based on the faunal data. This was done in order to increase the sample sizes of each group. The A levels provide by far the biggest bone sample with the B and C levels far less well represented. There are a small number of bones from unknown, topsoil, Islamic, Late Bronze Age and severely mixed contexts but these will not be included in the following analysis (figure 6.1).

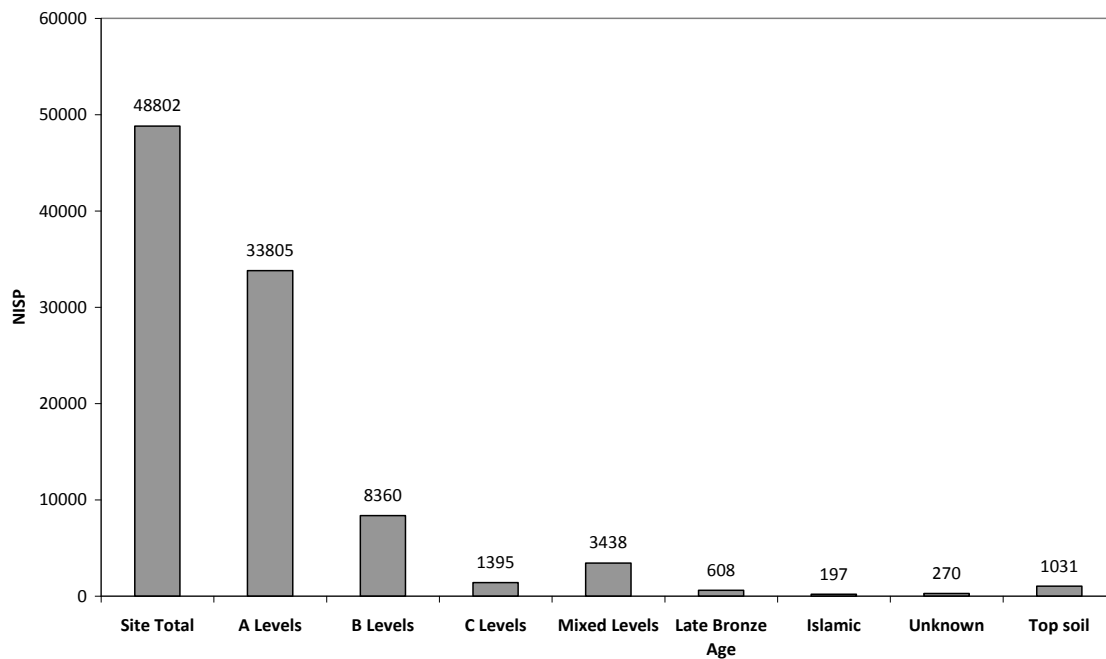


Fig 6.1: Total NISP by broad phase

Table 6.1: Bone weight (grams)

Species	A Levels	B Levels	C Levels	Mixed Levels	Late Bronze Age	Islamic	Unknown	Top soil	Site Total
Ovicaprid	39517.3	10123.5	1457.5	3706.4	697.8	375.2	357.5	1205.5	57440.7
Sus sp.	7172.4	471.7	102.5	142.7	18.9	1.4	23.2	62.7	7995.5
Bos sp.	18012.6	9818.7	1118.2	1310.3	198.4	171.9	625.2	186.9	31442.2
Dog	172.9	19.4	12.4	19.1			0.7	8.8	233.3
Fox	121.1	100.4		9.3	4.1			0.5	235.4
Dog/Wolf	26.0								26.0
Cat	8.3								8.3
Gazelle	2872.5	207.3	7.2	196.0		4.7	17.4	21.9	3327.0
Gazelle/Cervid	27.4			3.9					31.3
Equid	5885.8	759.3	127.1	448.5	17.2	3.7		38.4	7280.0
Roe deer	52.4	29.0		14.8					96.2
Fallow deer	34.0								34.0
Red deer								3.4	3.4
Cervid sp.	14.2	8.0							22.2
Brown bear	5.3	2.2							7.5
Hare	83.7			1.9					85.6
Mustelid	6.8						2.4		9.2
Bandicoot Rat sp.									0.0
Hedgehog sp.									0.0
Bat									0.0
Gerbil sp.									0.0
Rodent sp.	2.1			1.4					3.5
Anas sp.	0.1								0.1
Anser sp.	0.3								0.3
Chukar Partridge	0.2								0.2
Columbid	4.3			0.2					4.5
Demoiselle Crane		0.1							0.1
Falconid	0.3								0.3
Great Bustard	0.9								0.9
Grey partridge	0.1								0.1
Gull	0.1								0.1
Oyster catcher	0.1								0.1
Rail sp.	0.1								0.1
Redwing	0.1								0.1
Ruff	0.1								0.1
Song Thrush	0.1								0.1
Teal	0.3								0.3
Turdidae	0.2								0.2
White-fronted Goose	0.3								0.3
Wood pigeon	0.1								0.1
Woodcock	0.1								0.1
Unidentified Bird	13.7	0.3		0.1					14.1
Tortoise	5.7		2.0						7.7
Amphibian	4.0								4.0
Melanopsis costata	14.3	12.7	2.7	7.4					37.1
Melanopsis praemorsa	20.6	13.7	5.2	2.4		0.5			42.4
Snail sp.	2.8	1.4	2.6	1.4					8.2
Unio tigridis	342.9	99.5	92.8	53.3		15.7	0.2	11.5	615.9
Xeropicta	2.5								2.5
Large mammal	22232.0	5738.6	1020.7	2327.7	350.6	95.9	239.0	557.1	32561.6
Medium mammal	17466.7	2958.5	515.5	1264.8	307.4	162.9	149.6	739.2	23564.6
Medium to Large mammal	2816.6	540.2	155.2	231.6	56.0		17.6	64.6	3881.8
Small to Medium mammal	47.1	0.8		2.2	1.1		1.2	0.7	53.1
Unidentified Mammal	1903.2	326.1	33.4	134.2	28.4	3.4	13.6	74.1	2516.4
Level Total	118894.7	31231.4	4655.0	9879.6	1679.9	835.3	1447.6	2975.3	171598.8

Table 6.2: Species NISP

Species	A Levels	B Levels	C Levels	Mixed Levels	Late Bronze Age	Islamic	Top soil	Unknown	Site Total
Ovicaprid	10785	2491	432	911	209	82	250	69	15229
Sus sp.	1181	128	41	35	4	1	19	2	1411
Bos sp.	696	530	74	74	16	3	9	8	1410
Dog	33	7	7	3			8	1	59
Fox	45	45		11	3		1		105
Dog/Wolf	2								2
Cat	5								5
Gazelle	339	17	1	41		1	4	2	405
Gazelle/Cervid	6			1					7
Equid	286	56	5	3	3	1	2		356
Roe deer	5	2		1					8
Fallow deer	3								3
Red deer							1		1
Cervid sp.	3	1							4
Brown bear	4	1							5
Hare	47			3					50
Mustelid	3							1	4
Bandicoot Rat sp.	1								1
Hedgehog sp.			1						1
Bat	1								1
Gerbil sp.	4	3		1		1			9
Rodent sp.	174	73	44	11			1		303
Anas sp.	1								1
Anser sp.	3								3
Chukar Partridge	2								2
Columbid	43			2					45
Demoiselle Crane		1							1
Falconid	3								3
Great Bustard	9								9
Grey partridge	1								1
Gull	1								1
Oyster catcher	1								1
Rail sp.	1								1
Redwing	1								1
Ruff	1								1
Song Thrush	1								1
Teal	3								3
Turdidae	2								2
White-fronted Goose	3								3
Wood pigeon	1								1
Woodcock	1								1
Unidentified Bird	137	3		1					141
Tortoise	1		2						3
Amphibian	6								6
Melanopsis costata	16	13	1	7					37
Melanopsis praemorsa	28	19	10	3		1			61
Snail sp.	5	2	1	2				2	12
Unio tigridis	140	23	11	21		1	3	1	200
Xeropicta	11								11
Large mammal	3570	1240	160	548	83	7	124	43	5775
Medium mammal	11180	2424	433	864	221	84	390	98	15694
Medium to Large mammal	768	180	39	90	12		28	4	1121
Small to Medium mammal	85	4		3	3		2	1	98
Unidentified Mammal	4157	1097	133	478	76	15	189	38	6183
Level Total	33805	8360	1395	3114	630	197	1031	270	48802

6.2 General results

6.2.1 Relative importance of species

First, the relative importance of the top six species: ovic and capra (combined together as ovicaprid), bos, sus, gazelle and equid were calculated for each broad period using the bone weight and NISP (fig 6.2 and 6.3). Only data from the A, B and C levels will be considered in detail in this thesis. From the NISP data it is

clear that ovicaprids dominate the assemblage in numbers (fig 6.2) making up 81.0% of the top six species present. In terms of the other species present, we see that there are clear differences between the A, B and C levels (fig 6.2). The A levels contain far more sus, gazelle and equid than later levels where bos become more important. Ovicaprids remain the most common species exploited in all phases. Looking at bone weight is a better method to gauge the weight of meat produced from these species, and shows that in terms of meat weight, ovicaprids made up only 53.4% of the assemblage with bos the second most important species in all levels (fig 6.3). There are clear differences between the periods with an increase in bos and a decrease in sus from the A levels through to the B and C levels.

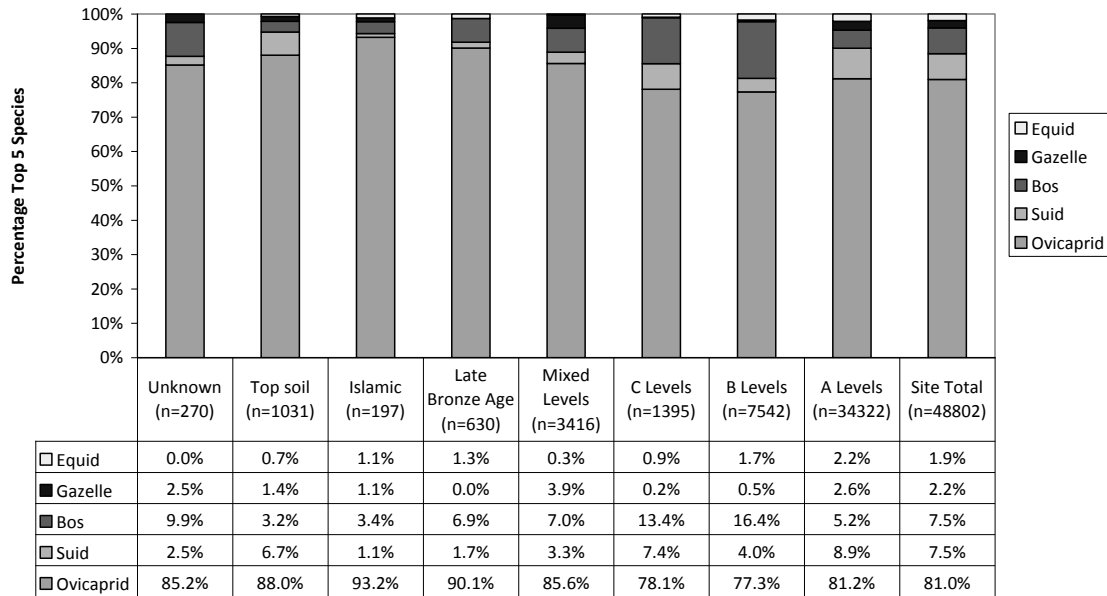


Fig 6.2: Relative proportion of the top six species by broad period (NISP)

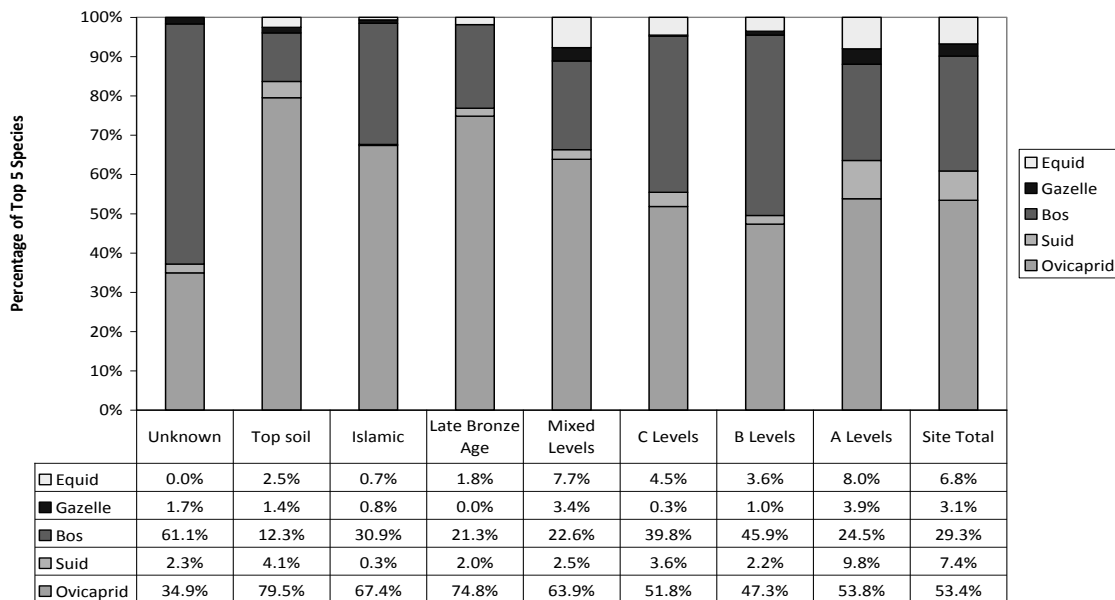


Fig 6.3: Relative proportion of the top six species by broad period (weight)

6.2.2 Temporal changes

Sequence A

The A sequence not only provides the best sample quantitatively but also qualitatively; there are very few levels that are mixed and those that are mixed are only mixed with the level above or below rather than with levels from the B or C sequence. The sample sizes for each level vary with by far the largest sample coming from level A1 (fig 6.4).

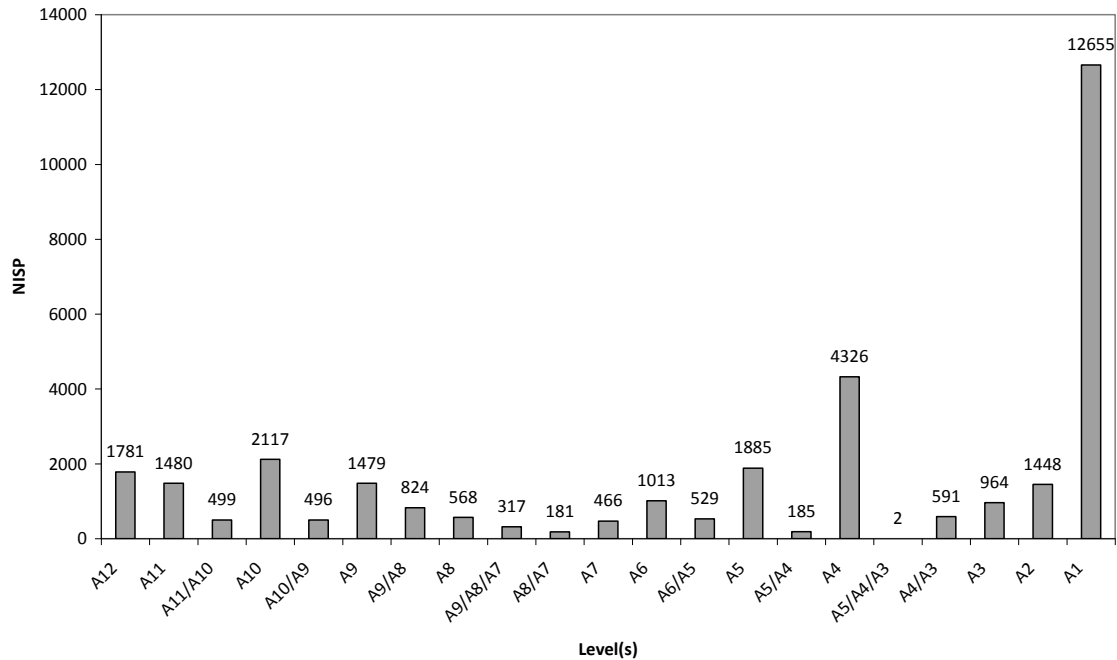


Fig 6.4: Total NISP by level in the A Sequence

In general c.40% of the bones from the A levels could be identified to species with the worse preservation occurring in the oldest levels (fig 6.5). This is the same as for the B levels (see below) but there is far less variability by level in the A levels.

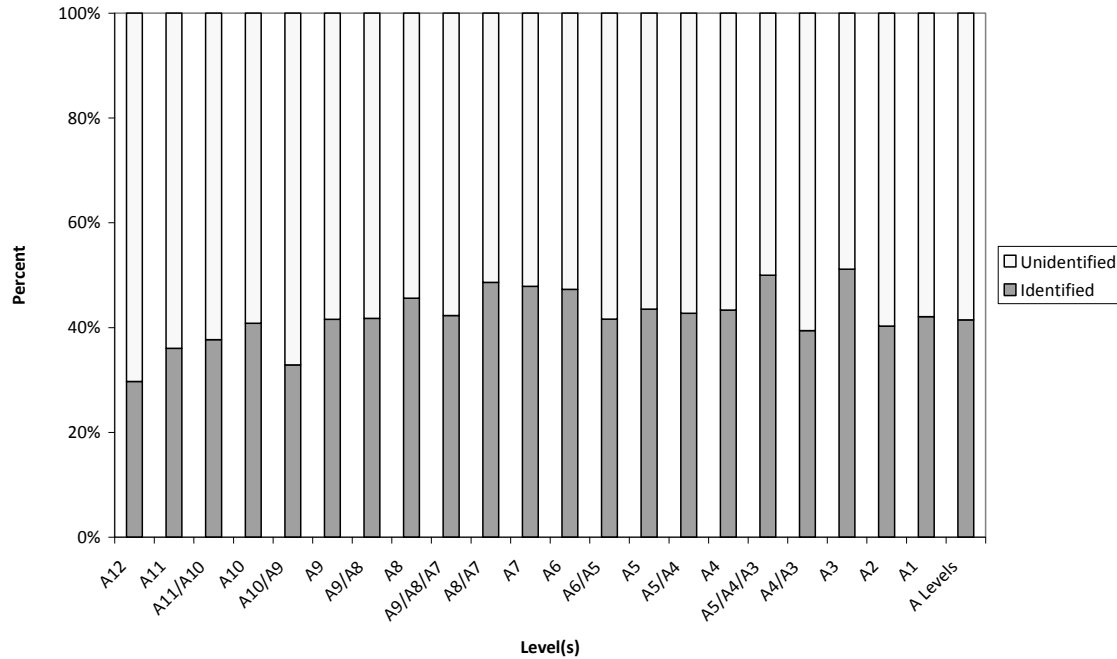


Fig 6.5: Percentage of bones identified to species in the A Levels

The relative proportion of species in the A levels (fig 6.6) shows that ovicaprids were always the most important animals in terms of numbers. In the oldest levels sus is the second most common species but this changes around level A2 when bos becomes the second most common species pushing sus into third position. The wild equid and gazelle are particularly well represented in levels A10 to A5.

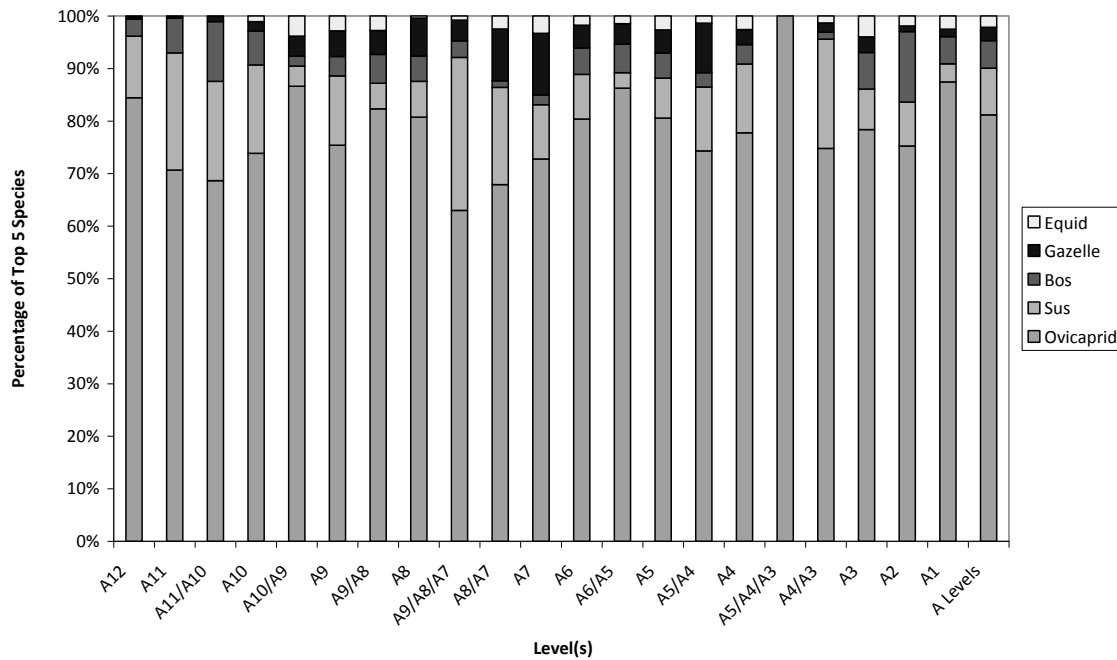


Fig 6.6: Relative Proportions of the top six species in the A Levels

Looking at trends within the A sequence the level can be grouped (table 6.3) in terms of the proportions of the main five species present, giving five A groups, or phases, in terms of animal exploitation (table 6.4). Of course this grouping of levels is somewhat subjective and by no means perfect. The advantage of combining levels is that it increases the dataset for each phase allowing for more complex analyses to be undertaken e.g. age profiles from toothwear. In general the number of bones in the mixed levels is low and as such, will not drastically change the species proportions of the phases they are included in. Within each phase each individual level may also be analysed in isolation to look for any subtle changes within these phases.

Table 6.3: Level grouping for A Levels

Animal Exploitation Phase	Levels included	n
A1	A1	12655
A2	A2	1448
A4-A3	A3, A4/A3, A4. A5/A4, A5/A4/A3	6068
A9-A5	A5, A6/A5, A6, A7, A8/A7, A9/A8/A7, A8, A8/A9, A9, A10/A9	7757
A12-A10	A10, A11/A10, A11, A12	5877
Total		33805

Table 6.4: Species NISP A Sequence animal exploitation phases

Common name	A12-A10	A9-A5	A4-A3	A2	A1	A Levels
Ovicaprid	1556	2497	1868	432	4432	10785
Sus sp.	354	294	311	48	174	1181
Bos sp.	127	134	96	77	262	696
Dog	5	5	14		9	33
Fox	1	11	25	1	7	45
Dog/Wolf	1	0	1			2
Cat	3	0	2			5
Gazelle	21	167	72	6	73	339
Gazelle/Cervid		2	3		1	6
Equid	10	74	64	11	127	286
Roe deer		1	1		3	5
Fallow deer		1			2	3
Cervid sp.	2				1	3
Brown bear		3		1		4
Hare	2	6	26	1	12	47
Mustelid		2	1			3
Bandicoot Rat sp.			1			1
Bat			1			1
Gerbil sp.			1		3	4
Rodent sp.		3	9		162	174
Anas sp.		1				1
Anser sp.		1	2			3
Chukar Partridge		1	1			2
Columbid	3	7	32		1	43
Falconid		2	1			3
Great Bustard	3	5	1			9
Grey partridge		1				1
Gull		1				1
Oyster catcher		1				1
Rail sp.			1			1
Redwing			1			1
Ruff			1			1
Song Thrush			1			1
Teal		2	1			3
Turdidae			2			2
White-fronted Goose		1	2			3
Wood pigeon			1			1
Woodcock		1				1
Unidentified Bird	7	54	63		13	137
Tortoise		1				1
Amphibian		3	2		1	6
Melanopsis costata	4	7	2		3	16
Melanopsis praemorsa	6	13	5		4	28
Snail sp.	1		4			5
Unio tigridis	8	36	58	6	32	140
Xeropicta		6	3		2	11
Large mammal	416	951	502	355	1346	3570
Medium mammal	2334	2679	1921	328	3918	11180
Medium to Large mammal	180	122	152	25	289	768
Small to Medium mammal	6	22	18	8	31	85
UUU	827	639	795	149	1747	4157
Level Total	5877	7757	6068	1448	12655	33805

The relative species proportions of ovicaprid, sus, bos, dog, gazelle and equid are significantly different in each of the six animal exploitation phases of the A Sequence (fig 6.7). Some care must be taken in interpreting these differences however as in some cases they can, at least, in part be put down to spatial differences within the site. This issue complicates analysis somewhat and will be largely ignored here to be readdressed later.

Ovicaprids are dominant in all animal exploitation phases but less so in levels A4-A3. This appears to be due to a greater exploitation of wild resources in these levels. Sus are most important in the oldest levels but begin to be phased out around level A2. At this time bos become more important. Gazelle and equid are hardly present in levels A12-A10 but seem to be far more important in levels A9-A5 and to a certain extent also in levels A4-A3.

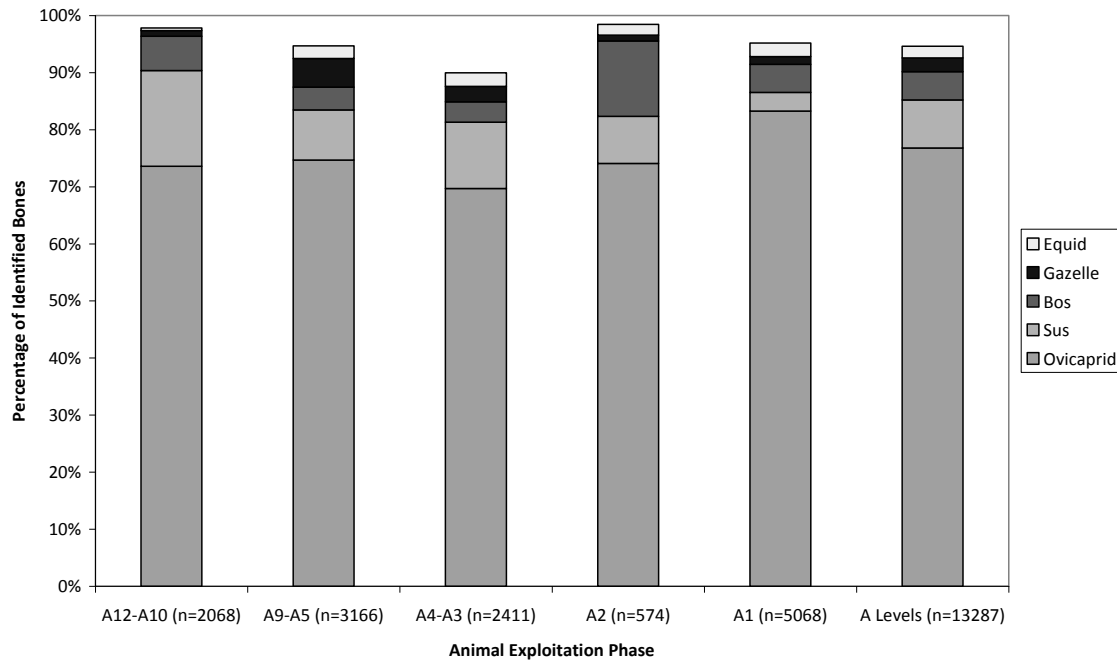


Fig 6.7: Absolute proportions of the top six species by Sequence A animal exploitation phases (based on NISP).

When looking at the other mammals present and/or exploited in these levels (fig 6.8 and table 6.4) it is clear that other wild animals did not play an important role in the economy. There are however trends apparent between the levels, with small game, particularly hare, being relatively important in levels A4-A3. In all other levels small game appears to play only an extremely minor role in the economy. Exploitation of small game (with the exception of canids) seems to rapidly diminish between levels A3 and A2.

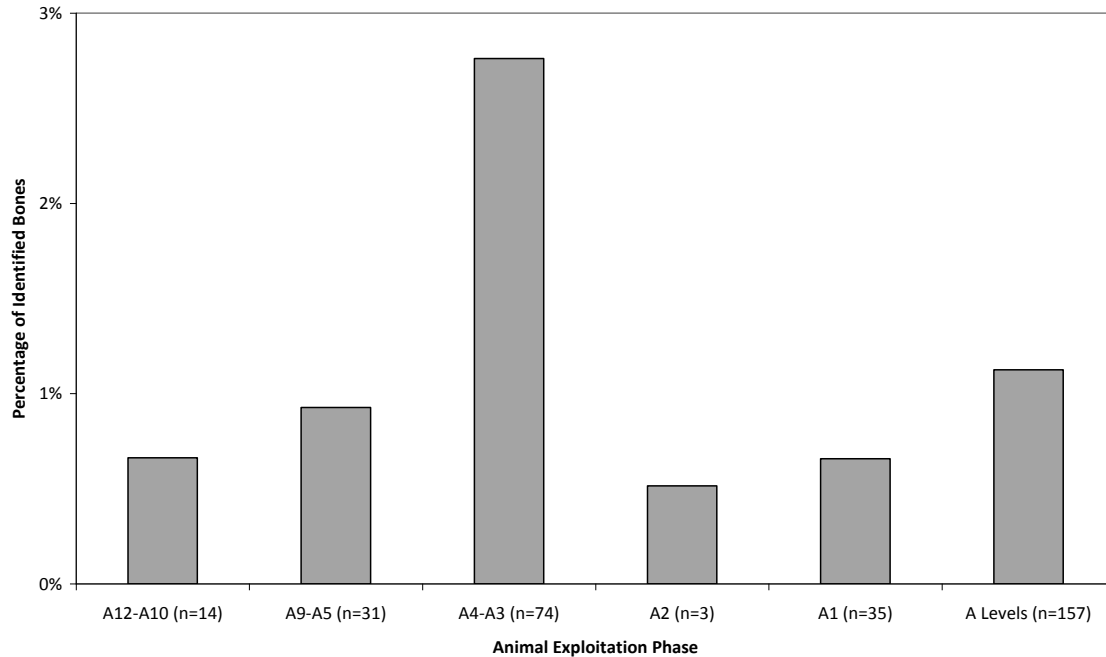


Fig 6.8: Other mammals exploited in the Sequence A animal exploitation phases (based on NISP). (NB. Rodent bones are excluded from this analysis as many of them are probably intrusive.)

Birds were also present only in very low proportions with the most common species being the Rock Dove (fig 6.9 and table 6.4). Birds were most common in levels A4-A3 which fits with the trend seen with small game seen above. Bird exploitation also seems to abruptly decrease after level A3 with no birds present in the assemblage in level A2.

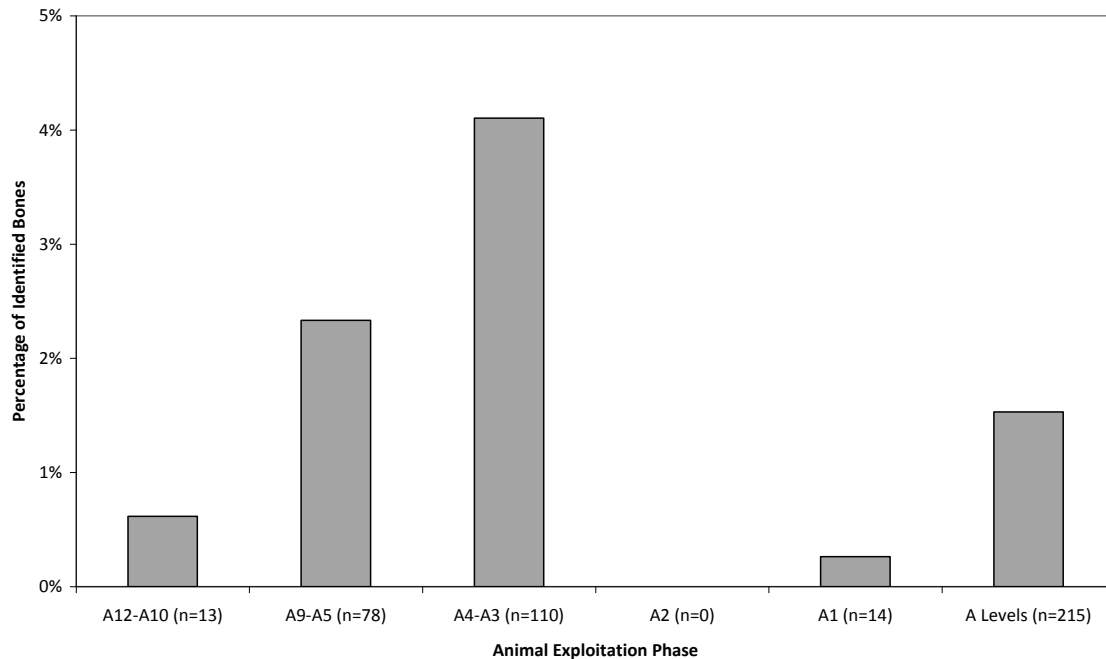


Fig 6.9: Birds exploited by Sequence A animal exploitation phase (based on NISP)

Some mollusc, amphibian and reptile species were also present at low levels (fig 6.10 and table 6.4). The most common species in all phases is *Unio tigris*, a freshwater mollusc.

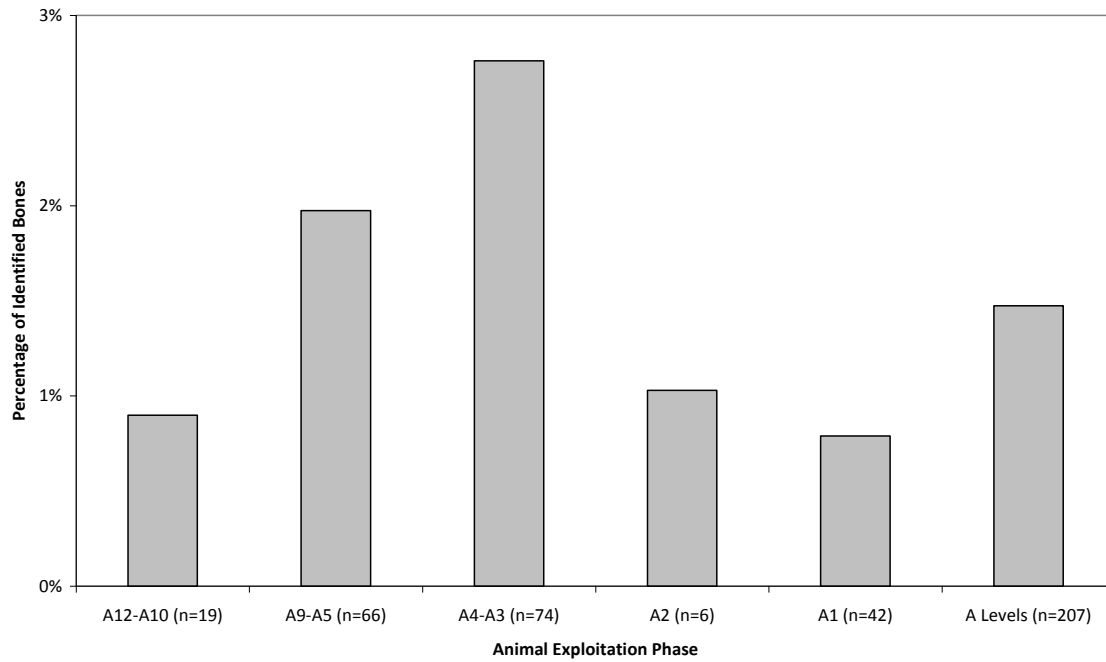


Fig 6.10: Molluscs, amphibians and reptiles exploited by Sequence A animal exploitation phase (based on NISP)

From these analyses it is clear that in all levels wild animals were of secondary importance to the subsistence economy, with the primary role being performed by the domestic animals (fig 6.11). Wild animals were exploited relatively more in levels A9-A3 where there appears to have been a broader subsistence strategy.

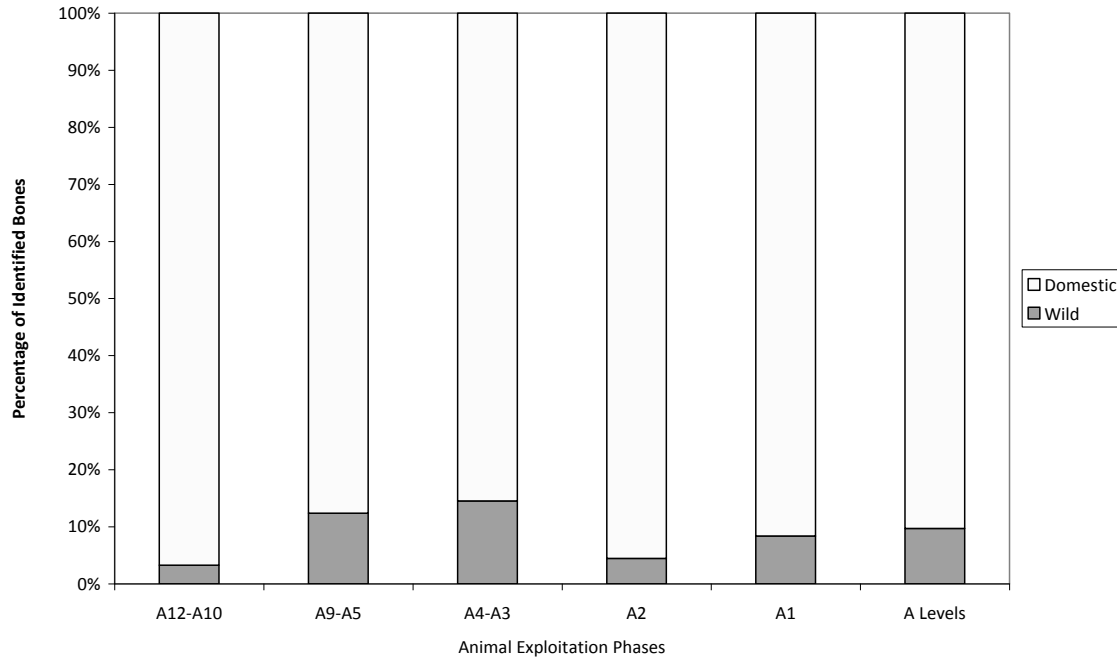


Fig 6.11: Domestic versus wild animals in the Sequence A animal exploitation phases (based on NISP). NB. For the purpose of this graph ovicaprids, bos and sus are assumed to be domestic.

Sequence B

The sample size from the B levels is quite modest, with most of the bones originating from level B4, an open area (fig 6.12). The levels from the B Sequence are quite mixed and many levels have only a small number of bones present; this makes combining the levels into broader phases with larger bodies of data quite important.

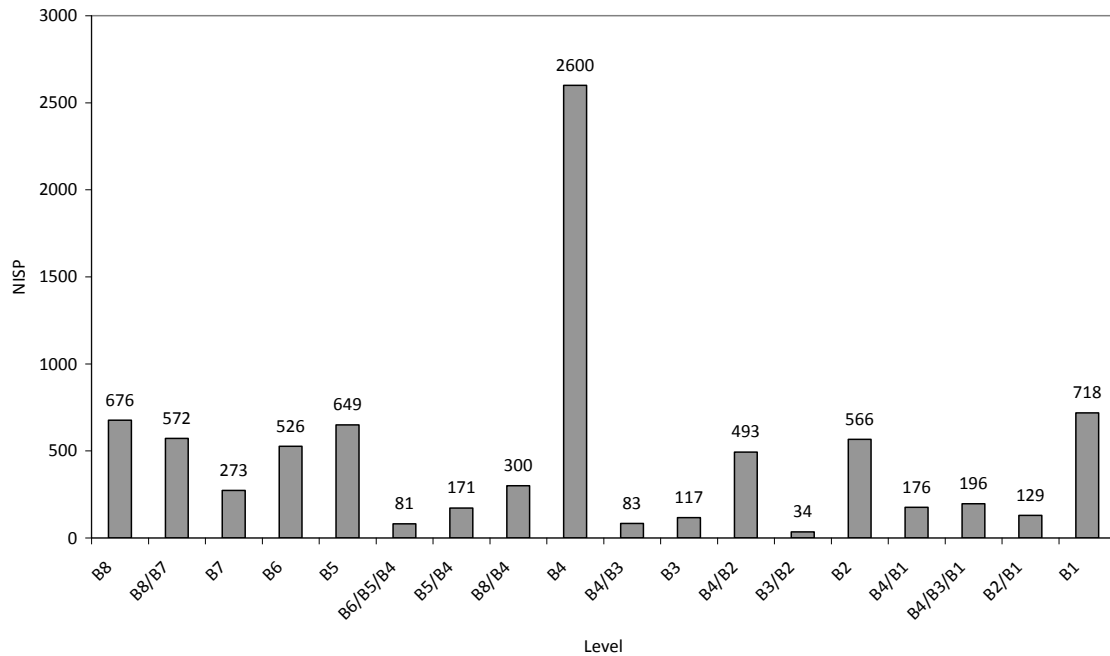


Fig 6.12: Total NISP by level

The percentage of bones identified to species varies from level to level (fig 6.13). The overall percentage of bones identified in the B levels is c. 40%.

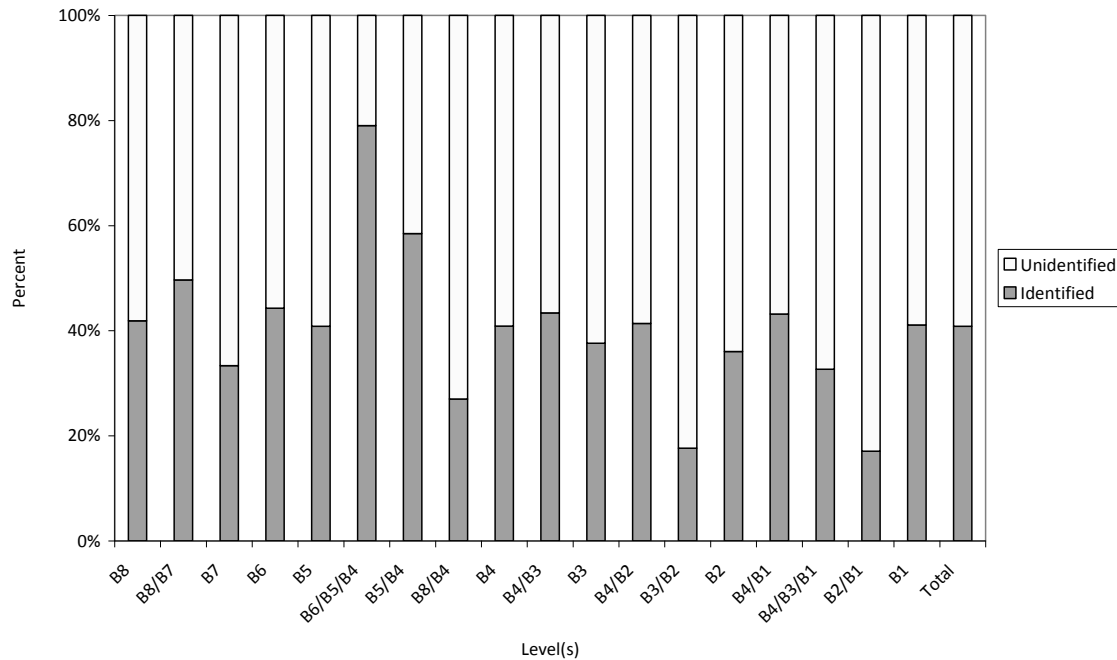


Fig 6.13: Percentage of bones identified to species in the B levels

The relative proportion of species in the B levels (fig 6.14) shows that the oldest B levels (B8-B4) are dominated by ovicaprids with bos becoming more important and hardly any sus, equid or gazelle present. In level B2 sus once again become important but far less so than bos. Bos are particularly dominant in level B1. Of course the ovicaprids still dominate the assemblage in all levels, but in terms of meat weight bos species were probably more important economically in the youngest B levels.

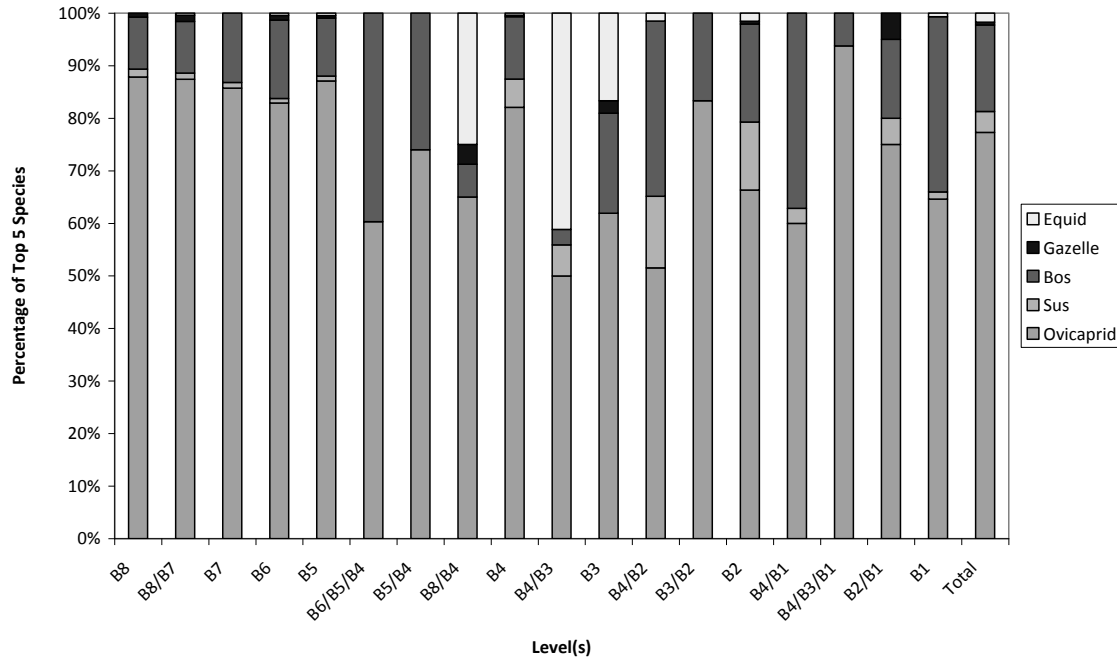


Fig 6.14: Relative proportions of the top six species in the B levels

Looking at trends within the 'B' levels, the levels can be split in two groups: B3-B1 with relatively low proportions of ovicaprids and high proportions of bos and sus, and B8-B4 with relatively higher proportions of ovicaprids and practically no sus present (table 6.5).

Table 6.5: Level groupings for B Levels

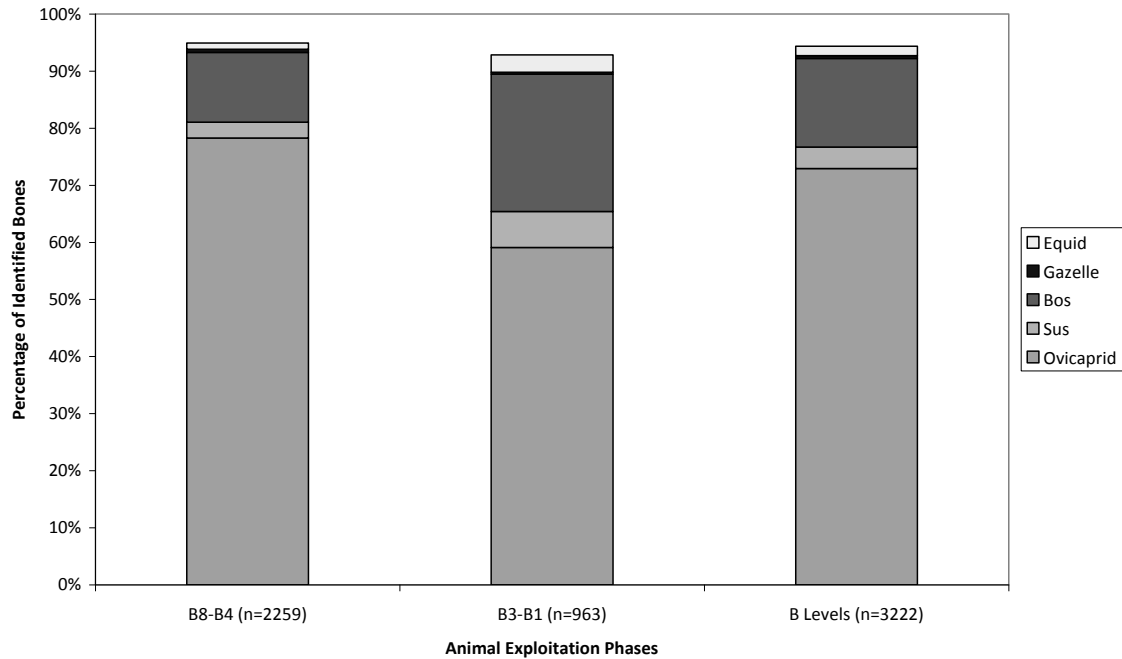
Animal Exploitation Phases	Levels included	n
B3-B1	B1, B2/B1, B4/B3/B1, B4/B1, B2, B3/B2, B4/B2, B3, B4/B3	2812
B8-B4	B4, B8/B4, B5/B4, B6/B5/B4, B7, B8/B7, B8	5548
Total		8360

The species proportions in each of these two groups are distinct from one another and show a trend towards increasing proportions of bos through time (fig 6.15). The amount of gazelle and equid exploitation is extremely low in all B levels.

Looking at the proportion of other mammals exploited (fig 6.16 and table 6.6) it is clear that wild game was not economically important in the B levels. The only animals present in any number are canids (mostly foxes). Brown bear and roe deer were exploited in levels B8-B4 and the remains from unidentified cervids were recovered from levels B3-B1. In general it appears that wild animals were not important to the subsistence economy. This is also reflected in the birds (fig 6.17 and table 6.6) and the molluscs exploited (fig 6.18 and table 6.6).

Table 6.6: Species NISP Sequence B animal exploitation phases

Common name	B8-B4	B3-B1	B Levels
Ovicaprid	1877	614	2491
Sus sp.	68	60	128
Bos sp.	296	234	530
Dog	3	4	7
Fox	42	3	45
Gazelle	11	6	17
Equid	7	49	56
Roe deer	2	0	2
Cervid sp.	0	1	1
Brown bear	1	0	1
Gerbil sp.	1	2	3
Rodent sp.	41	32	73
Demoiselle Crane	1	0	1
Unidentified Bird	3	0	3
Melanopsis costata	4	9	13
Melanopsis praemorsa	5	14	19
Snail sp.	2	0	2
Unio tigridis	19	4	23
Large mammal	689	551	1240
Medium mammal	1693	731	2424
Medium to Large mammal	136	44	180
Small to Medium mammal	4	0	4
UUU	643	454	1097
Level Total	5548	2812	8360

**Fig 6.15: Absolute proportions of the top six species by Sequence B animal exploitation phase (based on NISP)**

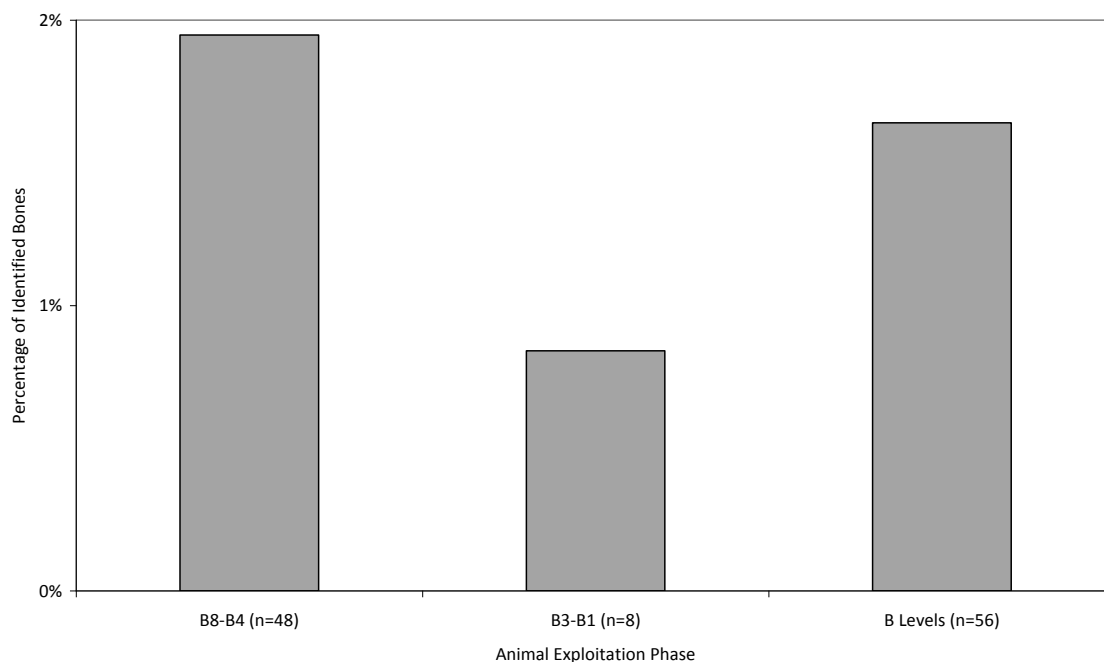


Fig 6.16: Other mammals exploited in the Sequence B animal exploitation phases (based on NISP). (NB. Rodent bones are excluded from this analysis as many of them are probably intrusive)

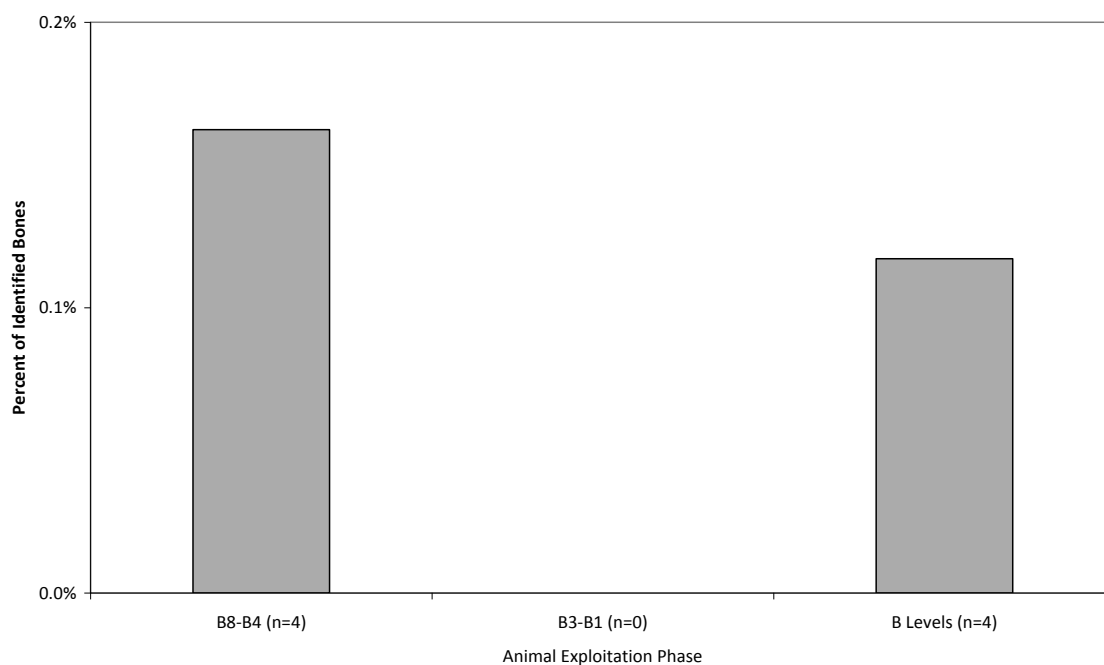


Fig 6.17: Birds exploited by Sequence B animal exploitation phase (based on NISP)

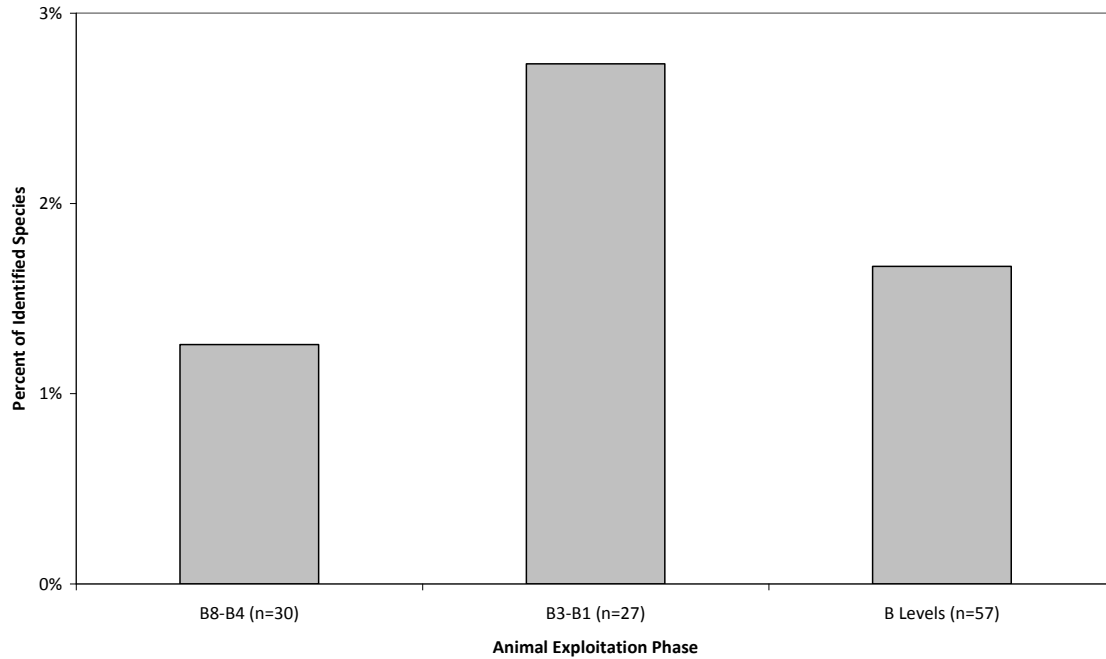


Fig 6.18: Molluscs, amphibians and reptiles exploited by Sequence B animal exploitation phase (based on NISP)

Very few bird bones were recovered from the B levels suggesting that birds were not really exploited in these levels (fig 6.17). Most of the bird remains came from the oldest B levels, B8-B4, and they had disappeared by levels B3-B1. The only bird identified to species was the demoiselle crane.

No amphibian or reptile remains were recovered from the B levels; only molluscs were exploited but only at very low levels. Fresh water molluscs made up the bulk of this group and they were most common in level B3-B1. This increase in freshwater mollusc exploitation coincides with an increase in the exploitation of equids seen in B3-B1.

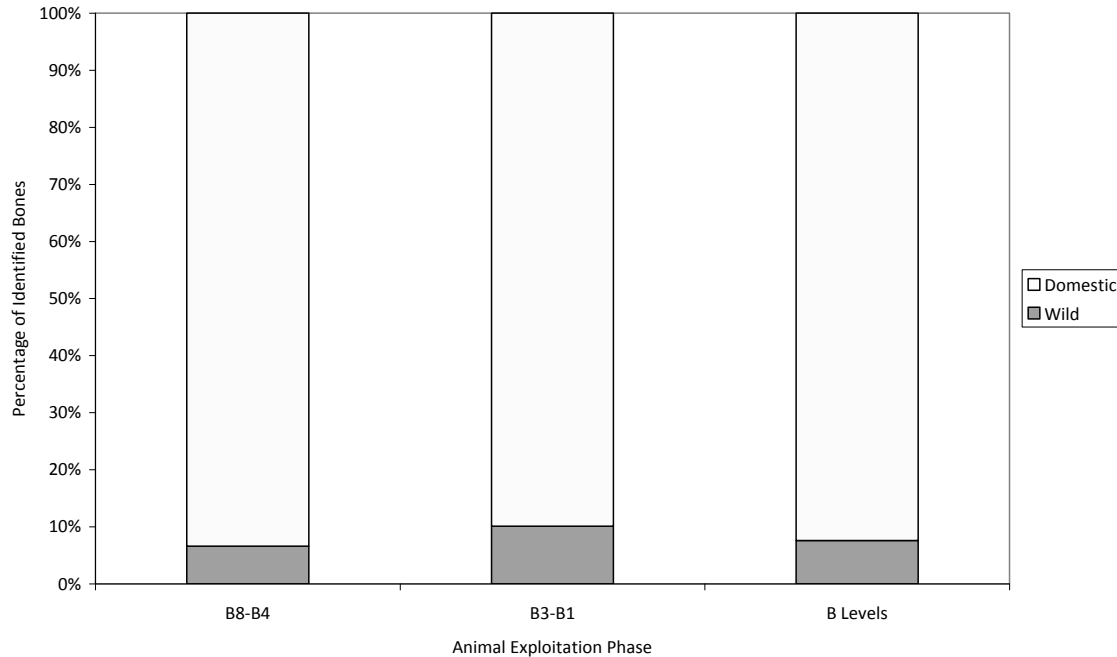


Fig 6.19: Domestic versus wild animals in the Sequence B animal exploitation phases (based on NISP). NB. For the purpose of this graph ovicaprids, bos and sus are assumed to be domestic.

From these analyses it is clear that wild animals make up only a very small proportion of the assemblage (fig 6.19). It appears that wild animals were not important to the subsistence economy in the B phases.

Sequence C

The faunal sample from the C (Halaf) levels is very small with only 1395 bones coming from unmixed contexts. Approximately 45% of the bones from these levels could be identified to species. As the dataset is so poor from these levels they will not be analysed in detail here. Later, the sample analysed by Cavallo (2000) will be used to supplement the data from these levels. For now the C levels will be taken as one phase.

Table 6.7: Species NISP C (Halaf) levels

Species	C Levels
Ovicaprid	432
Sus sp.	41
Bos sp.	74
Dog	3
Fox	4
Equid	5
Gazelle	1
Hedgehog sp.	1
Small mammal	44
Tortoise	2
Melanopsis costata	1
Melanopsis praemorsa	10
Snail sp.	1
Unio tigridis	11
Large mammal	160
Medium mammal	433
Medium to Large mammal	39
Unidentified	133
Grand Total	1395

Comparison of animal exploitation phases

The species proportions in the Sequence A, B and C animal exploitation phases will now be directly compared. Figure 6.20 shows that there are clear differences between the phases and between Sequence A and B with a gradual transition from sus to bos exploitation starting around level A1 or A2. The exploitation of gazelle and equid also appears to wane at this time. Ovicaprid proportions remain very high until levels B3-B1 where it is clear that bos were becoming the most important domestic species. This seems to be somewhat reversed in Sequence C. The trends seen in the species proportions from the NISP data are reflected in the bone weight data (fig 6.21).

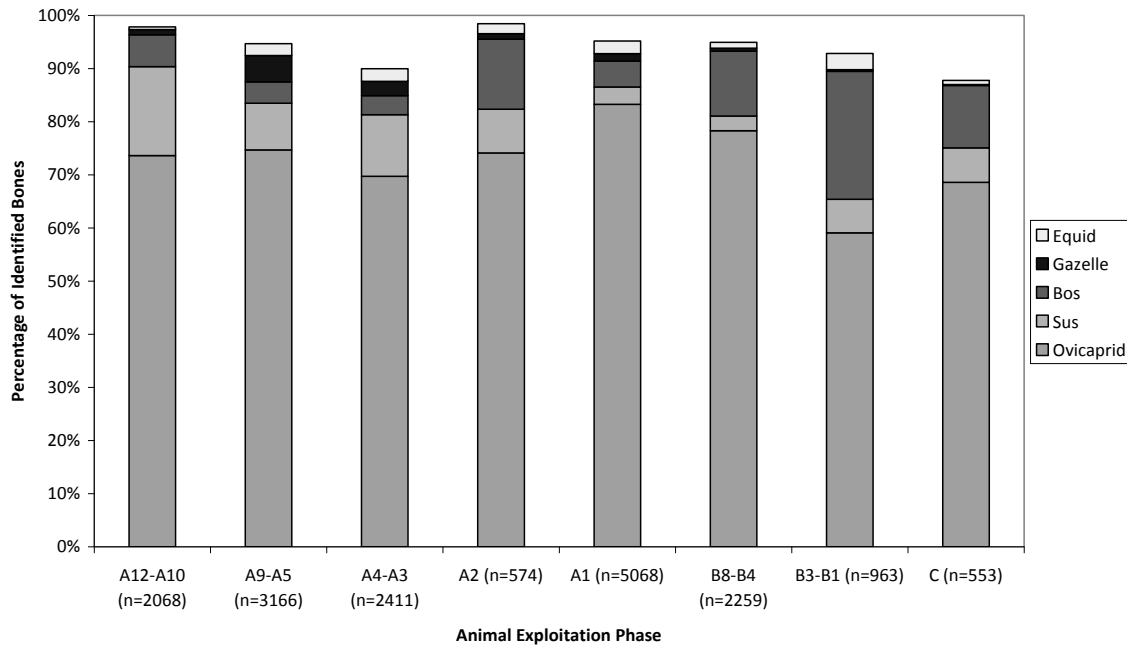


Fig 6.20: Absolute proportions of the top six species by animal exploitation phase (NISP)

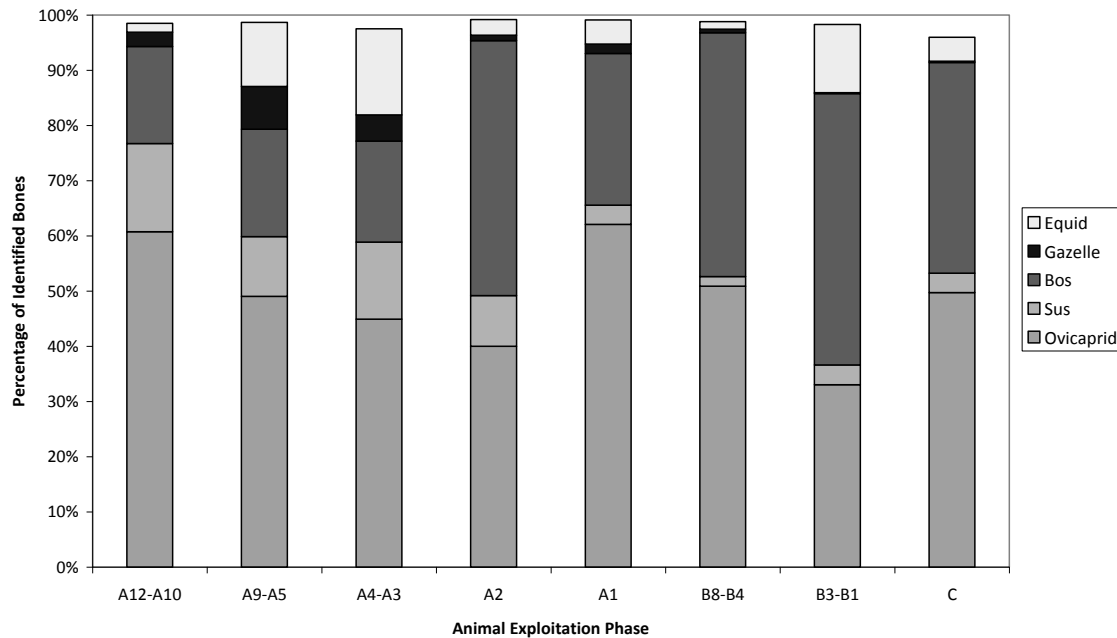


Fig 6.21: Absolute proportions of the top six species by animal exploitation phase (bone weight)

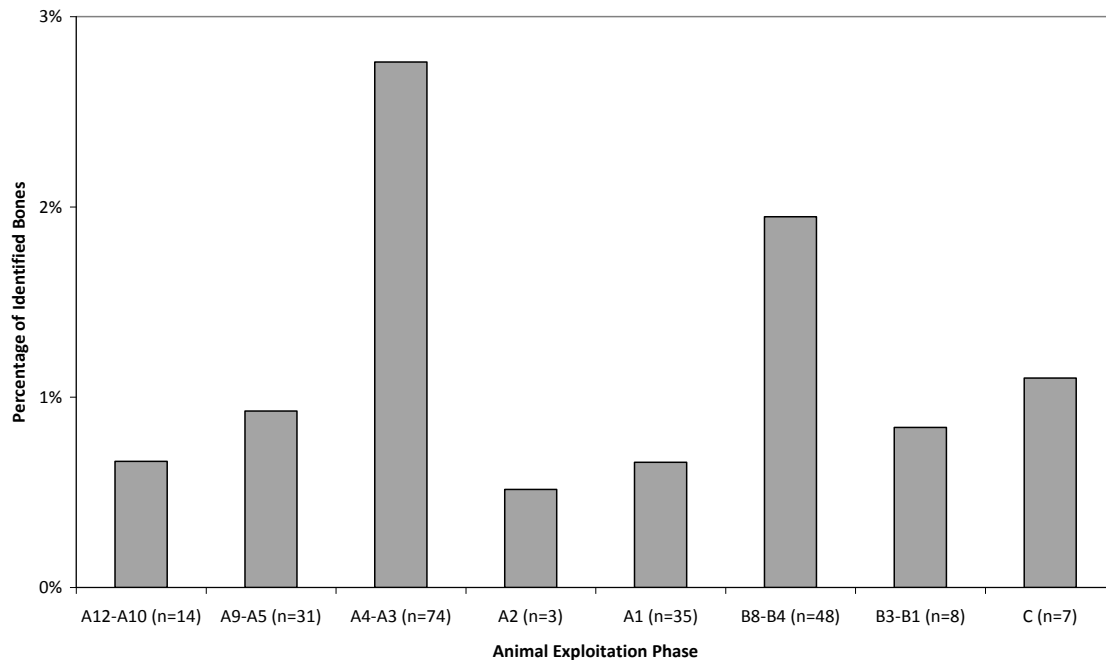


Fig 6.22: Other mammals exploited by animal exploitation phase (based on NISP). (NB. Rodent bones are excluded from this analysis as many of them are probably intrusive).

There are also clear trends within the other mammals exploited with hare only being exploited in the A levels and disappearing from the assemblage after level A1 (fig 6.22, see also section 6.8.6). Foxes and dogs are the only mammals in this group seen consistently in all levels but they are notably prevalent in levels B8-B4 (see also section 6.8.1).

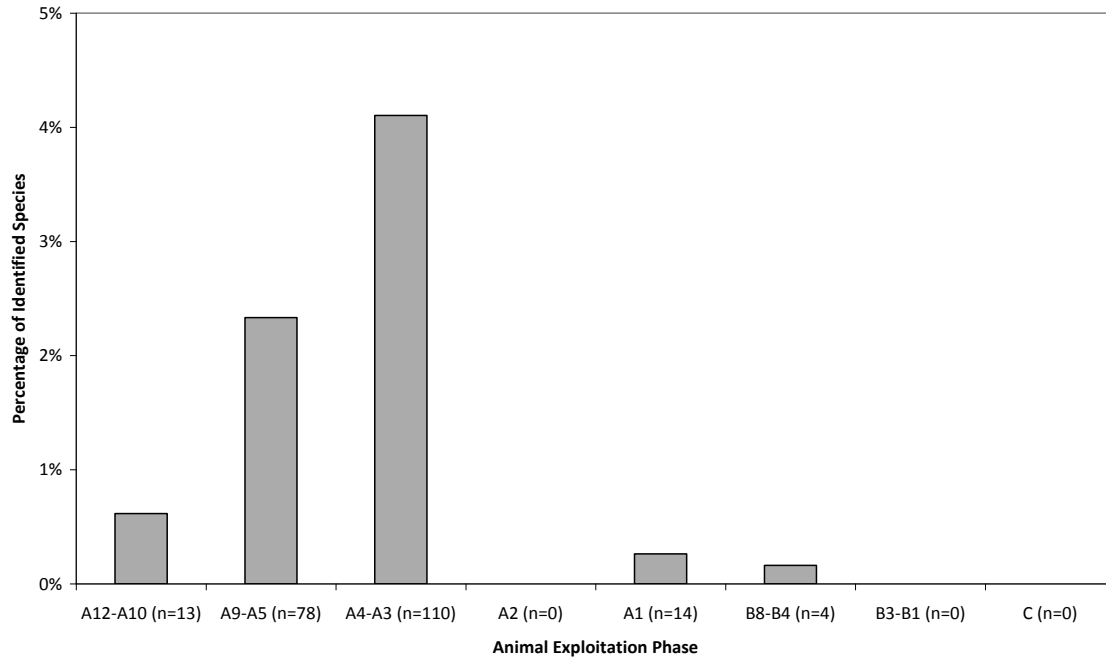


Fig 6.23: Birds exploited by animal exploitation phase (based on NISP)

There are also clear differences between Sequence A and B in terms of the birds exploited (fig 6.23). There are not only a greater number of bird bones in the A levels, but also a far greater diversity of species (see section 6.8.8). Only one species was identified in the B levels compared to 18 in the A levels. The number of birds present in the assemblage appears to peak during levels A4-A3 and quickly tails off by level A2 never to reach the same proportions again in the B levels.

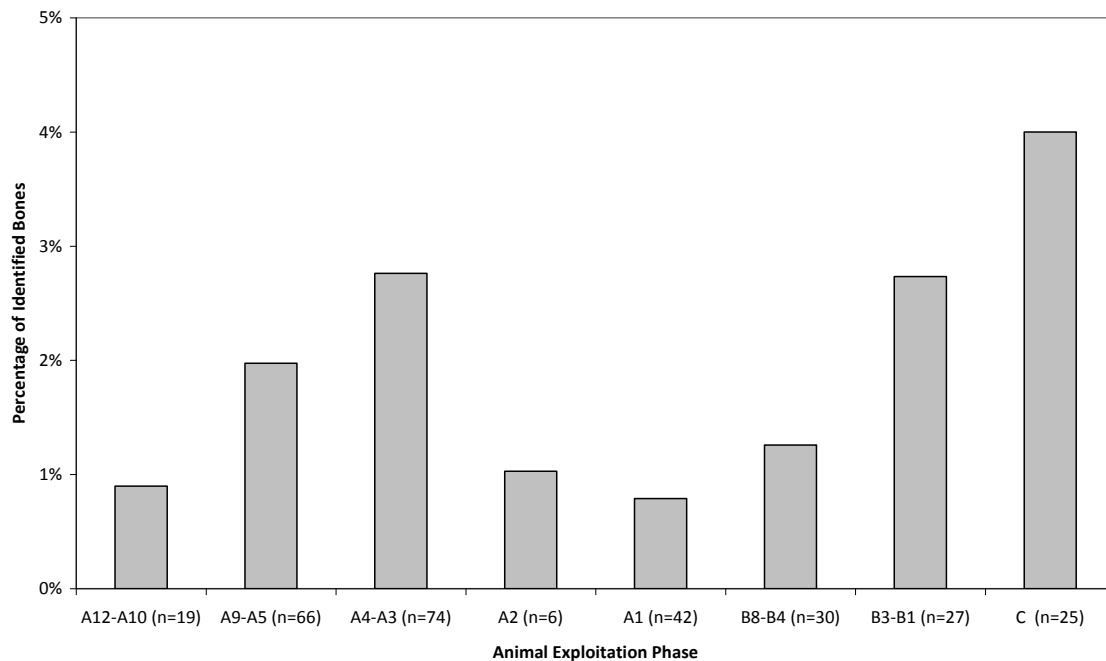


Fig 6.24: Molluscs, amphibians and reptiles exploited by animal exploitation phase (based on NISP).

Amphibians and reptiles were only present in the A levels and the C levels, and then they were only present in extremely low numbers (fig 6.24 and see section 6.8.9). Molluscs were found in all phases in particular *Unio tigris* was dominant in levels A12-A1 and B8-B4. In levels B3-B1 the *Melanopsis* species dominate (see section 6.8.10).

Summary

This first level of analysis has determined that there are definite phases with the faunal sample and therefore in animal exploitation and husbandry strategies at the site. Several changes occur and the transitions can be traced through the levels of the site. The main changes are:

1. A shift from the exploitation of sus to that of bos
2. A shift from the exploitation wild animals to a reliance on domestic species
3. A shift from the exploitation of a wide range a species to a concentration on certain domestic species only.

These changes happen gradually through the phases with a definite change occurring around levels A1 and A2.

6.2.3 Preservation, fragmentation and other taphonomic factors

Before the more in-depth analyses are undertaken it is important to assess the taphonomy of the bone sample by phase and context. Such an analysis is important as significant differences in preservation could impact the results.

The colour of the majority of the bones is a pale creamy yellow with only a few having been darkened by the soil. The general surface preservation of the bone material was very good with little evidence of weathering or erosion (fig 6.25). The preservation of the bones by animal exploitation phase and context was somewhat variable with the worst surface preservation being present in the oldest levels (A12-A10) and the youngest levels (B3-B1 and C). Surface preservation by context was also variable with the worst preservation in bins, burials, platforms and vessels (fig 6.25 and 6.26). Some bones had heavy crystal formations on the surface and deep into the bone but this was very rare. Although the preservation of the bones was by and large very good, the amount of fragmentation was very high with the vast majority of fragments representing only 1-20% of the original bone (fig 6.27). There seems to be little difference between animal exploitation phases or contexts, although basins contained the highest proportion of complete bones (fig 6.28).

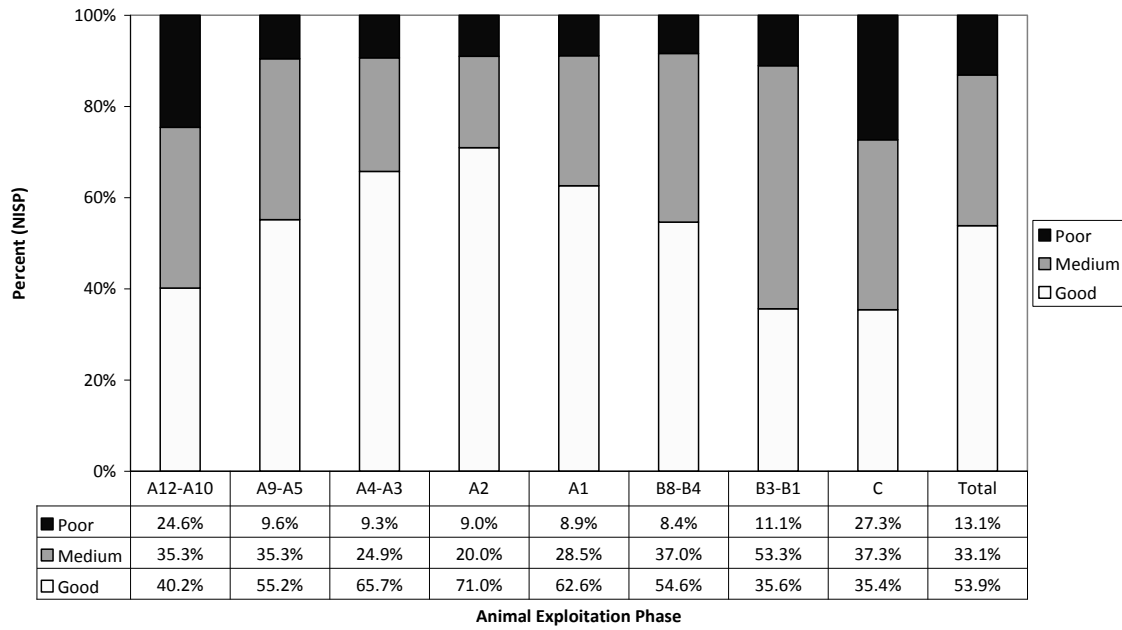


Fig 6.25: Bone surface preservation by animal exploitation phase

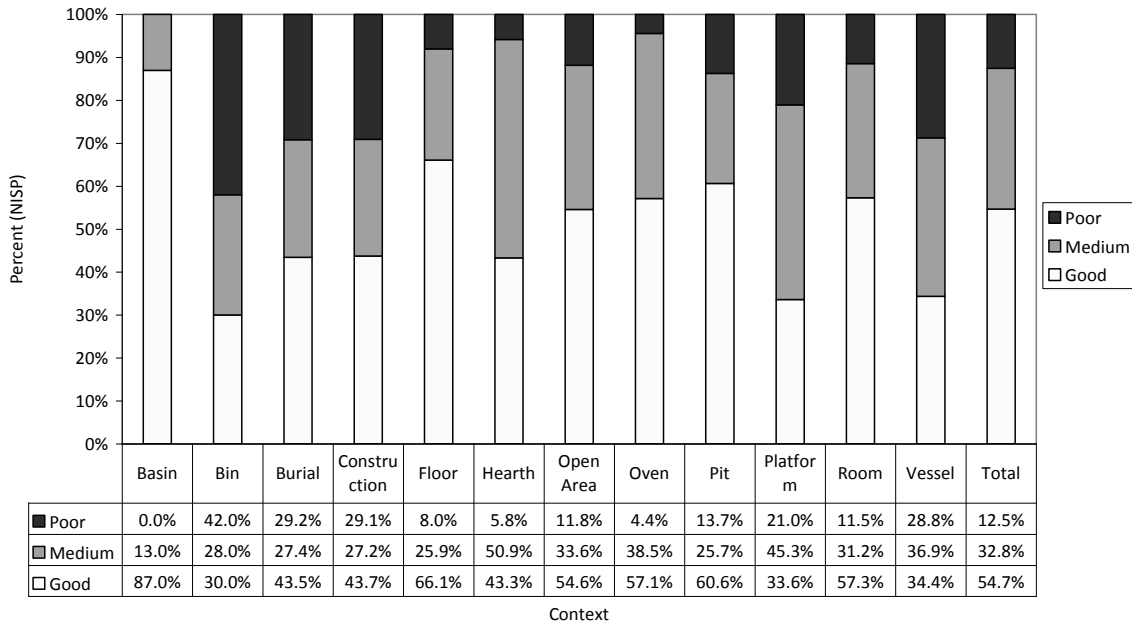


Fig 6.26: Surface preservation by context

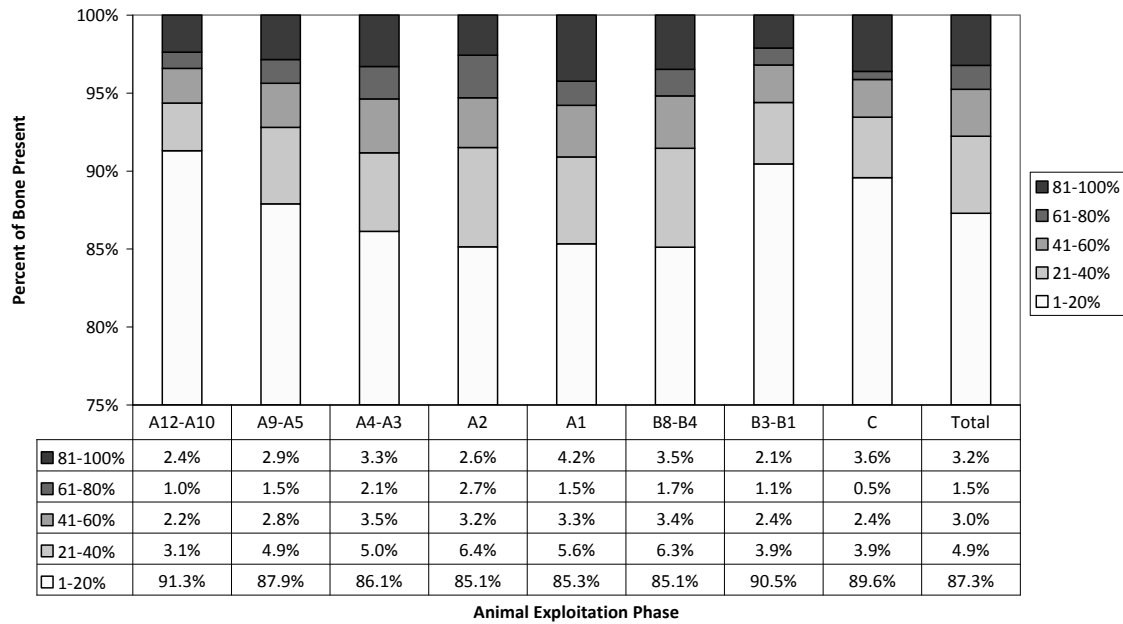


Fig 6.27: Completeness of bone fragments by animal exploitation phase

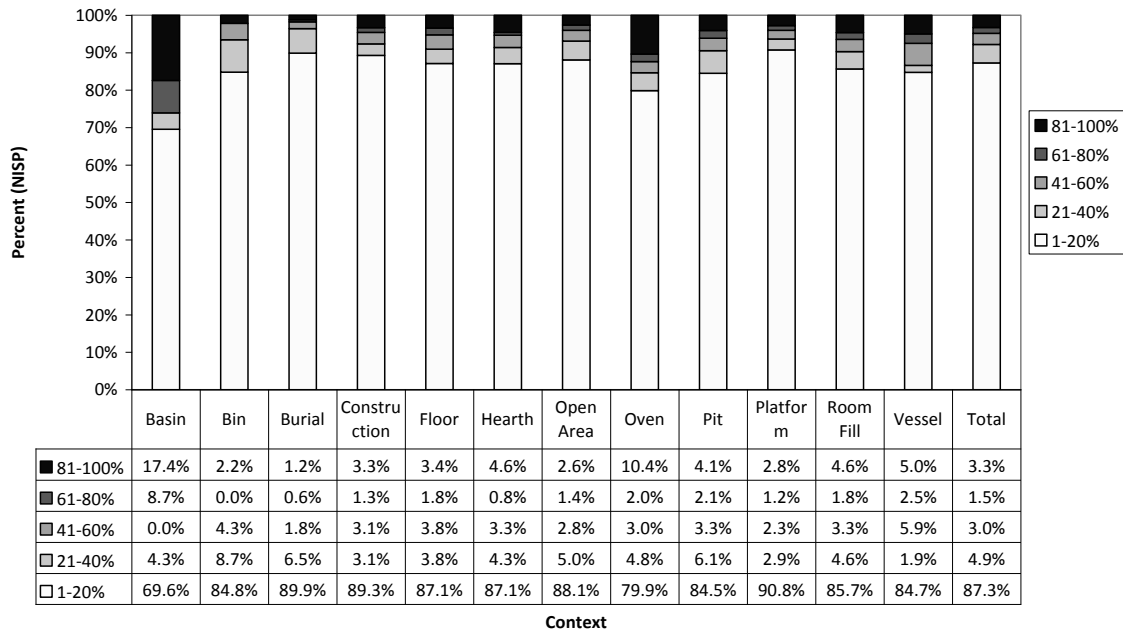


Fig 6.28: Completeness of bone fragments by context

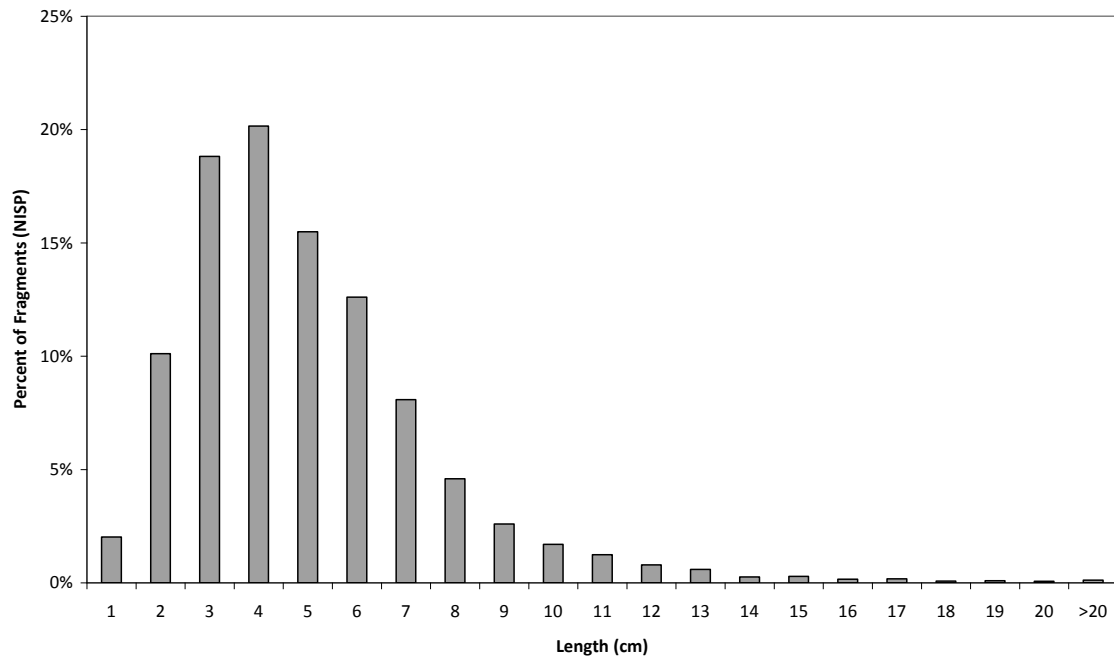


Fig 6.29: Length of bone fragments (total)

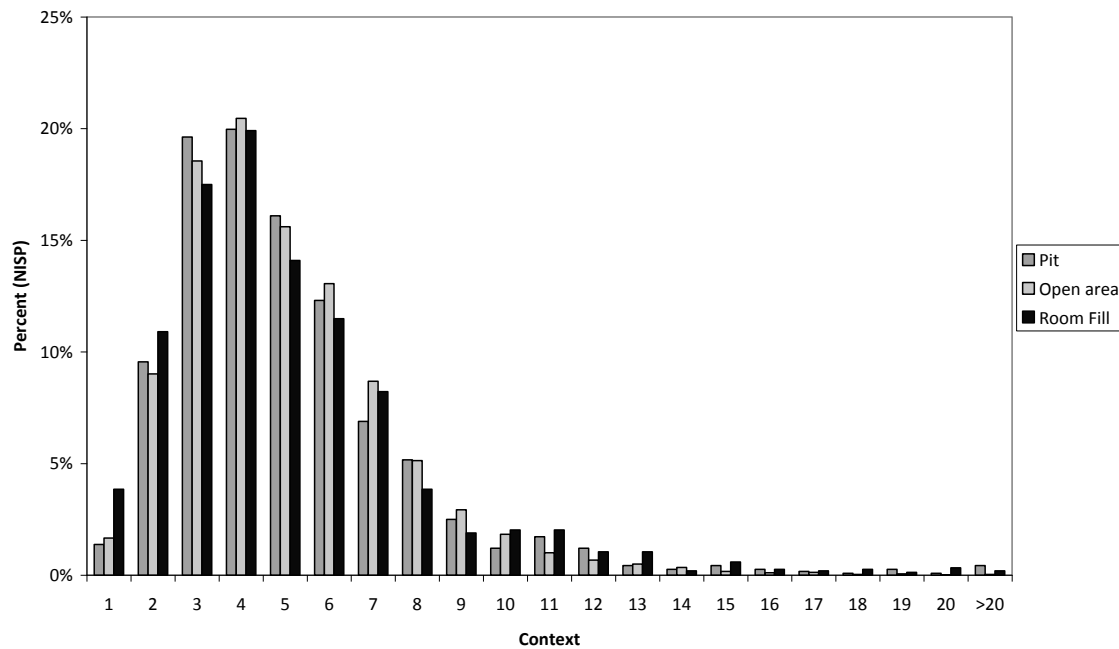


Fig 6.30: Fragment length by context

The average bone fragment recorded was approximately four centimetres in length. Figures 6.29 and 6.30 show that fragment size has a binomial distribution. There was no significant difference between levels or contexts.

Extremely low proportions of bones showed signs of either canid or rodent gnawing in any of the animal exploitation phases or contexts (fig 6.31 and 6.32). Less than 0.5% of bones showed signs of gnawing (fig 6.31). Pits contained bones with the most gnawing but this was still only c. 0.75% of bones. This suggests that in general canids did not have access to bone refuse and they were either kept away and/or bone waste was rapidly covered.

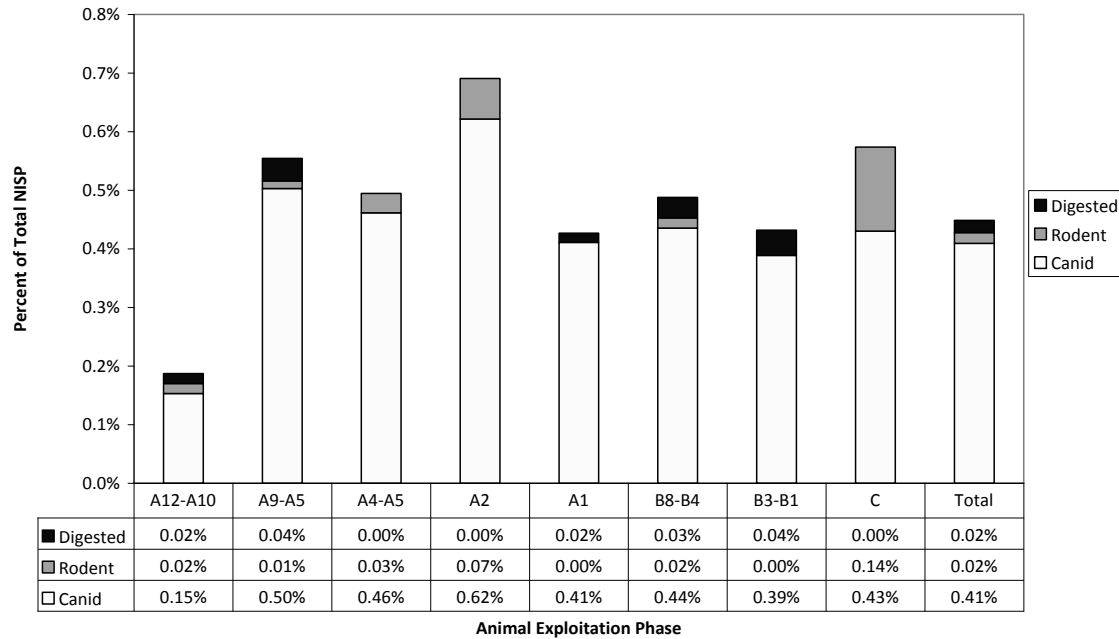


Fig 6.31: Percent of gnawing present by animal exploitation phase

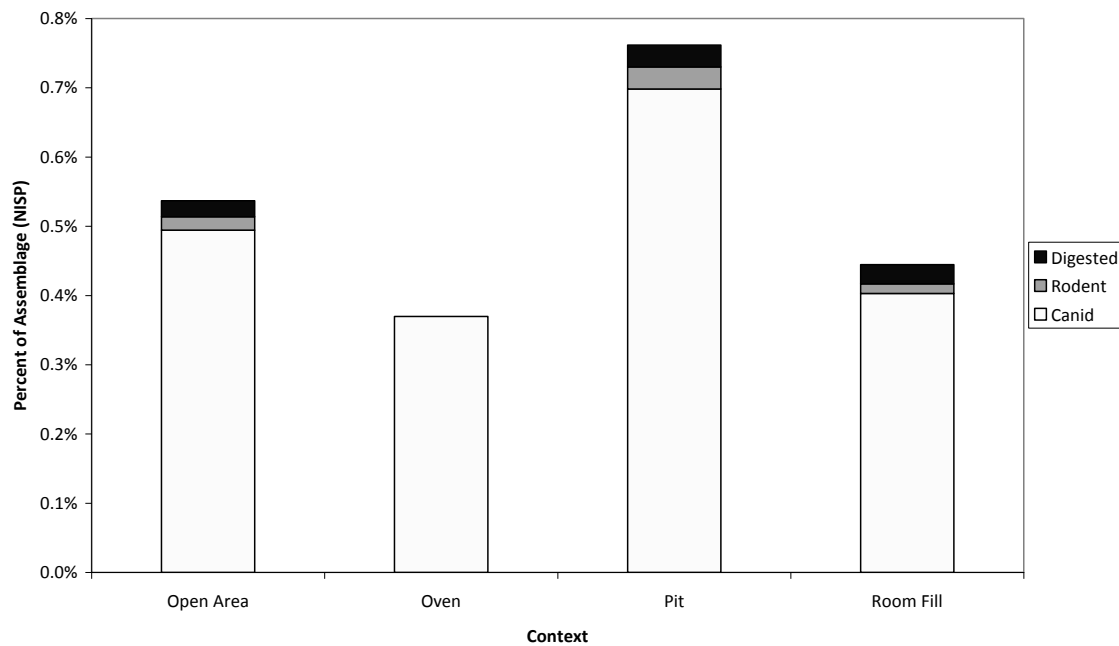


Fig 6.32: Percent of gnawing present by context

The number of butchery marks present on bones was also very low. In total less than 0.2% of bones showed any signs of butchery such as cut marks (fig 6.33). Level A3 had the highest percent of butchered bone at >0.8% of bones displaying fine and heavy cut marks (fig 6.33). The most common type of butchery marks were cut marks, usually found around the epiphyses of the bones. Pits had the most bones with cut marks, followed by room fills (fig 6.34). Surprisingly open areas had the lowest proportion of bones with butchery marks present. Perhaps these areas were cleaned and the waste disposed of in the pits?

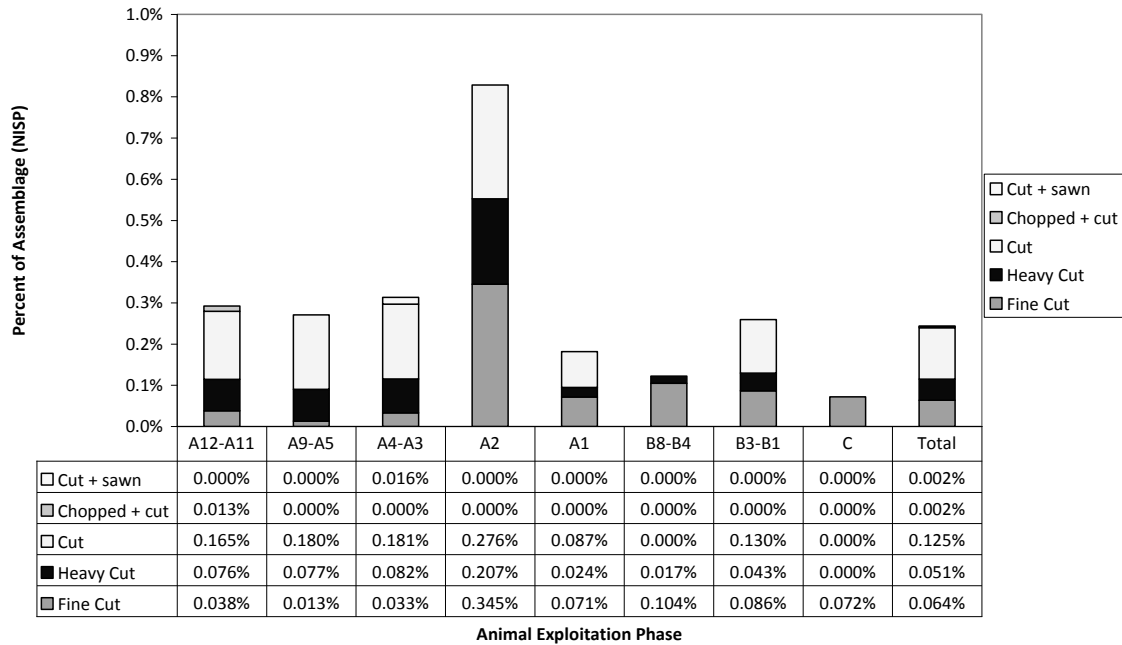


Fig 6.33: Percent of butchery marks present by animal exploitation phase

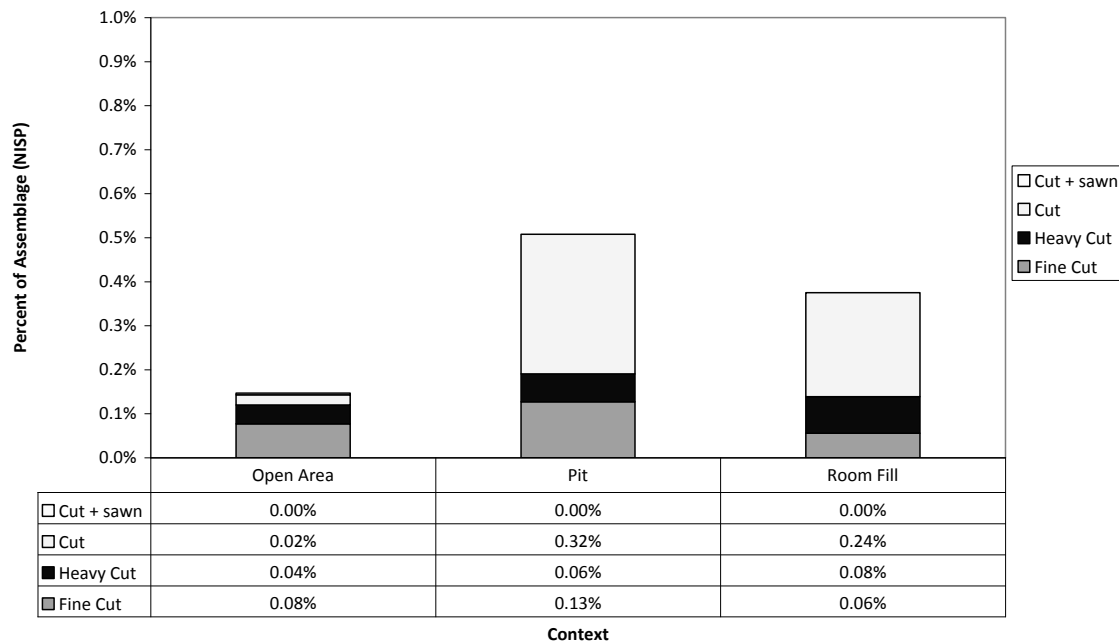


Fig 6.34: Percent of butchery marks present by context

Burnt bones were relatively rare within the assemblage with only c. 5.5% of bones showing signs of any kind of burning (fig 6.35). Levels B3-B1 had the most burnt bones, level A1 the least. A small percentage of bones were calcined (burnt at temperatures c. 645°C) suggesting that they were deliberately burnt, possibly as a form of fuel. The singed and partially burnt bones are likely to be cooking waste. The burnt bones were carbonised (c. 525°C) and are unlikely to result from cooking but were perhaps cooking waste thrown into the fire. The contexts with by far the most burnt and calcined bones were hearths, which of course fits very well with the function of these contexts. Alternatively ovens contained very few burnt bones (fig 6.36).

Summary

Fragmentation is arguably the biggest taphonomic factor at Tell Sabi Abyad. Inevitably the high levels of fragmentation decreased the number of bones that could be identified to species and element. As such only c. 40% of the bones could be fully identified. The affect of other taphonomic factors such as carnivore gnawing and burning were minor throughout the assemblage. As there was little significant difference between the taphonomy of the different animal exploitation phases and contexts, it can be relatively safely assumed that any differences between animal exploitation phases in terms of species proportions etc are real and not merely a factor of differential taphonomy.

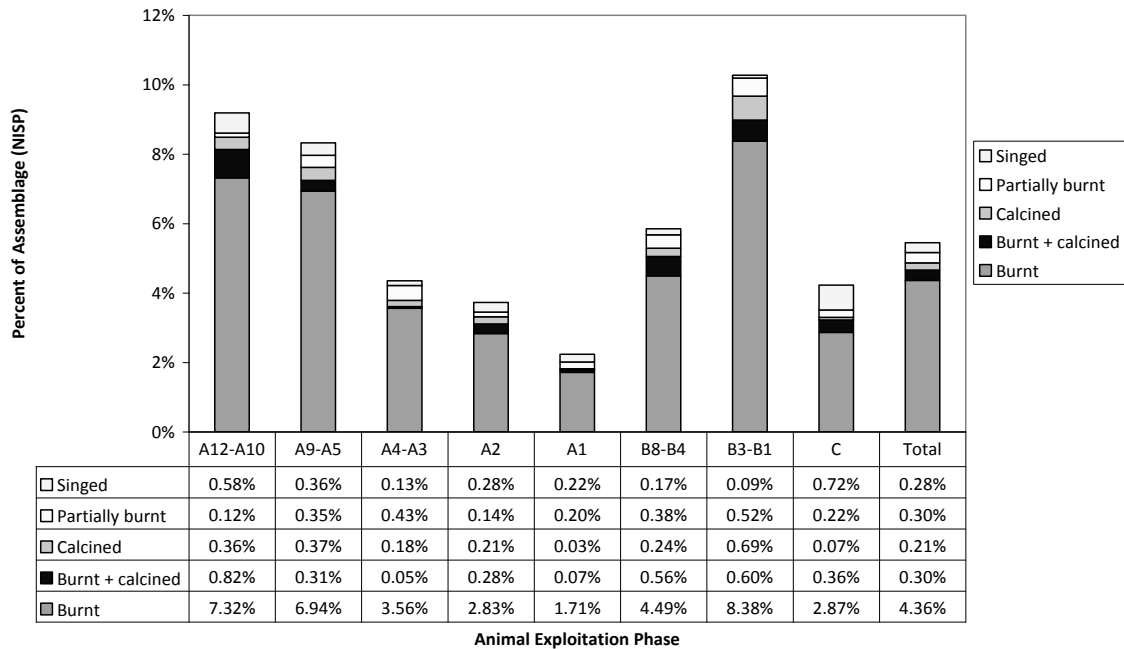


Fig 6.35: Percent of burnt bone by animal exploitation phase

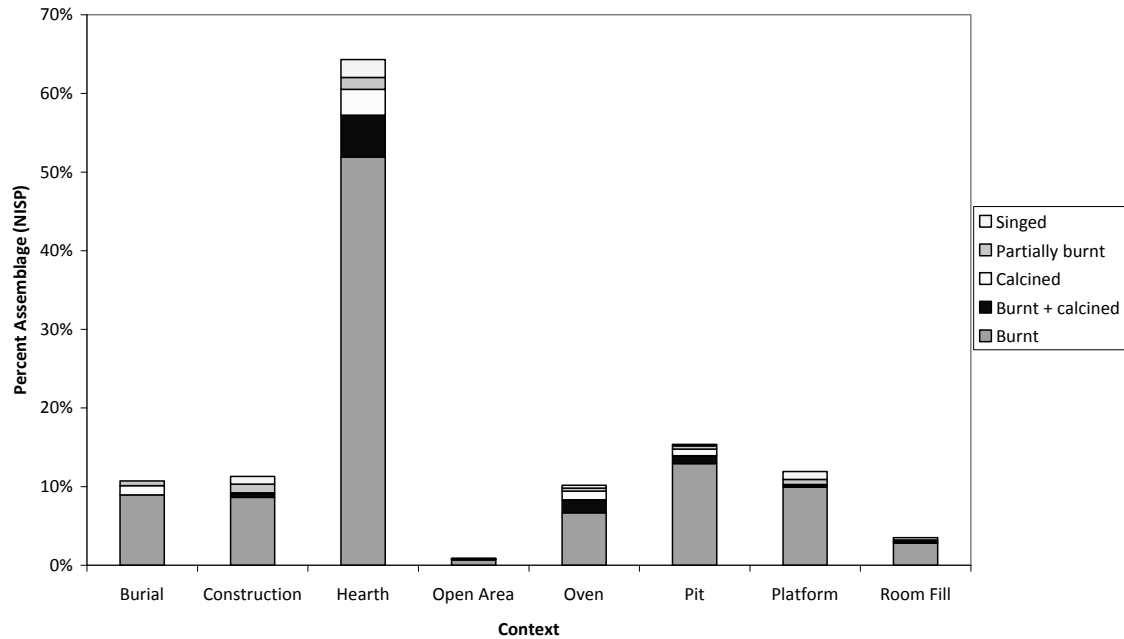


Fig 6.36: Percent of burnt bone by context

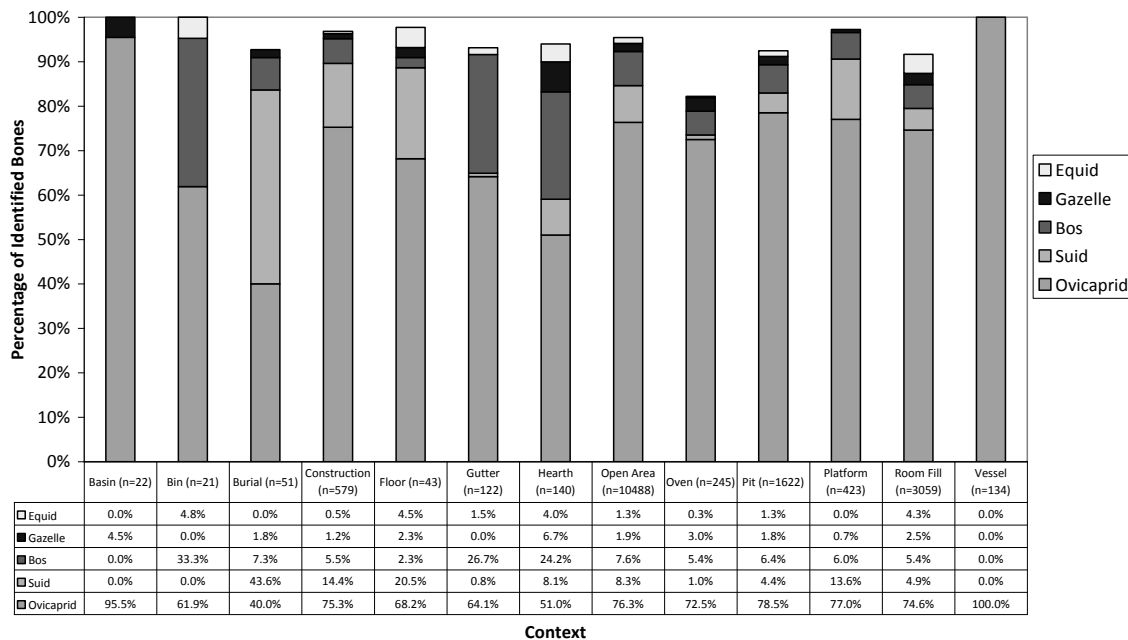
6.2.4 Animal use across the site

The bone sample was analysed by context in order to detect any spatial patterns in the material. In all phases the majority of the material was recovered from open areas, followed by room fills and pits (table 6.8). Material from room fills was most common in level A1. In levels B8-B4 the percentage of material recovered from ovens was much higher than in other phases.

Table 6.8: Proportion of assemblage by context and animal exploitation phase (percentage of total NISP)

Context	A12-A10	A9-A5	A4-A3	A2	A1	B8-B4	B3-B1	C	Site Total
Basin	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.1%
Bin	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.0%	1.9%	0.1%
Burial	0.0%	0.5%	0.0%	0.0%	0.0%	1.0%	2.6%	0.9%	0.4%
Construction	11.2%	1.3%	9.4%	0.0%	1.0%	1.5%	0.0%	4.3%	3.7%
Floor	1.3%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Gutter	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
Hearth	2.1%	1.8%	0.3%	0.0%	0.1%	0.0%	6.2%	0.0%	1.0%
Open Area	67.0%	69.5%	58.9%	67.7%	47.7%	75.2%	72.2%	71.6%	62.1%
Oven	0.0%	0.6%	0.1%	0.2%	0.7%	7.9%	0.0%	0.0%	1.4%
Pit	5.3%	7.1%	11.0%	29.4%	8.1%	8.7%	10.4%	4.5%	8.7%
Platform	11.4%	4.6%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	2.4%
Room Fill	1.6%	14.5%	20.2%	2.7%	39.0%	5.3%	8.6%	16.8%	19.0%
Vessel	0.0%	0.0%	0.0%	0.0%	2.5%	0.2%	0.0%	0.0%	0.8%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

The species proportions in each context across the site, from all levels, was analysed revealing some spatial differences in terms of species proportions (fig 6.37).

**Fig 6.37: Species proportions of the top six species by context (site total, from NISP)**

All contexts are dominated by ovicaprid remains. Burials had relatively very high proportions of sus bones present. Construction contexts (such as walls and foundations), floors and platforms also showed high proportions of sus (fig 6.37). Bos remains were well represented in hearths, gutters and bins. Comparing the dominant features of open areas, room fills and pits show that the species proportions are similar, and reflect the site total species proportions. There are however some subtle differences, namely a high proportion of equids in room fills.

The proportions of the other mammals present were also analysed by context (fig 6.38). The contexts with the largest sample sizes (open areas, room fills and pits) showed the greatest variety of species and this is

probably purely a factor of sample size. With such a limited data set it is practically impossible to see any trends in the data that would suggest any structural deposition or use of space.

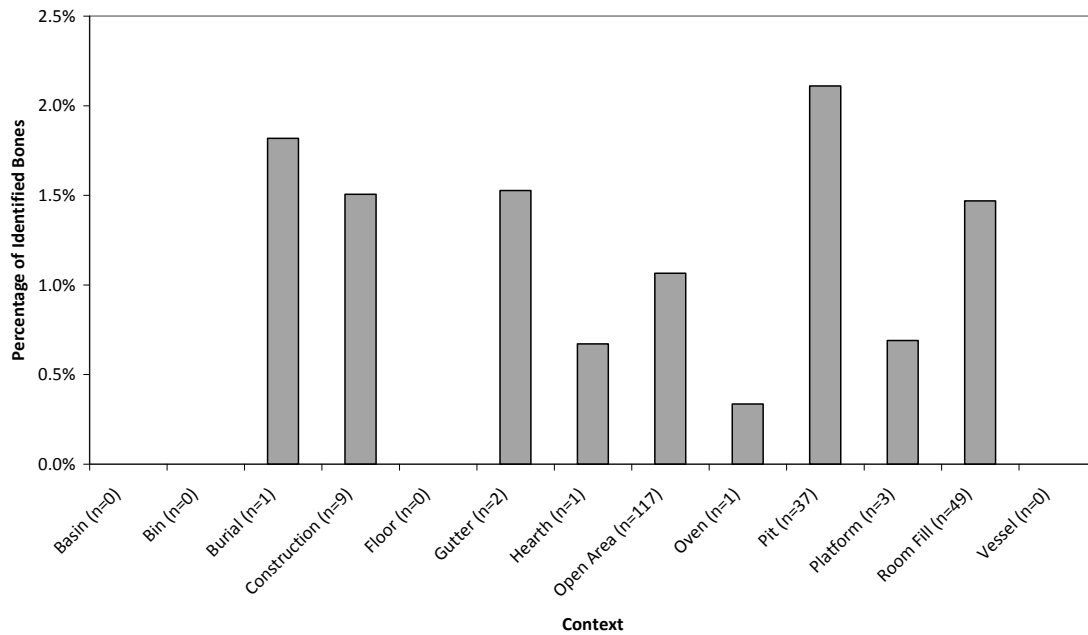


Fig 6.38: Other mammal species proportions by context (site total, from NISP)

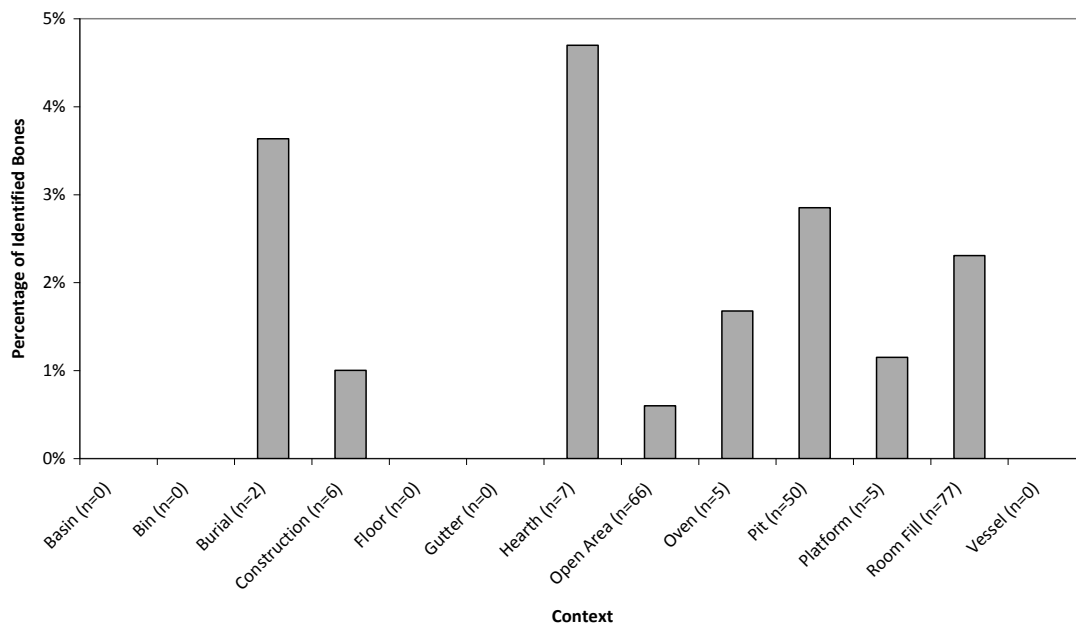


Fig 6.39: Bird species proportions by context (site total, from NISP)

In contrast to other animal groups, bird bones were rare in open areas and were far more common in pits and room fills (fig 6.39). Two associated bone groups of columbid bones, most likely representing two

complete corpses, found two large pits in level A4 dominate the bird assemblage in the pit group. The widest diversity of species was found in the room fills.

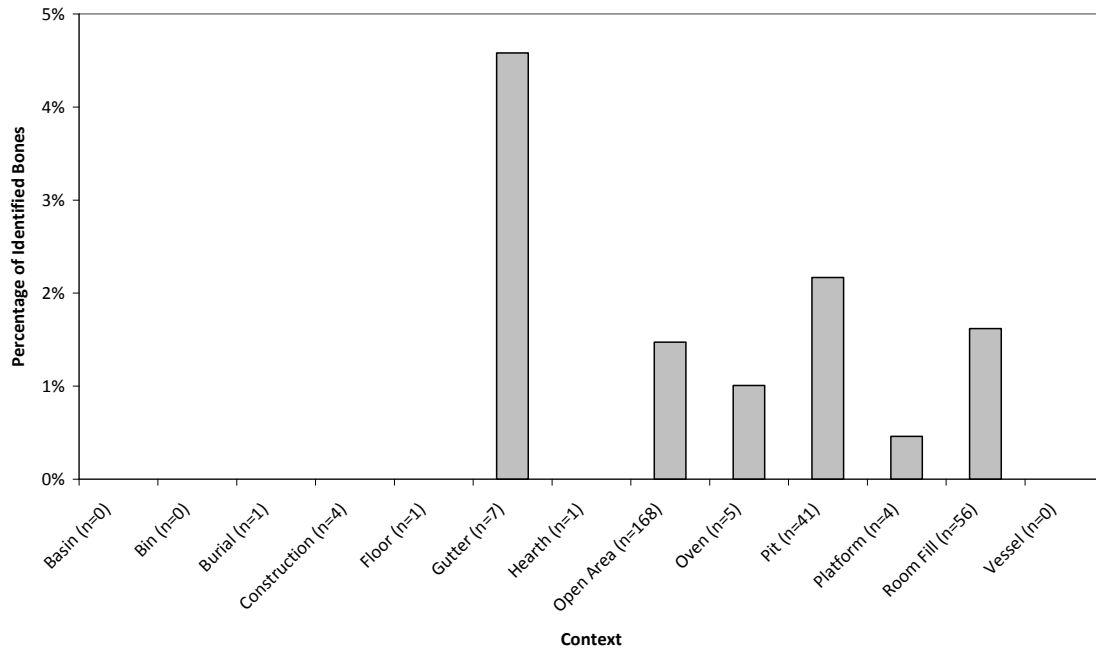


Fig 6.40: Mollusc proportions by context (site total, from NISP)

Molluscs were only found in a gutter fill, open areas, ovens, pits, platforms and room fills (fig 6.40). *Unio tigridis* was the only species found in the gutter fill with seven shells recovered. *Melanopsis costata* was the dominant mollusc species in the other features.

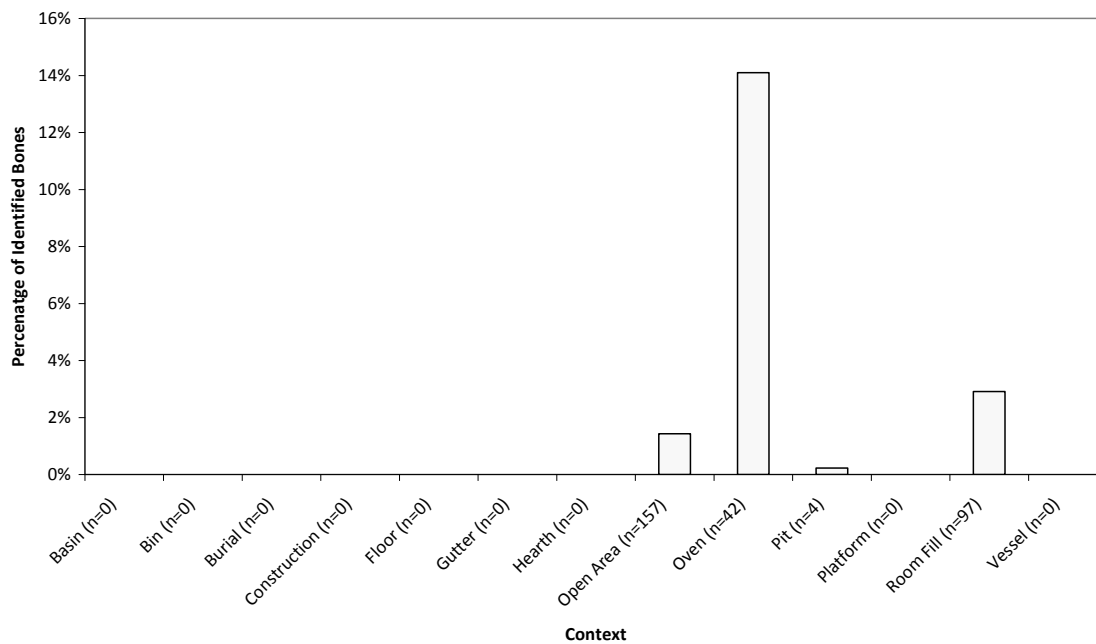


Fig 6.41: Rodent proportions by context (site total, from NISP)

The majority of rodent bones were recovered from open areas and room fills but in terms of species proportions rodents were dominant in ovens but this is due to a concentration of 42 rodent bones being found in one oven in level B5 (fig 6.41). This may be the remains of an intrusive nest.

Summary

Although there are certainly some differences in species proportions in the different contexts this seems in general to be a factor of sample size in the case of the rarer contexts. Open areas, room fills and pits show little major differences in terms of species proportions. Stratigraphic evidence suggests that houses were kept clean and the floors often re-plastered and as such any animal bones recovered in-situ were probably placed in the houses after they had been abandoned. Pits were also probably either dug for the express purpose of rubbish disposal or later reused for that function and open areas may have naturally accumulated a certain amount of household waste. All the material in this study likely represents secondary deposits of animal bone material resulting in different features being almost entirely homologous in terms of animal bones. This is discussed in more detail in chapter 8.

6.3 Ovicaprids

6.3.1 Introduction

Ovicaprids dominate the assemblage in all phases and contexts and make up 81.0% of the identified fragments analysed and 54.3% of the bone weight.

6.3.2 Sheep and goat ratios

The distinction of sheep from goat is notoriously difficult for fragmented faunal material. Species distinction of the ovicaprids was undertaken using the methods described in section 5.5 and using the statistical methods of Buitenhuis (in press) in SPSS. In total 801 ovicaprid bone fragments could be identified as sheep and 297 as goat giving a ratio of approximately 3:1 (fig 6.42). The ratio of sheep to goat varies slightly by phase but sheep remain the dominant species in all animal exploitation phases.

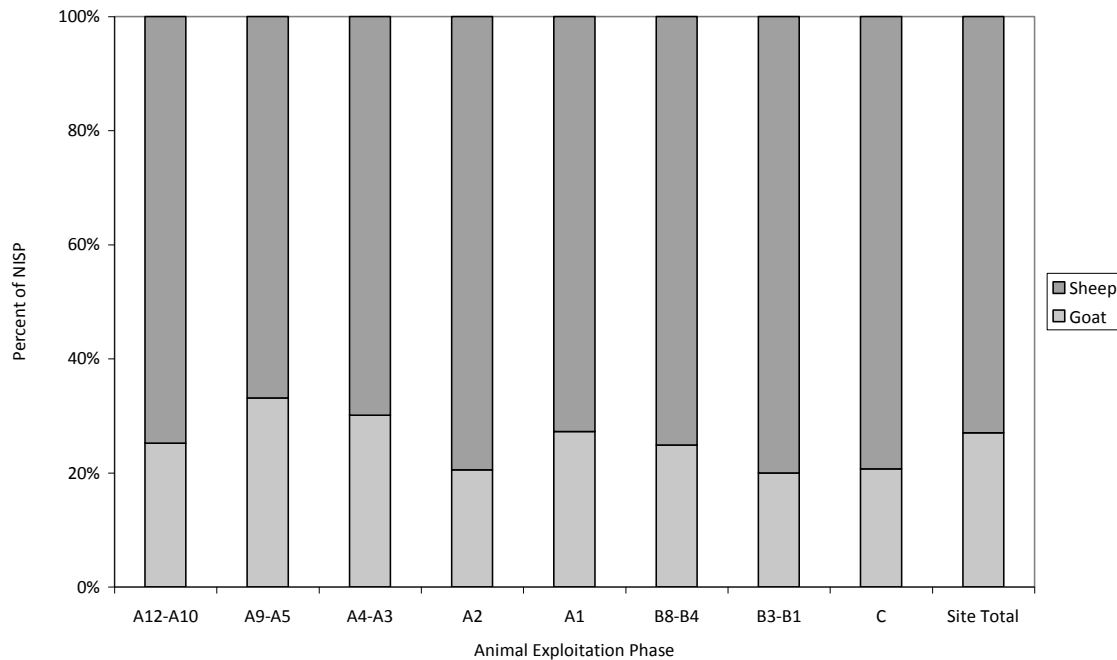


Fig 6.42: Proportions of sheep and goat in the ovicaprid assemblage by animal exploitation phase (including only those ovicaprids that could confidently be assigned as either sheep or goat)

6.3.3 Ovicaprid Proportions

Although ovicaprids remain the dominant species in all animal exploitation phases there are differences between the phases with the highest proportions present in animal exploitation phases A1 and B8-B4. Adding a trend line shows that there appears to be a slight decrease in the importance of ovicaprids through time (fig 6.43 and fig 6.44). Ovicaprids are far more important in terms of numbers (fig 6.43) than they are in terms of meat weight (fig 6.44).

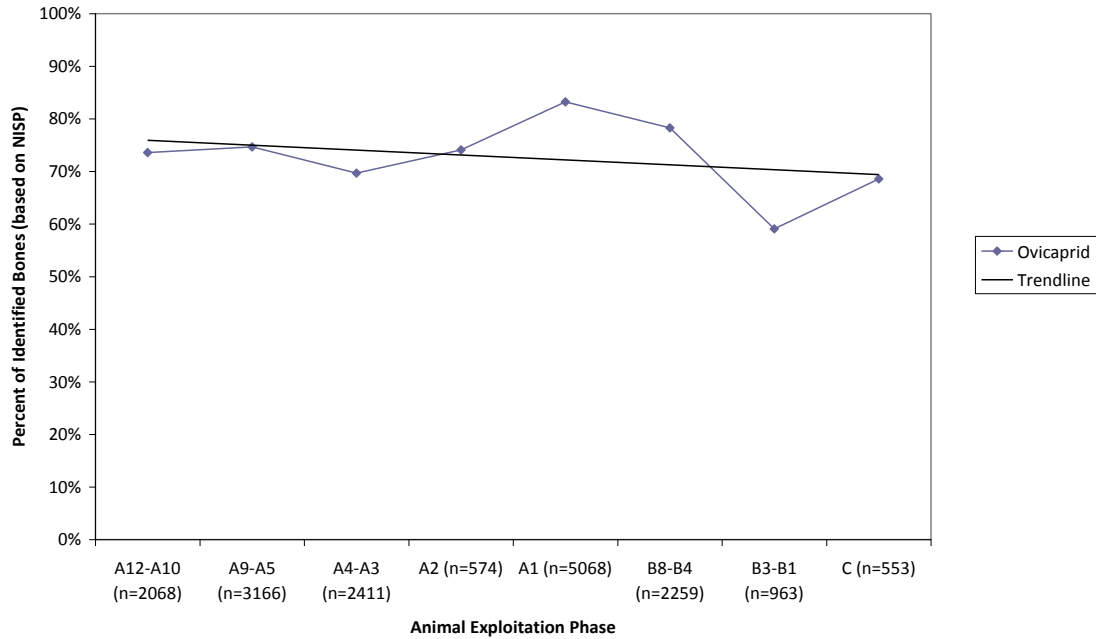


Fig 6.43: Ovicaprid proportion by animal exploitation phase based on NISP

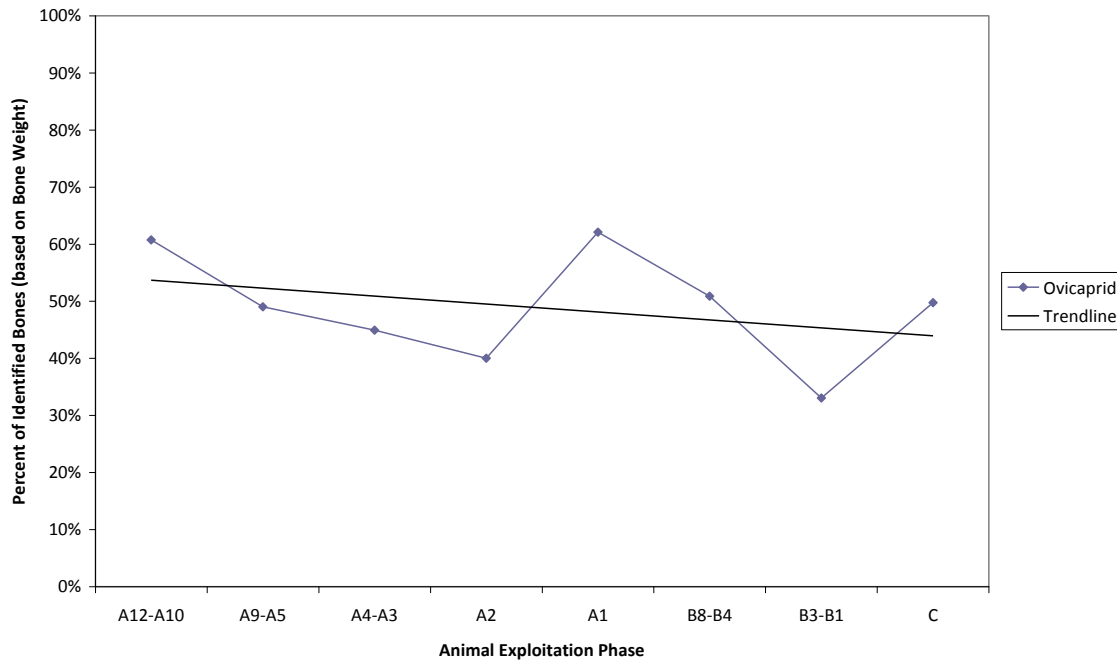


Fig 6.44: Ovicaprid proportion by animal exploitation phase based on bone weight

6.3.3 Body Part Distribution

Body part distribution was calculated using both the NISP and MNI (the Minimum Number of Individuals which was used to compensate for the bias of naturally more common bone elements in the skeleton) by both animal exploitation phase (fig 6.45 – fig 6.52) and for open areas (fig 6.53), pits (fig 6.54) and room fills (fig 6.55). Vertebrae (with the exception of the first two vertebrae the axis and atlas) and ribs were excluded because of the difficulties associated in identifying the elements to species.

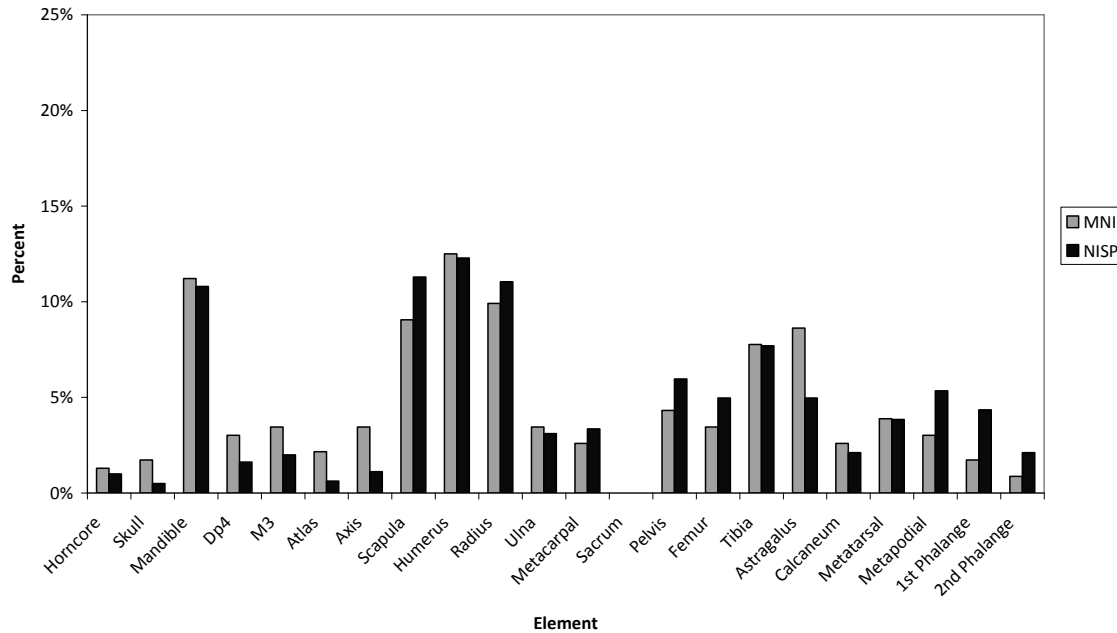


Fig 6.45: Levels A12-A10 ovicaprid body part proportions

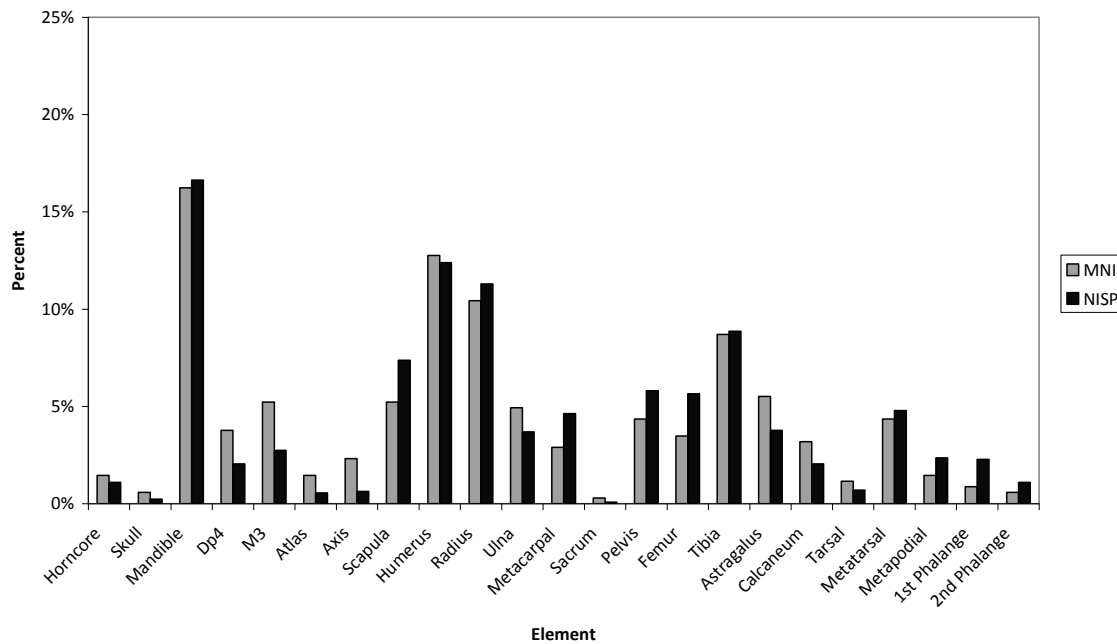


Fig 6.46: Levels A9-A5 ovicaprid body part proportions

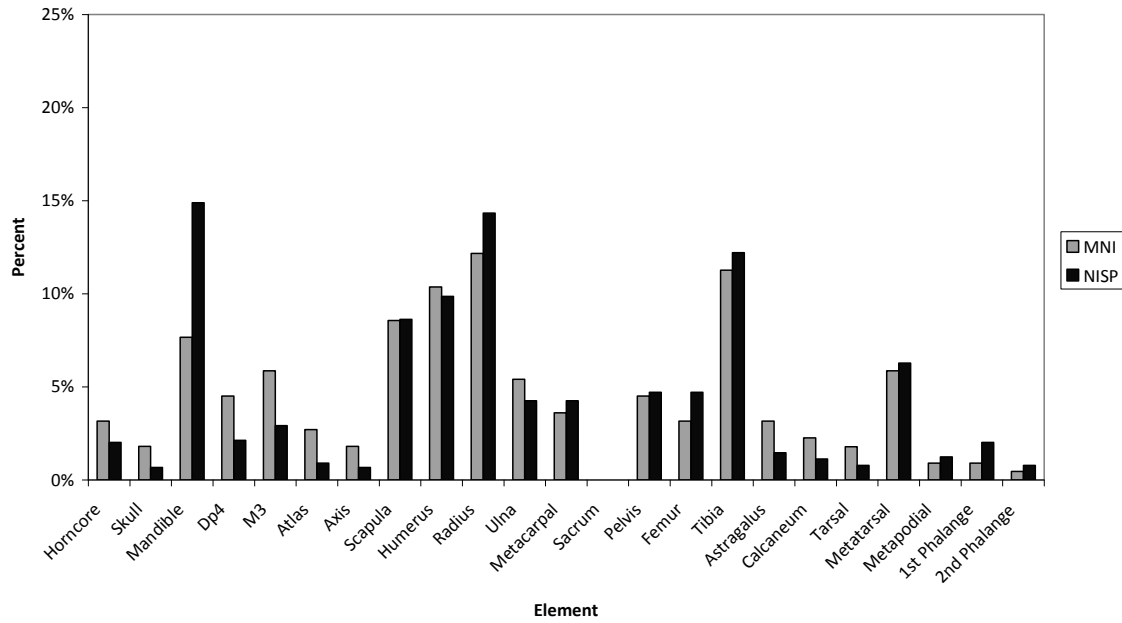


Fig 6.47: Levels A4-A3 ovicaprid body part proportions

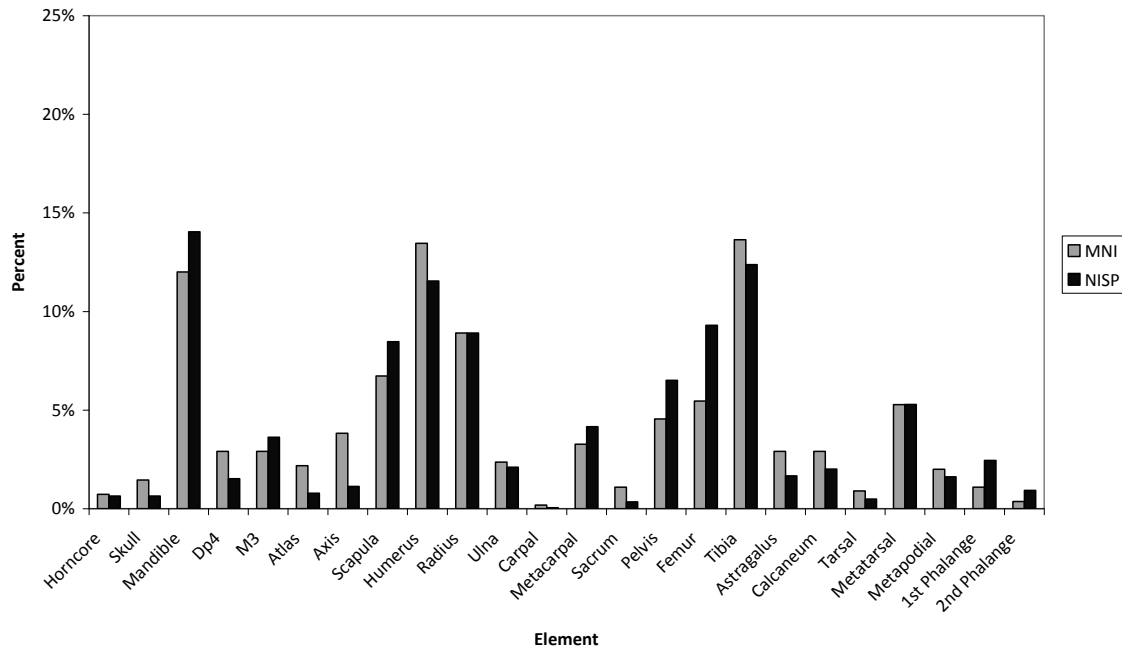


Fig 6.48: Level A2 ovicaprid body part proportions

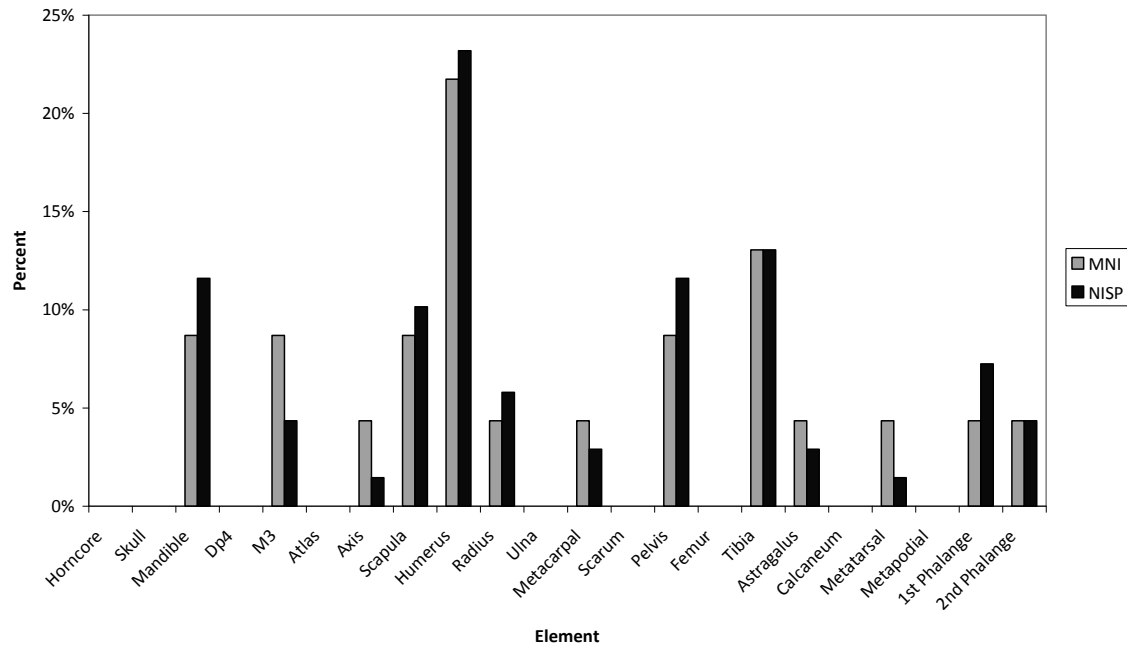


Fig 6.49: Level A1 ovicaprid body part proportions

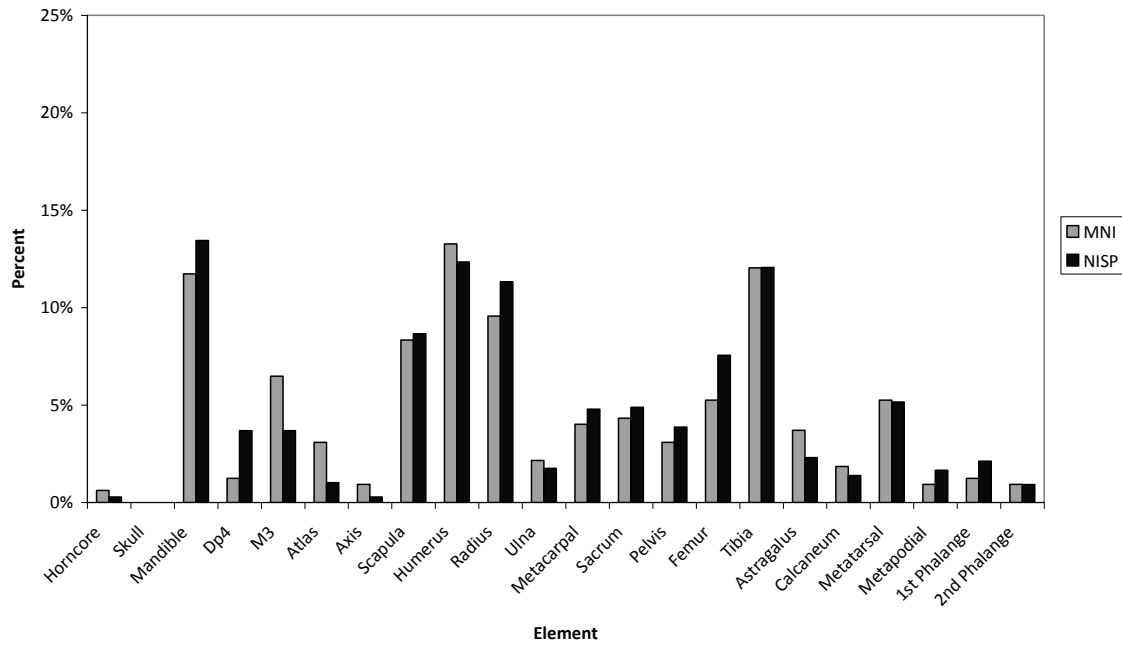


Fig 6.50 Levels B8-B4 ovicaprid body part proportions

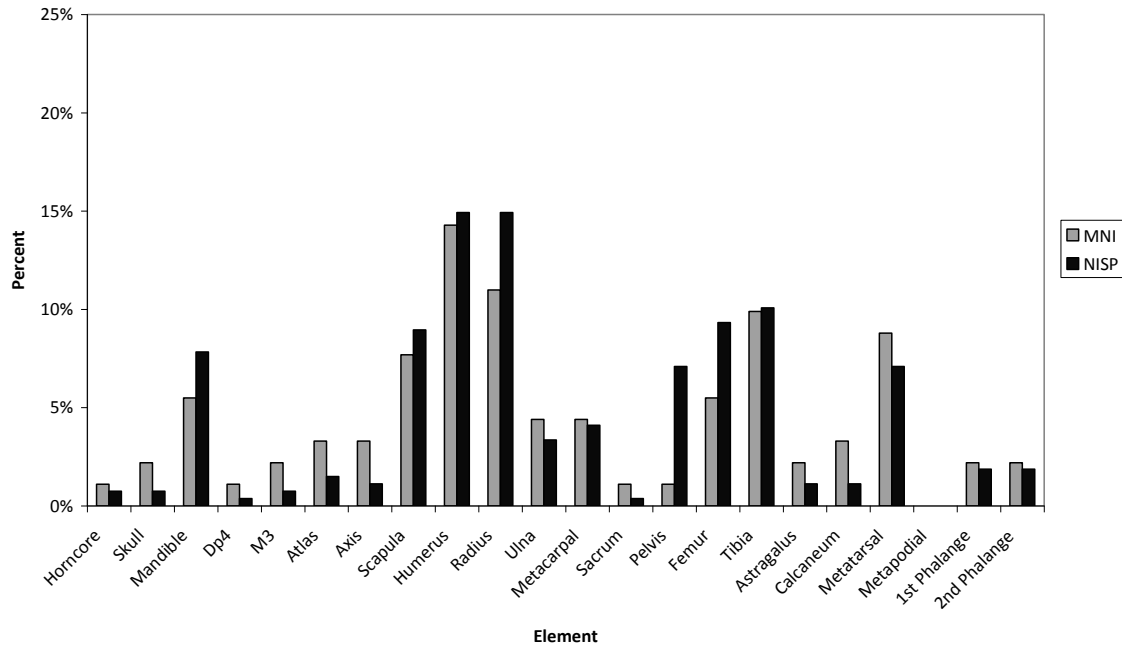


Fig 6.51: Levels B3-B1 ovicaprid body part proportions

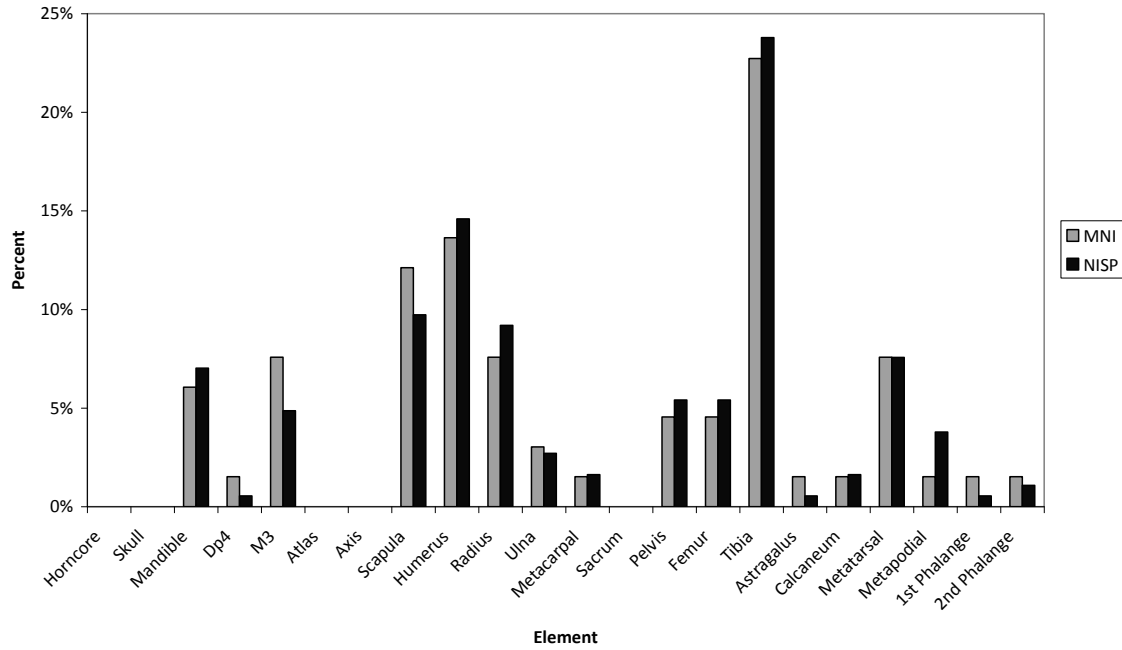


Fig 6.52: Level C ovicaprid body part proportions

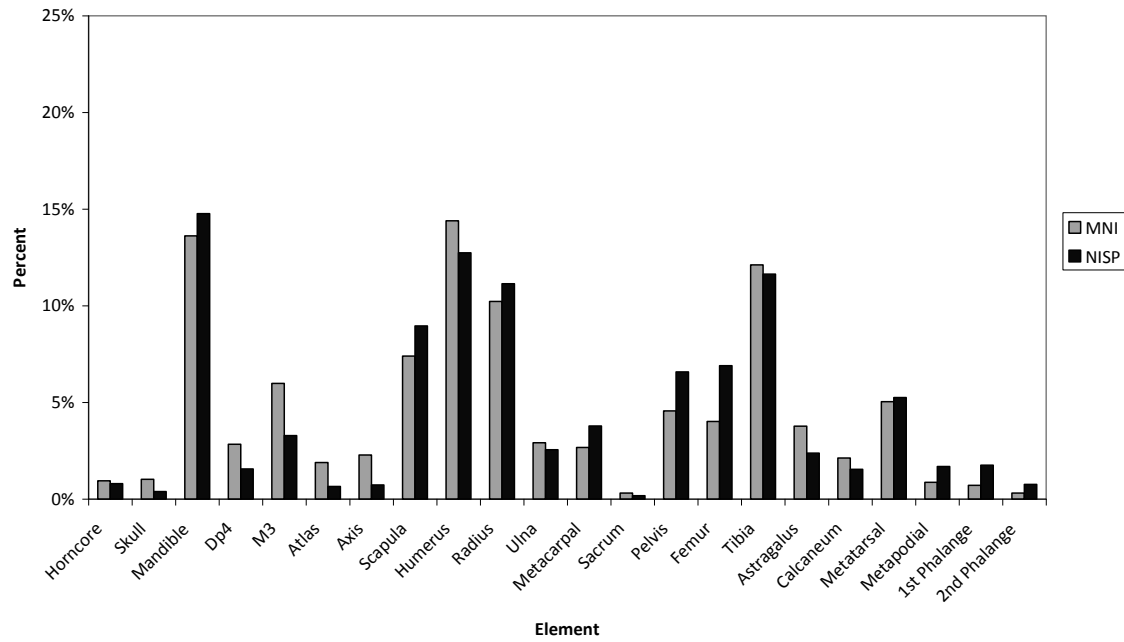


Fig 6.53: Open area ovicaprid body part proportions

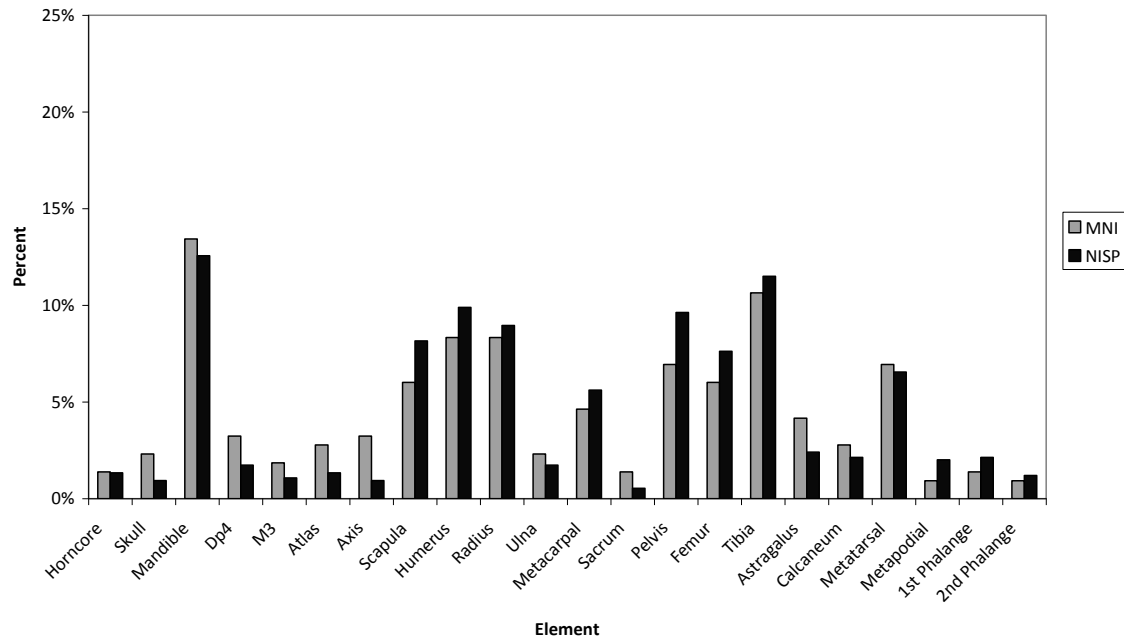


Fig 6.54: Pit ovicaprid body part proportions

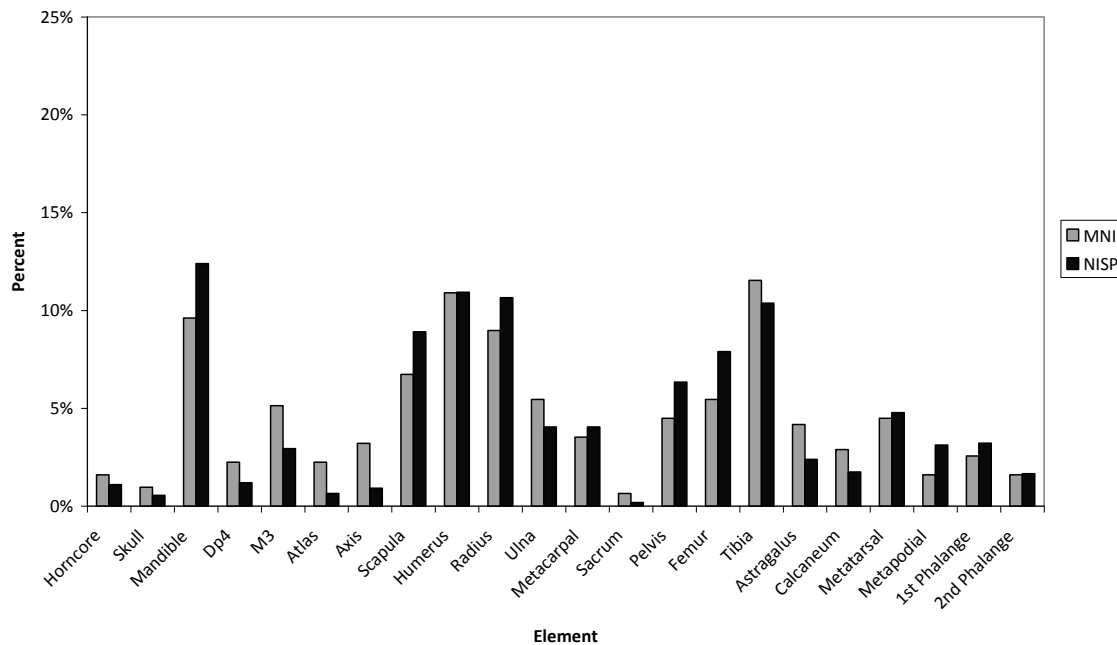


Fig 6.55: Room fill ovicaprid body part proportions

All body parts are generally represented suggesting that whole carcasses were present and processed at the site. There appears to be little difference in the body part distribution through time. There is also little difference between the contexts, which was to be expected if they all contain secondary deposits of rubbish. Both fore and hind limbs are the most common parts of the ovicaprid carcass present. There was very little difference between the NISP and the MNI plots. The phalanges of the feet, metapodials and skulls were relatively absent from the assemblage, perhaps suggesting that primary butchery waste was discarded outside of the settlement.

6.3.5 Butchery

Only 63 fragments of ovicaprid bones had butchery marks present. The location of the butchery marks is shown in figure 6.56 below. The majority of cut marks were located around the articulation of the distal humerus and the proximal radius and ulna. The location of the cut marks suggests that these marks were caused by the disarticulation and skinning of the carcass.

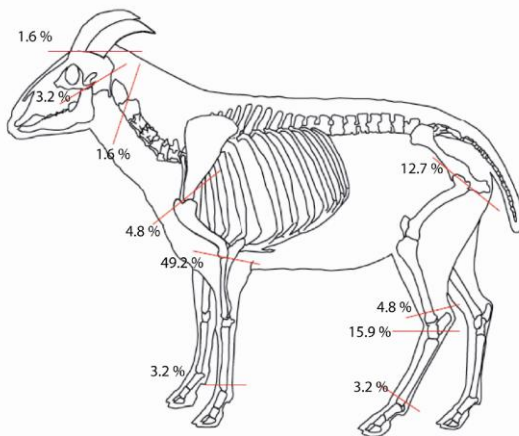


Fig 6.56: Location of butchery marks on the ovicaprid skeleton.

6.3.6 Age profiles

Age profiles were calculated using both postcranial fusion (fig 6.57 – 6.64) and mandibular toothwear (fig 6.65 – 6.72). Analysis of postcranial fusion shows that c. 90% of the ovicaprids reached up to 18 months of age in levels A12 to B1. In level C only 75% of ovicaprids reached 18 months. With the exception of levels C and A2, c. 70% of ovicaprids reached up to 30 months of age in all levels. In level A2 mortality was high with a very high proportion of neonates present compared to other levels, with only 35% of animals reaching c. 30 months and just 20% reaching up to 42 months of age. In level C the main culling age was around 18 months and there were a relatively high proportion of neonates present. In all other levels the main culling age was around 30 months of age. The proportion of animals reaching up to 42 months of age was lowest in levels A12 to A2 at c. 20-30 %, the proportion of older animals increasing to c. 40% in levels A1 to B4 and to c. 50% in levels B3 to C. In general the proportion of neonates present was low.

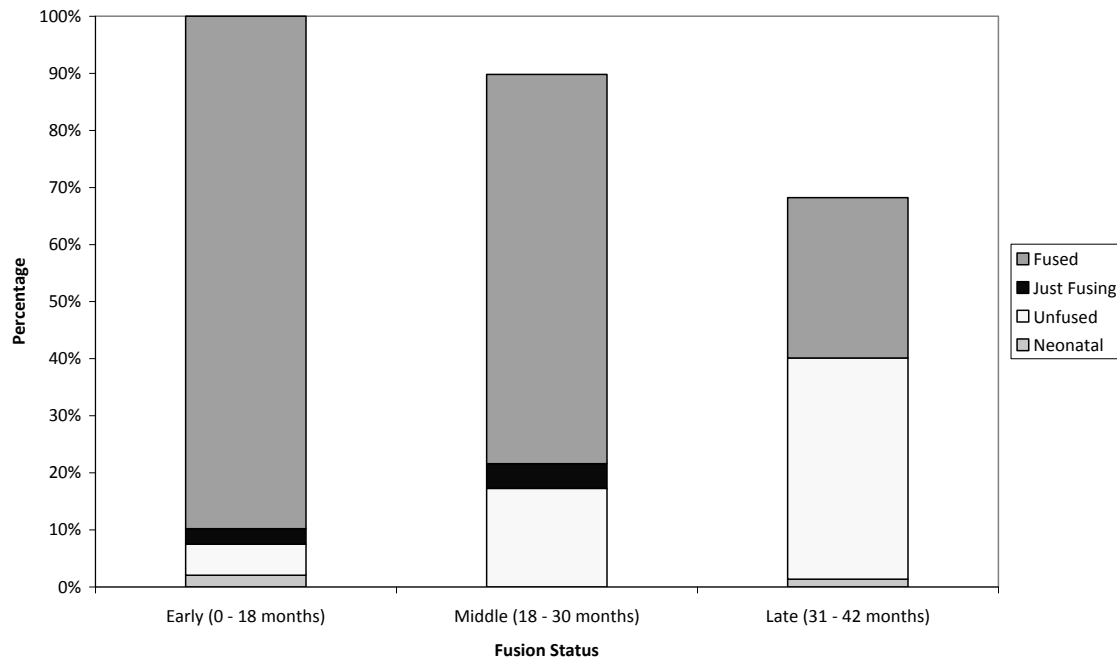


Fig 6.57: Levels A12-A10 ovicaprid age profiles from bone fusion

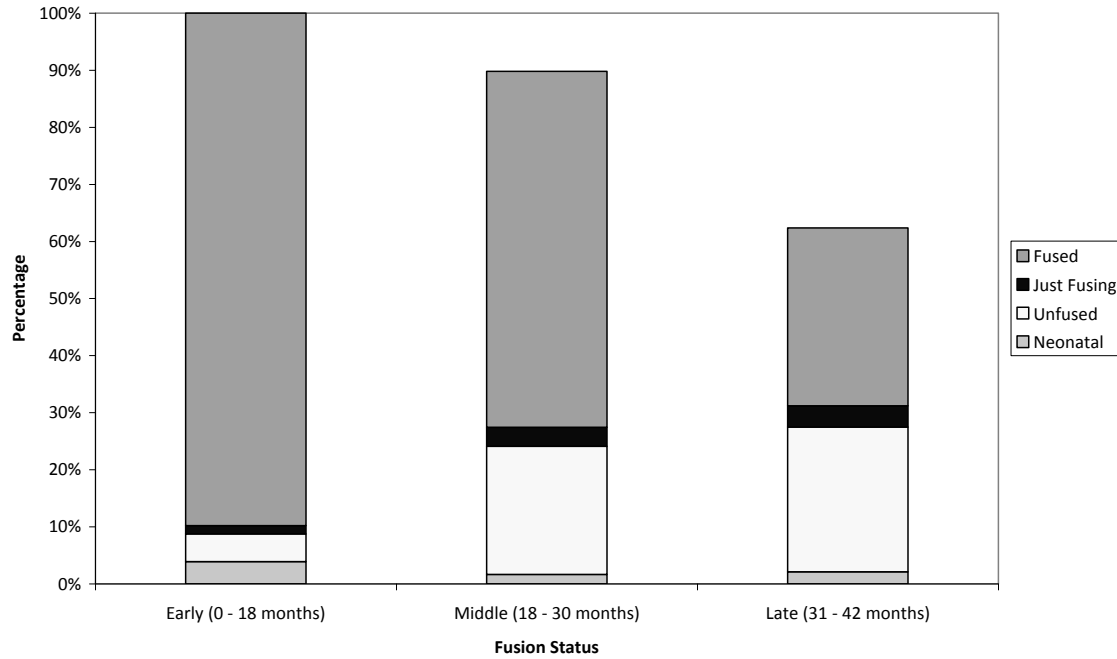


Fig 6.58: Levels A9-A5 ovicaprid age profiles from bone fusion

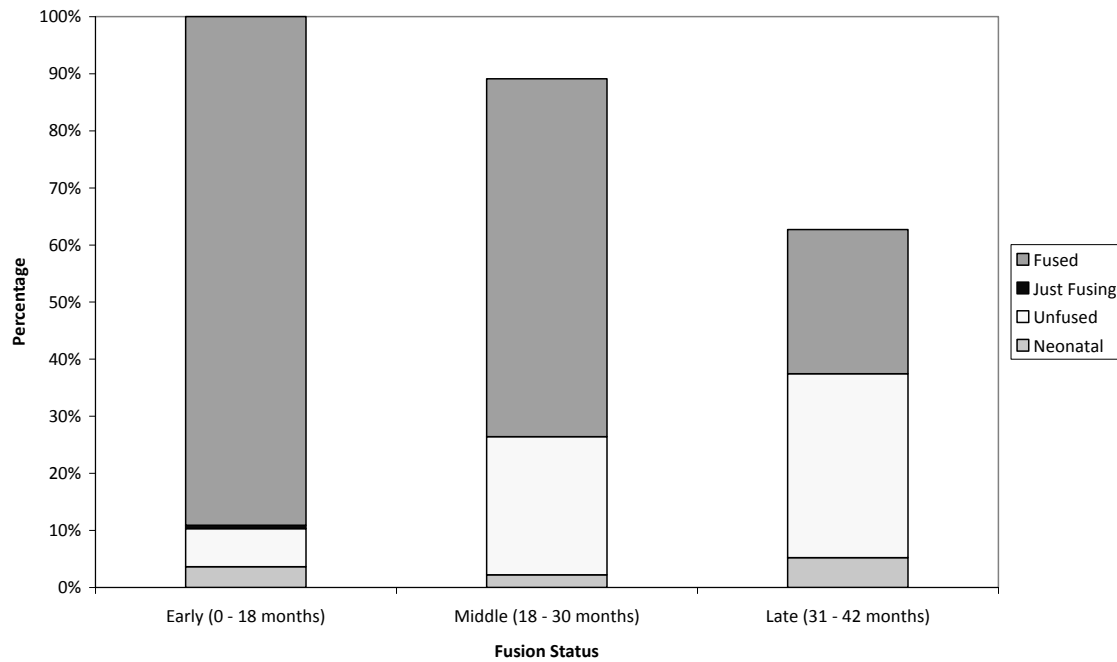


Fig 6.59: Levels A4-A3 ovicaprid age profiles from bone fusion

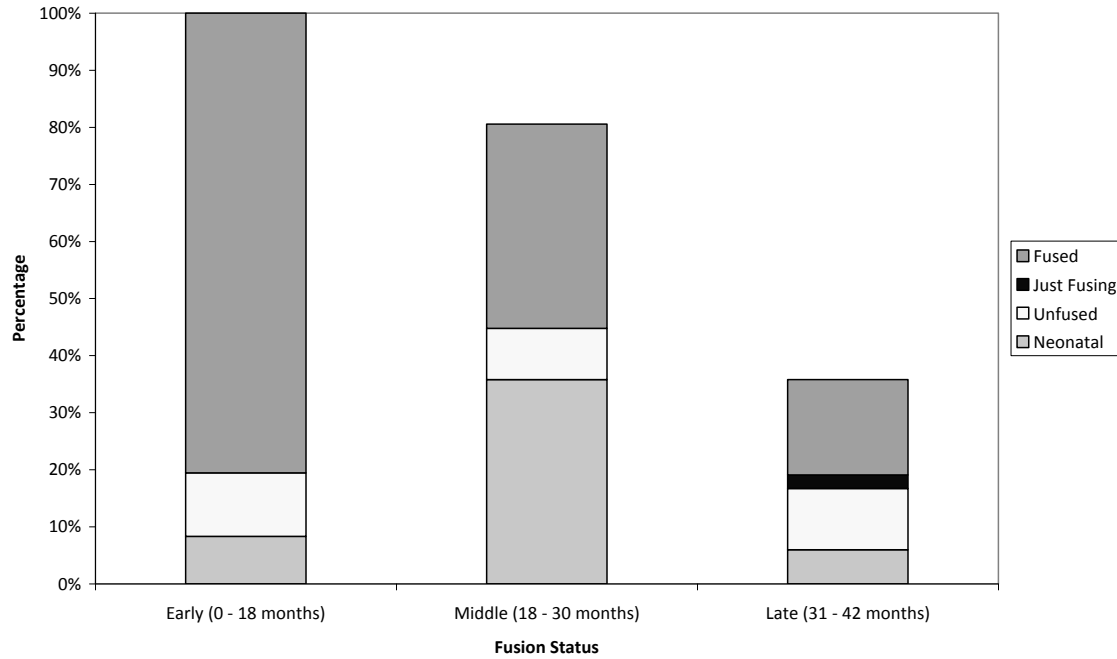


Fig 6.60: Level A2 ovicaprid age profiles from bone fusion

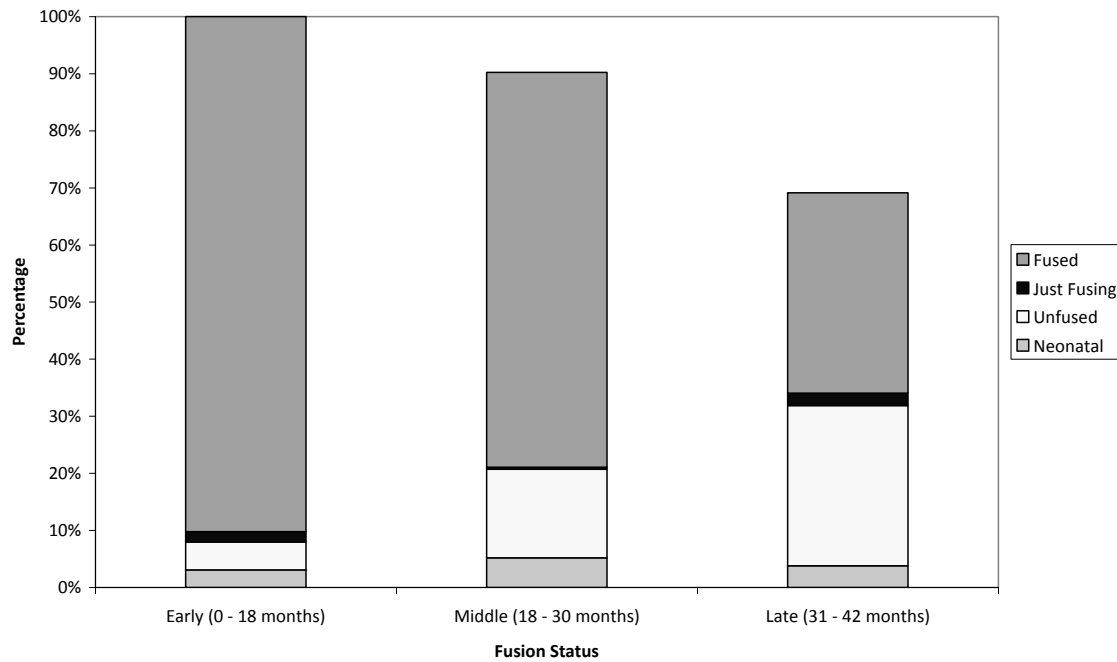


Fig 6.61: Level A1 ovicaprid age profiles from bone fusion

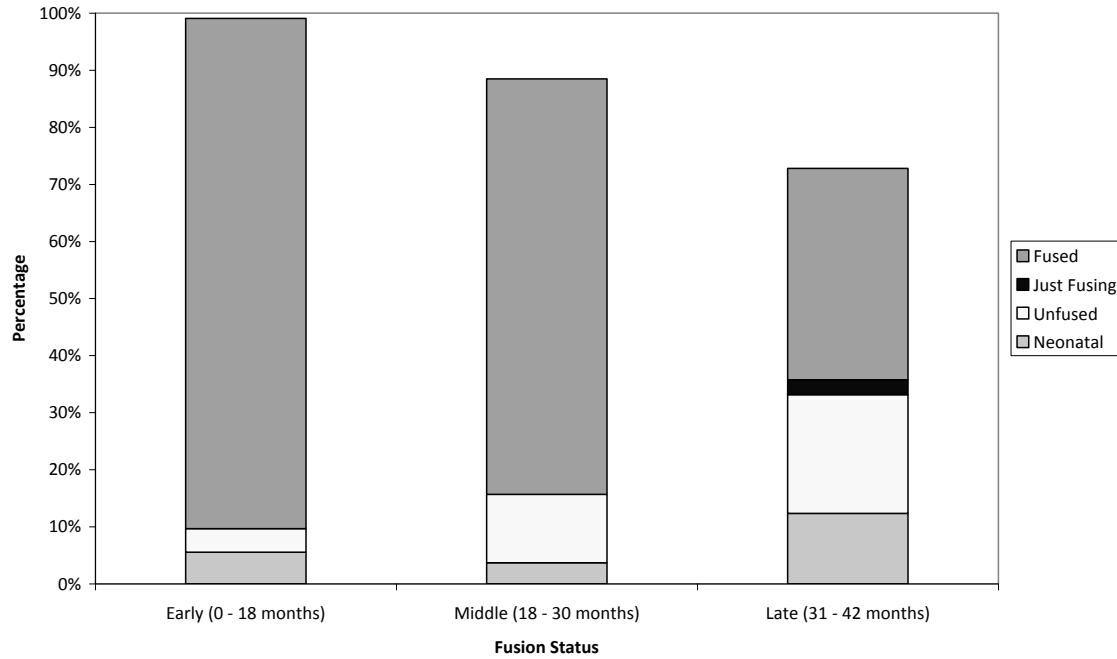


Fig 6.62: Levels B8-B4 ovicaprid age profiles from bone fusion

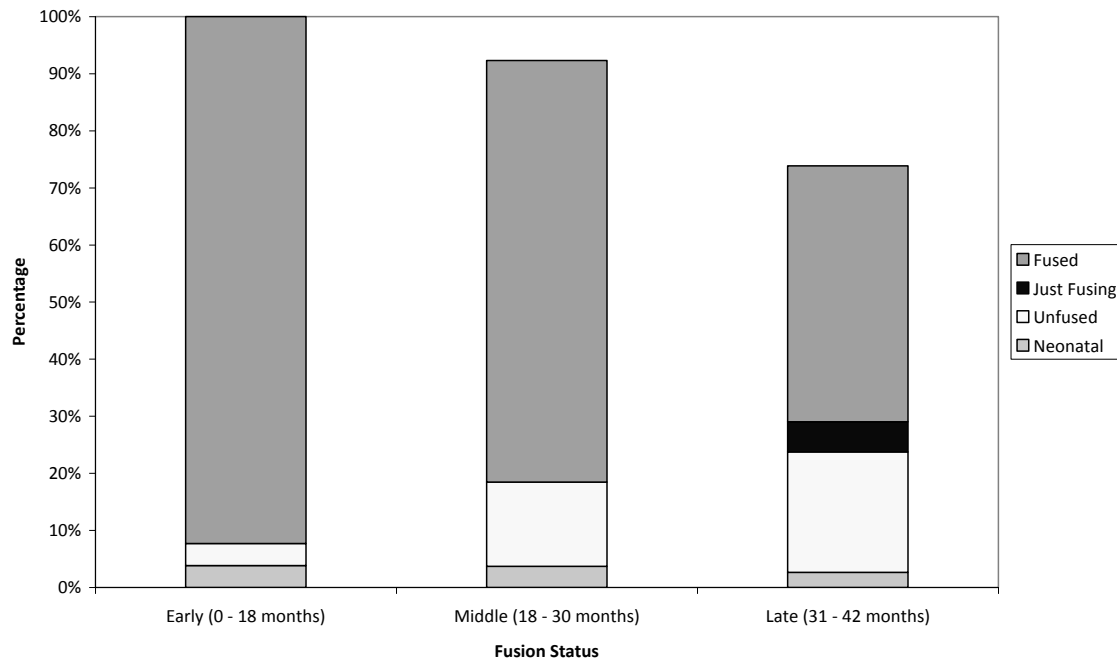


Fig 6.63: Levels B3-B1 ovicaprid age profiles from bone fusion

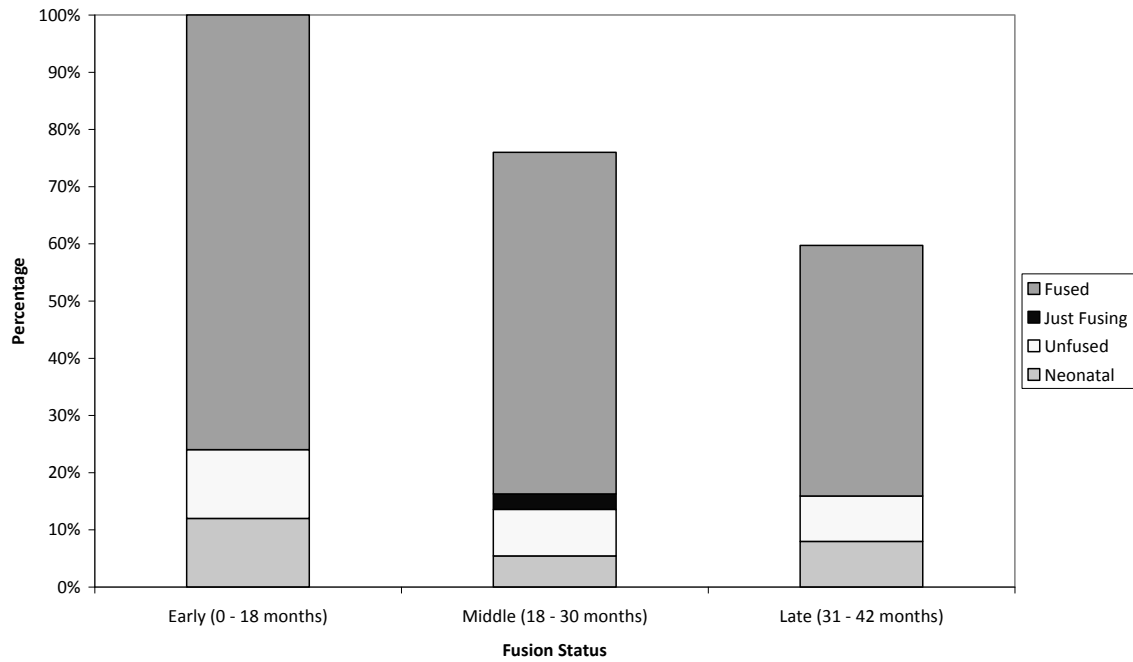


Fig 6.64: Levels C ovicaprid age profiles from bone fusion

Based on toothwear 50% of the ovicaprids were culled by c. 20 months of age in levels A12 to A2 (fig 6.65 – fig 6.68). In levels A1 to C 50% of animals lived to 30-40 months of age (fig 6.69). Neonatal mortalities were low in all phases with the exception of levels A2 and B3-B1 (fig 6.65 – fig 6.72).

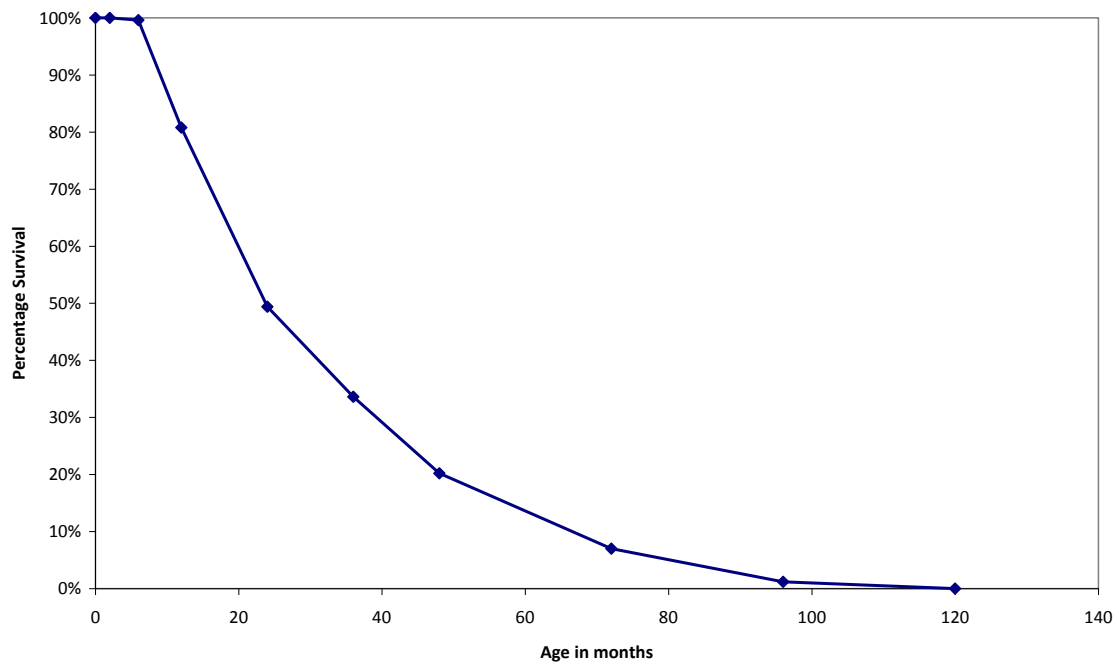


Fig 6.65: Levels A12-A10 ovicaprid mortality curve based on toothwear

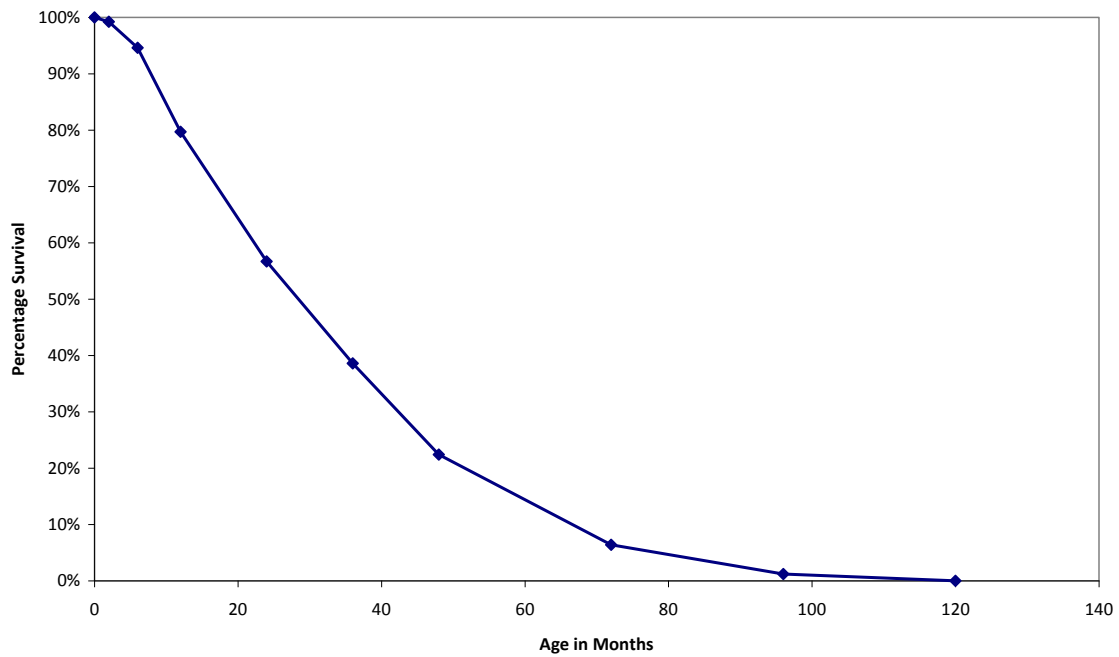


Fig 6.66: Levels A9-A5 ovicaprid mortality curve based on toothwear

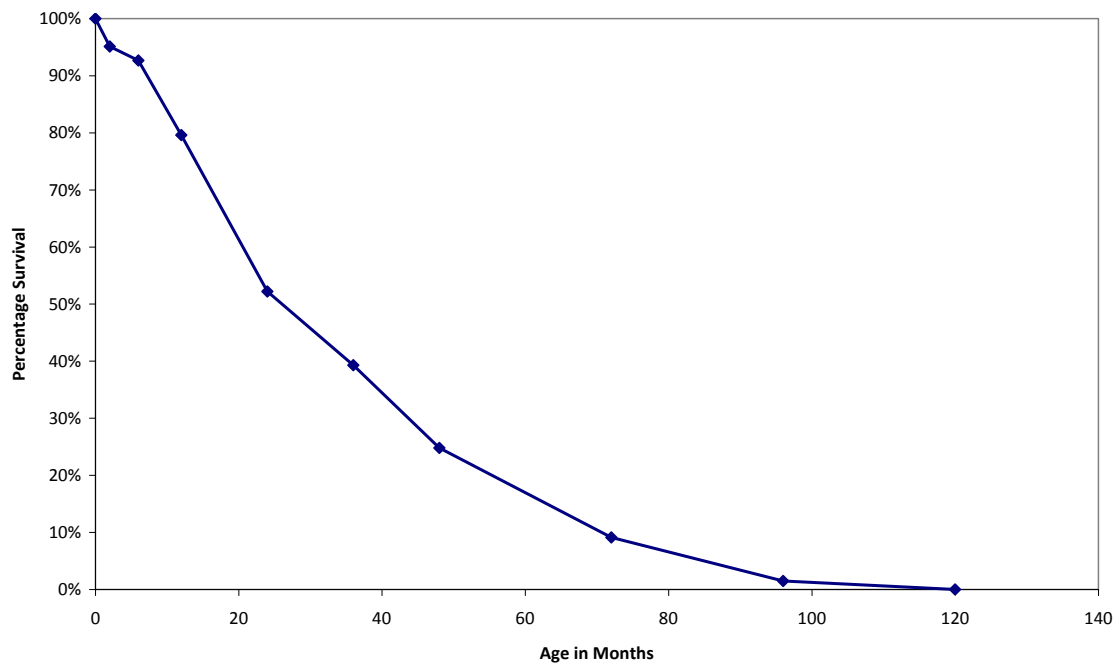


Fig 6.67: Levels A4-A3 ovicaprid mortality curve based on toothwear

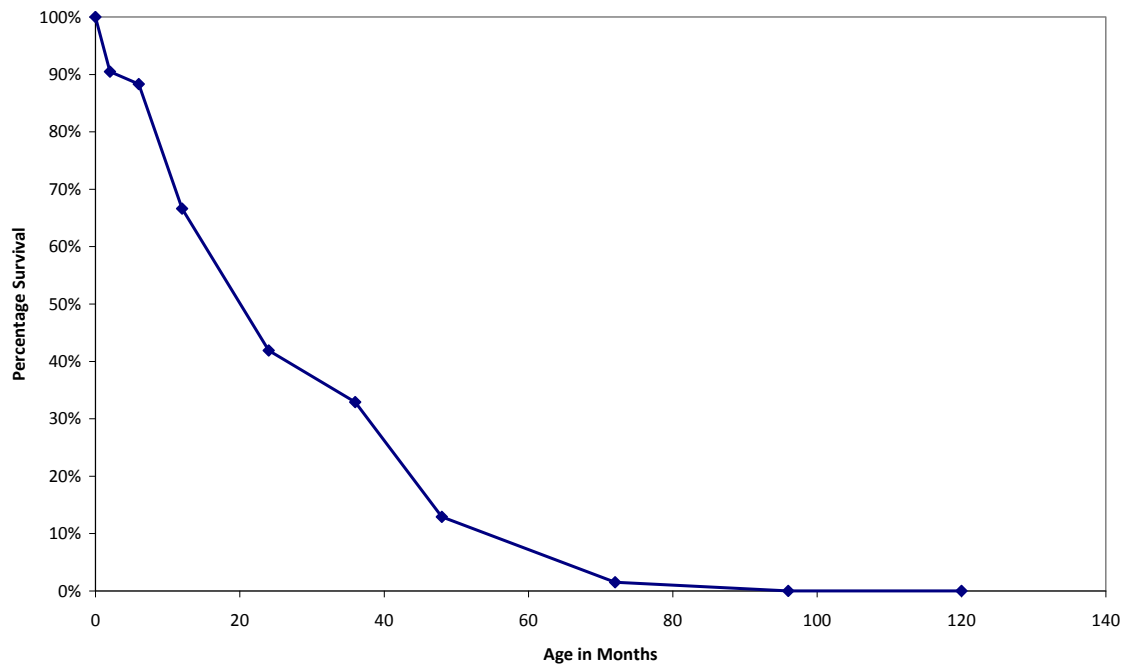


Fig 6.68: Level A2 ovicaprid mortality curve based on toothwear

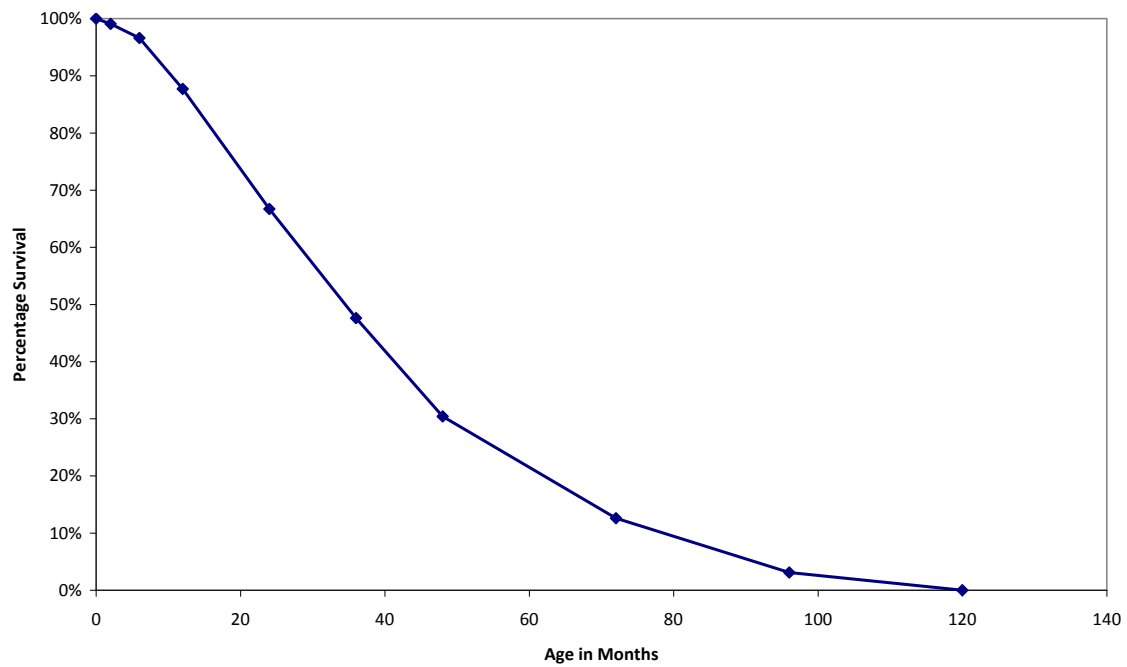


Fig 6.69: Level A1 ovicaprid mortality curve based on toothwear

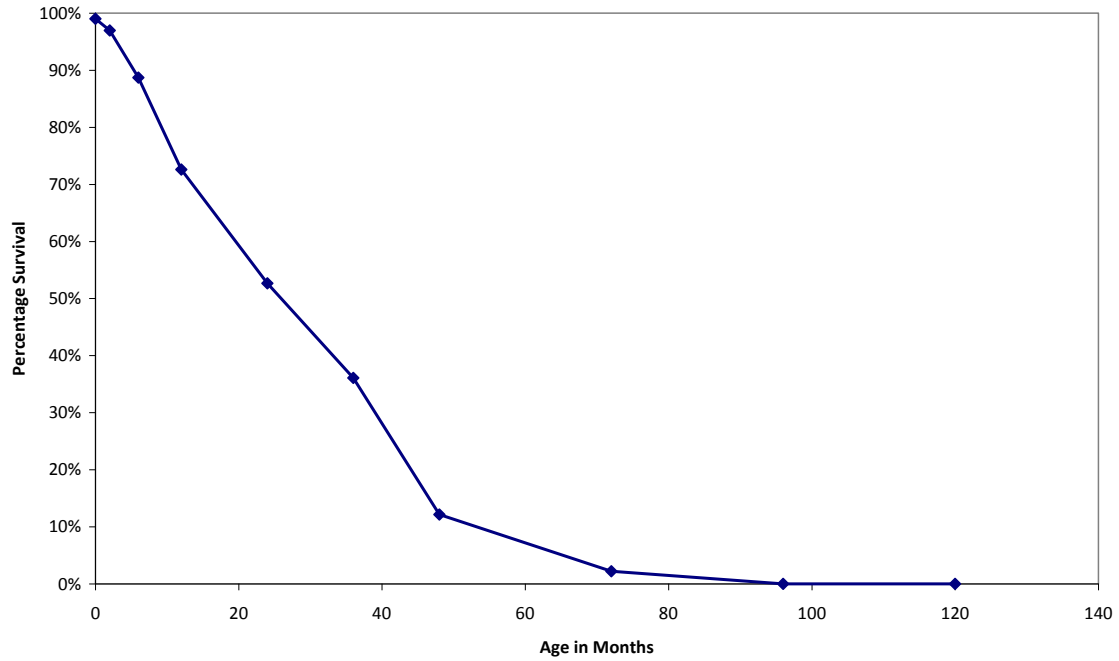


Fig 6.70: Levels B8-B4 ovicaprid mortality curve based on toothwear

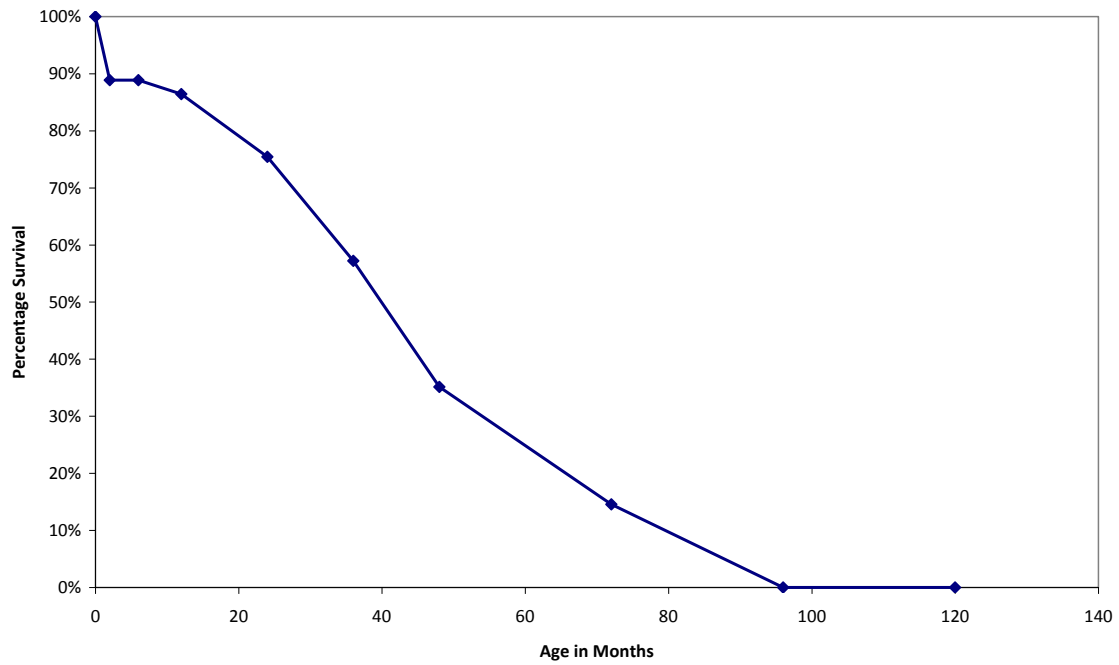


Fig 6.71: Levels B3-B1 ovicaprid mortality curve based on toothwear

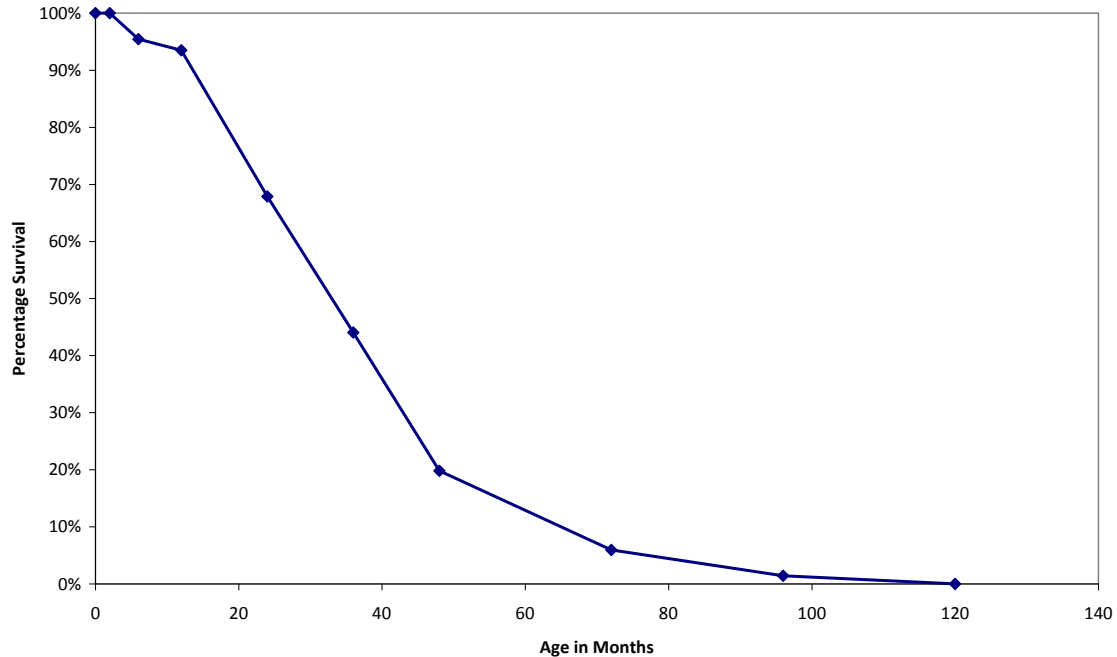


Fig 6.72: Levels C ovicaprid mortality curve based on toothwear

Both bone fusion and toothwear show similar mortality profiles for each group of levels. In general there were only subtle changes through time with a few trends appearing. Levels A12-A10 to A2 show a slightly younger culling age of approximately two years of age with very few animals over three years of age present. In levels A1 and B8-B4 the main culling age was one year later at around three years of age with more animals living up to four years of age and older. In levels B3-B1 and C this trend continues with even more animals living over four years of age but in these levels there is a relatively high neonatal mortality rate.

The mortality profiles from Tell Sabi Abyad show that in the oldest levels the main drive for ovicaprid husbandry was meat production, the majority of animals being culled at the prime meat age of two years with only a small number of breeding stock maintained. Through time there appears to be a shift to a mixed economy of both meat and secondary product production. The slight increase in neonatal mortality from levels A2 could suggest an increasing importance of milk production. The hair or fleeces of the ovicaprids may also have been important as the numbers of older animals also increased. In all levels it is apparent that the mortality profiles are derived from a domestic herd and that herd security was always of prime importance.

In addition to the mortality profiles above, those teeth and mandibles that could be positively identified as either sheep or goat were plotted separately in fig 6.73 (all the levels were combined due to the small sample size). The sample size of sheep was particularly small due to the difficulties in positively identifying ovicaprid teeth to sheep, the vast majority of teeth remained as ovicaprid with generally only the unmistakably goat teeth being identified. From the species identification based on postcranial elements we know that sheep outnumber goats and it is likely that the majority of the ovicaprid teeth are in fact sheep. The low sample size of the sheep tooththrows certainly affects the mortality curve. The goat mortality curve matches that of the ovicaprids and it can be assumed that both the sheep and goats underwent the same form of management and animal husbandry.

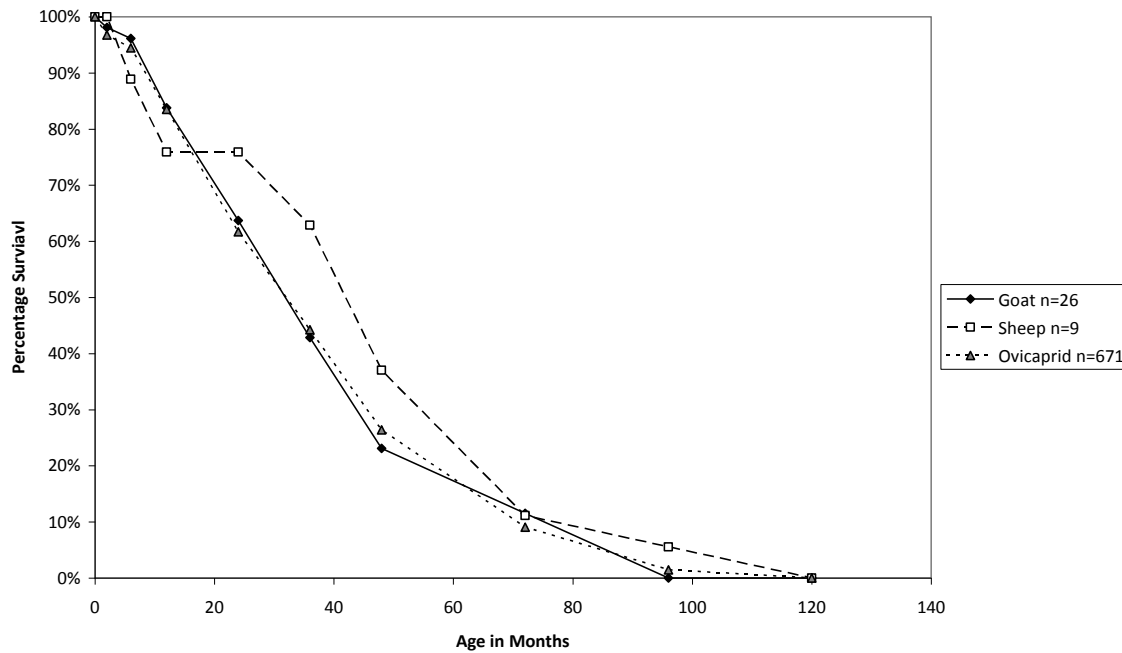


Fig 6.73: Sheep versus goat mortality curve based on toothwear

6.3.7 Pathology

Nineteen ovicaprid bone fragments showed signs of pathology, the majority of which were dental pathologies such as periodontal disease (an infection of the alveolar bone and adjacent tissues) with several abscesses formed (table 6.9). The poor condition of ovicaprids' mouths is ubiquitous in archaeological material from all periods and locations and sheep are still notoriously susceptible to tooth infections today (Iles and Clark, 2005). Animals with dental problems do not thrive but the prevalence of dental pathologies at Tell Sabi Abyad is very low. One non-metric trait was discovered in the jaw of one ovicaprid; the hypocunulid (3rd cusp) of the lower third molar failed to develop. This is a congenital abnormality and occurs in many populations of ovicaprid. Osteoarthritis, or degenerative joint disease, was noted in three cases. This inflammation of the joint can result from trauma as well as bone and joint infections or simply as a result of ageing. Other pathological conditions include periostitis and irregular bone growth. One young individual had two 1st phalanges fused to a metapodial perhaps as a result of some kind of trauma to the area.

Table 6.9: Ovicaprid pathologies

Levels	Species	Element	Pathology	Notes
A11	Ovicaprid	1st Phalanx	Bones fused together	Fused to adjacent 1st Phalanx and Metapodial
A11	Ovicaprid	1st Phalanx	Bones fused together	Fused to adjacent 1st Phalanx and Metapodial
A11	Ovicaprid	Metapodial	Bones fused together	Fused to both 1sts Phalanges
A11	Ovicaprid	Mandible	Tooth wear	Assymetrical tooth wear
A10	Ovicaprid	Mandible	Periodontal disease	Swollen alveolar margins and abscess
A10	Ovicaprid	Metacarpal	Indeterminate	Pitting on the proximal epiphysis
A7	Ovicaprid	Humerus	Arthritis	Severe; eburnation of fossa olecranon and bone growth around lateral condyle
A6/A7	Ovicaprid	Metacarpal	Indeterminate	New bone growth around the proximal epiphysis
A5	Ovicaprid	Mandible	Periodontal disease	Swollen alveolar margins
A5	Ovicaprid	Mandible	Dental disease	Loss of P4 and M1; new bone growth
A5	Ovicaprid	Metacarpal	Arthritis	Eburnation on the distal condyles
A2	Ovis	Radius	Arthritis	Osteophytes present on the lateral side of the proximal epiphysis
A2	Ovicaprid	Calcaneum	Periostitis	Around articular surface
A2	Ovicaprid	Mandible	Periodontal disease	Swollen alveolar margins
A2	Ovicaprid	Mandible	Periodontal disease	Swollen alveolar margins
A2	Ovicaprid	Mandible	Periodontal disease	Swollen alveolar margins
A2	Ovicaprid	Mandible	Congenital	Congenital absence of 3rd cusp on M3
A1	Ovicaprid	Mandible	Periodontal disease	Abscess
B7/B8	Ovicaprid	Radius	Exocytosis	Plate of bone growth under lateral proximal epiphysis

6.3.8 Metrical analysis

During the recording of the Tell Sabi Abyad material measurements were taken where possible. For a full list of the measurements taken see appendix 1.

Among the most common measurements taken were the Bd (greatest breadth of the distal end) and BT (breadth of the trochlea) of the distal humerus. The Bd and BT measurements from the humeri identified as ovis from Tell Sabi Abyad were compared to modern wild specimens of *Ovis orientalis* (Buitenhuis, *per comms*. See appendix 2) in figure 6.74.

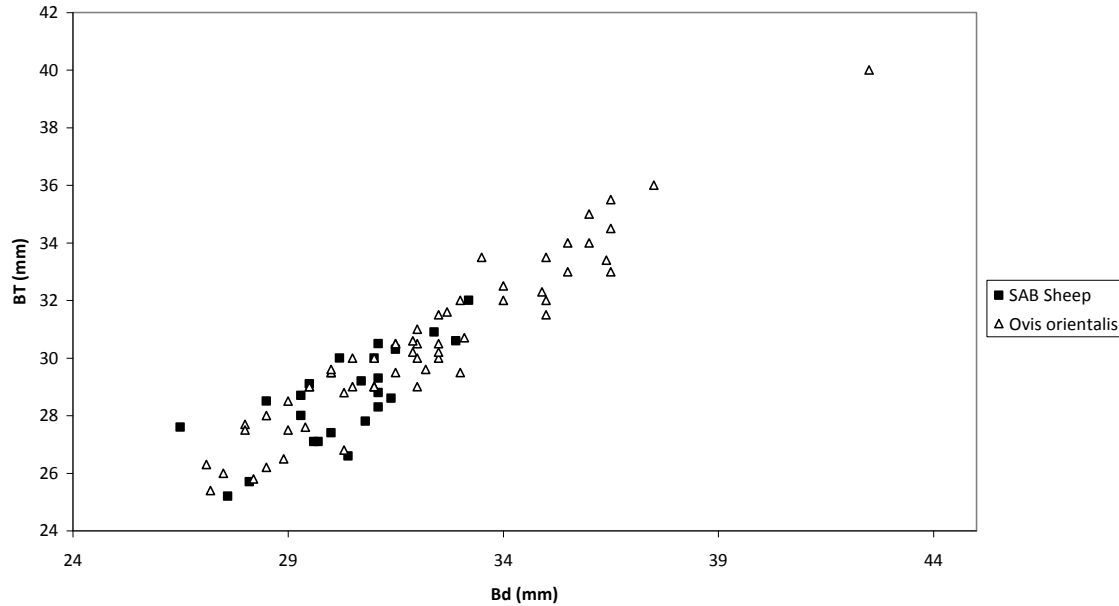


Fig 6.74: Comparison of Tell Sabi Abyad (SAB) sheep to modern *Ovis orientalis* – Correlation between Bd and BT humeri measurements.

This shows that all the Tell Sabi Abyad sheep fit within the range of the modern wild specimens but they all fall within the lower end of the spectrum. This fits with the interpretation that all the ovicaprids were domestic (based on mortality profiles above). This suggests that the Tell Sabi Abyad sheep were the size of small wild *Ovis orientalis* and were probably mostly females.

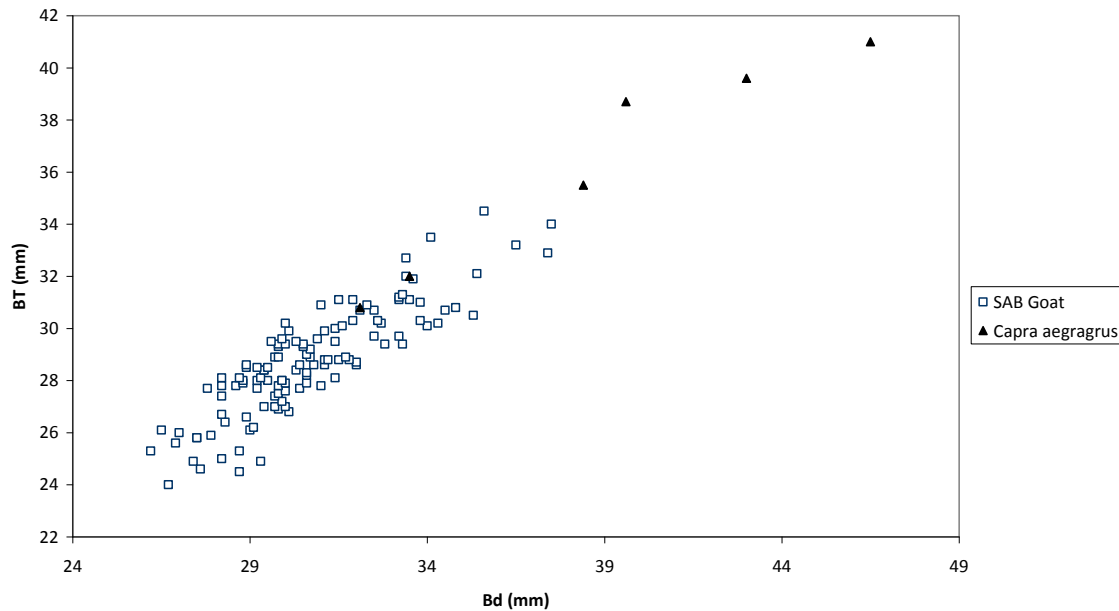


Fig 6.75: Comparison of Tell Sabi Abyad (SAB) goat to modern *Capra aegagrus* – Correlation between Bd and BT humeri measurements.

A similar analysis was carried out for the goats at Tell Sabi Abyad (fig 6.75). This shows that all the Tell Sabi Abyad goats were small when compared to wild specimens of *Capra aegagrus*, falling at the very bottom of the wild size spectrum and well below it. This suggests that all the goats at Tell Sabi Abyad were domestic and far smaller than their wild progenitors. This is to be expected as the natural range of *Capra aegagrus* does not extend to the Jazirah and this is not an optimum environment for this species.

The ovicaprids that could not be identified as either sheep or goat were compared to the reference wild species (fig 6.76) showing that the majority of ovicaprids sat in the range of the smaller wild *Ovis orientalis* and are likely, in the majority, to belong to the ovis species.

Finally, the Bd and BT measurements of the Tell Sabi Abyad ovicaprids (assumed to be mostly sheep) and sheep were compared to *Ovis orientalis* of known sex (fig 6.77). This shows that the majority of the Tell Sabi Abyad sheep were female with only a few individuals, which likely represent either wild females or domestic males, fitting into the crossover of wild male and female ranges. If we assume all the sheep at Tell Sabi Abyad are domestic this gives a rough sex ratio of four females to every male.

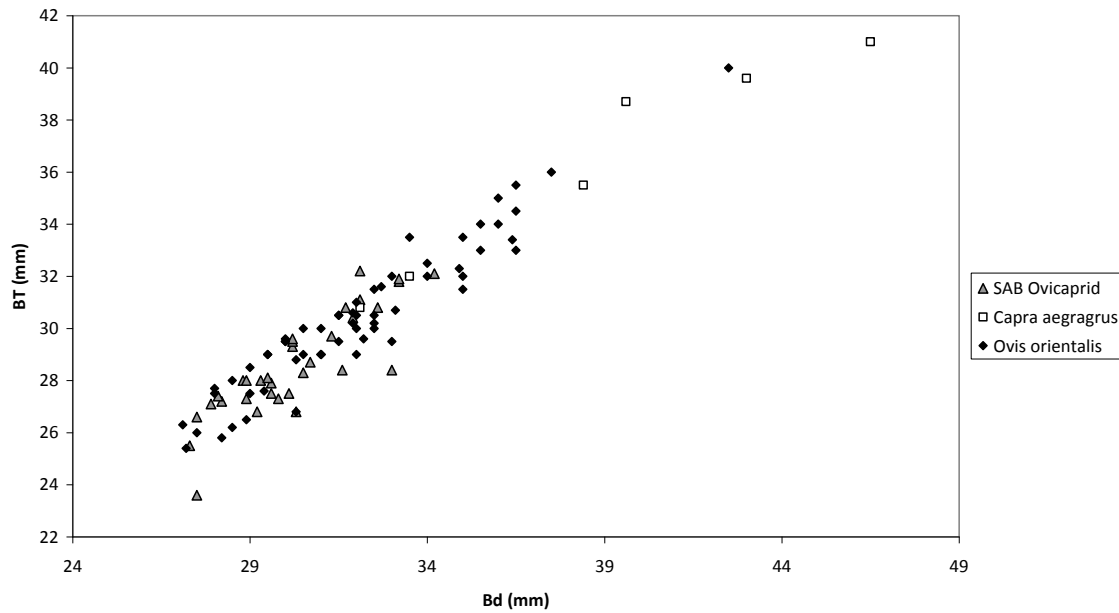


Fig 6.76: Comparison of Tell Sabi Abyad (SAB) ovicaprids to modern *Ovis orientalis* and *Capra aegragus* – Correlation between Bd and BT humeri measurements.

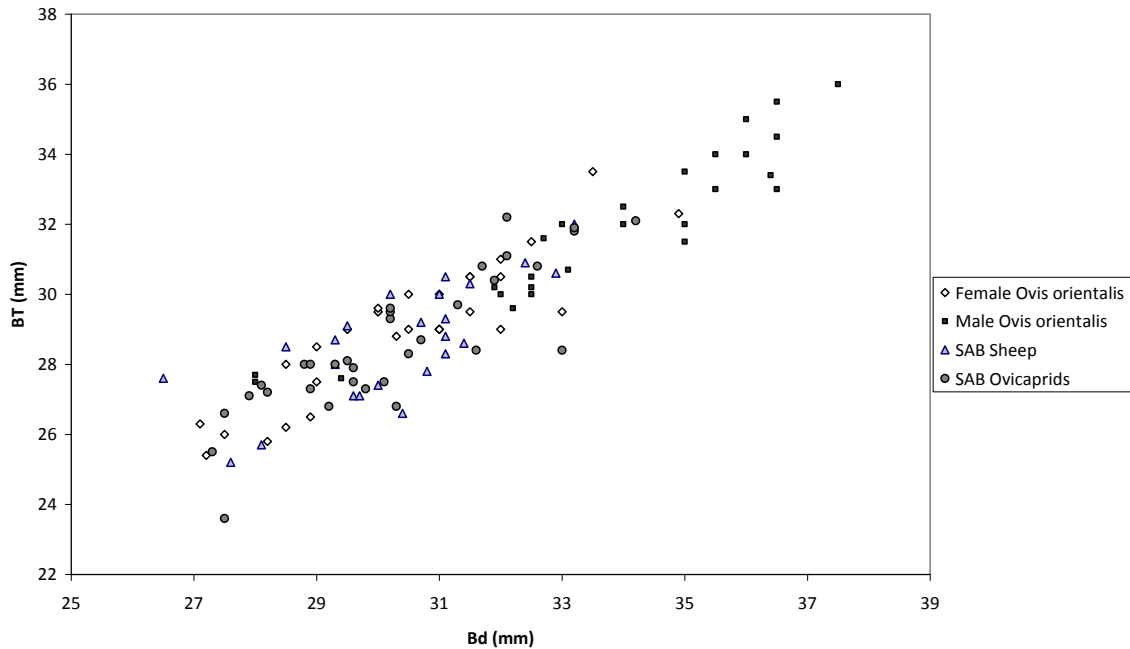


Fig 6.77: Comparison of Tell Sabi Abyad (SAB) sheep and ovicaprids to modern *Ovis orientalis* of known sex – Correlation between Bd and BT humeri measurements.

As the number of individual measurements by species and element by level are so small all length, width and depth were grouped and analysed using the LSI technique (see chapter 5) by animal exploitation

phase (fig 6.78 – 6.107). Only measurements from bones that could be identified as either goat or sheep were considered here.

The goat measurements will be considered first. The measurements from one female were used as the standard (point 0.00). The measurements of a modern wild female *Capra aegagrus* (Buitenhuis, *per comms*; see appendix 2) were used as the standard. For a list of the measurements used see appendix 2. Figure 6.81 shows the length LSI for all levels combined. This graph shows three groups of measurements: one group between 0 and 0.07, one between -0.01 and -0.04 and another between -0.04 and -0.10. Those measurements in the first group are likely to represent domestic males (based on the assumption that no wild individuals were present), the last group most likely contains small domestic females and the middle group a mixture of larger females and smaller males. There is a skewed value of 1.00¹.

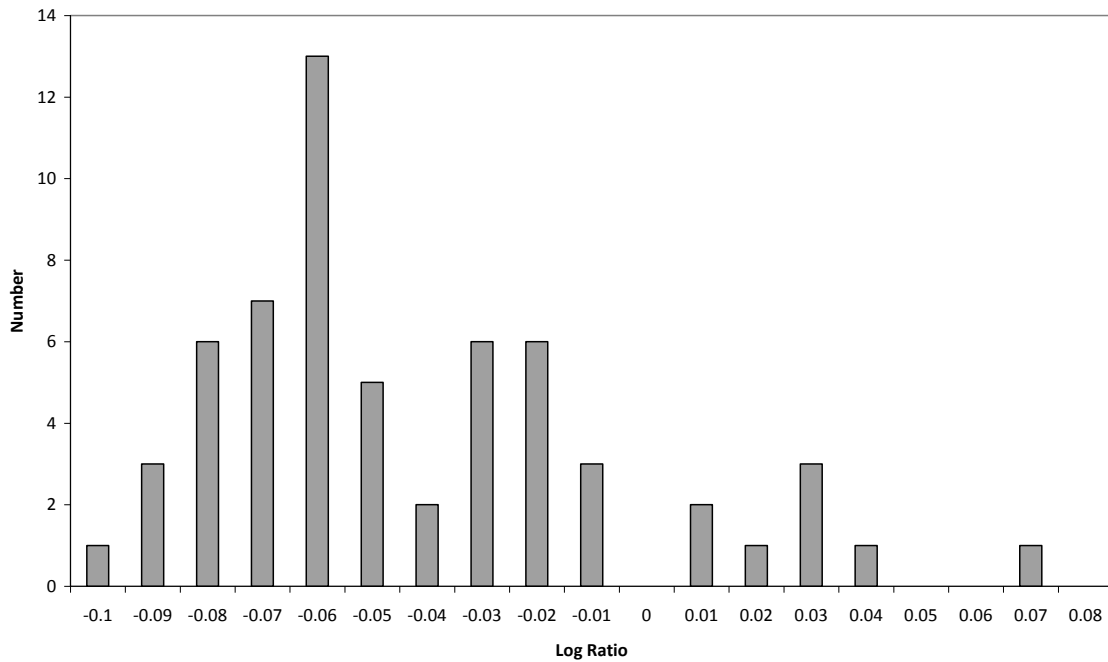


Fig 6.78: Goat length log ratio (site total): standard measurements based on modern female *Capra aegagrus*

¹ Positive skewness indicates a distribution with an asymmetric tail extending toward more positive values. Negative skewness indicates a distribution with an asymmetric tail extending toward more negative values

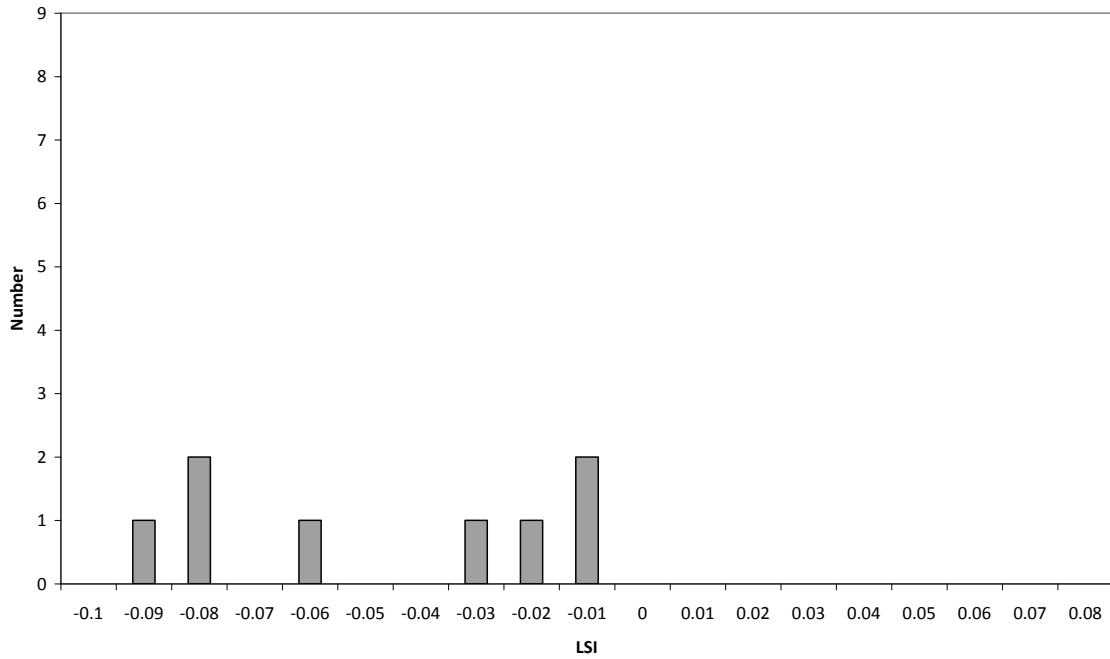


Fig 6.79: Levels A12-A10 goat length log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.05)

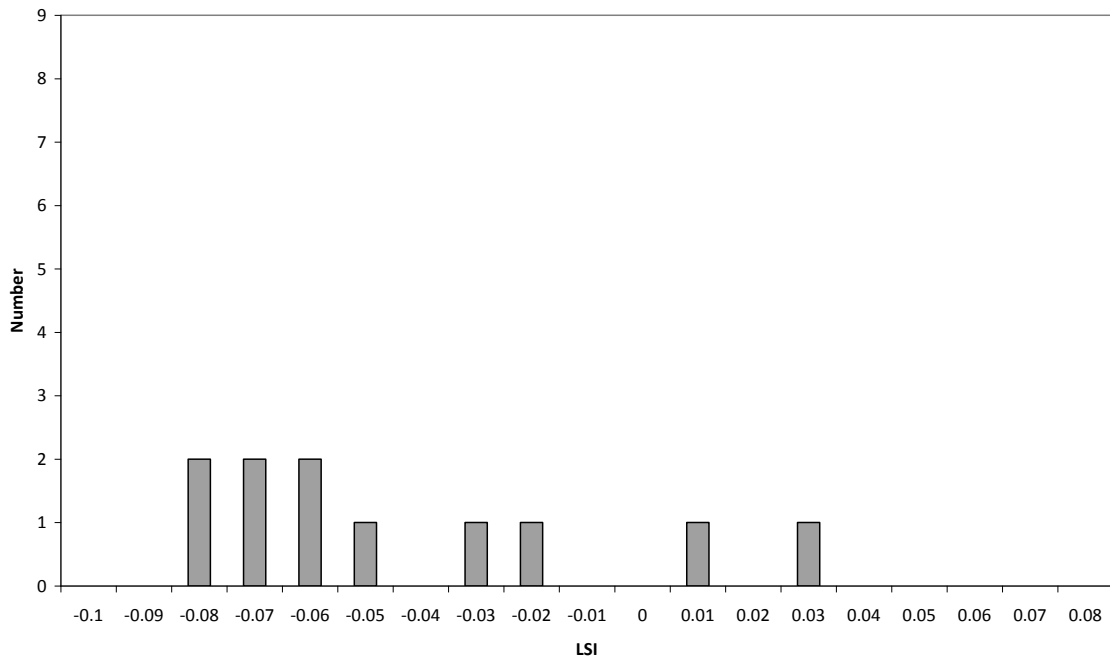


Fig 6.80: Levels A9-A5 goat length log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.04)

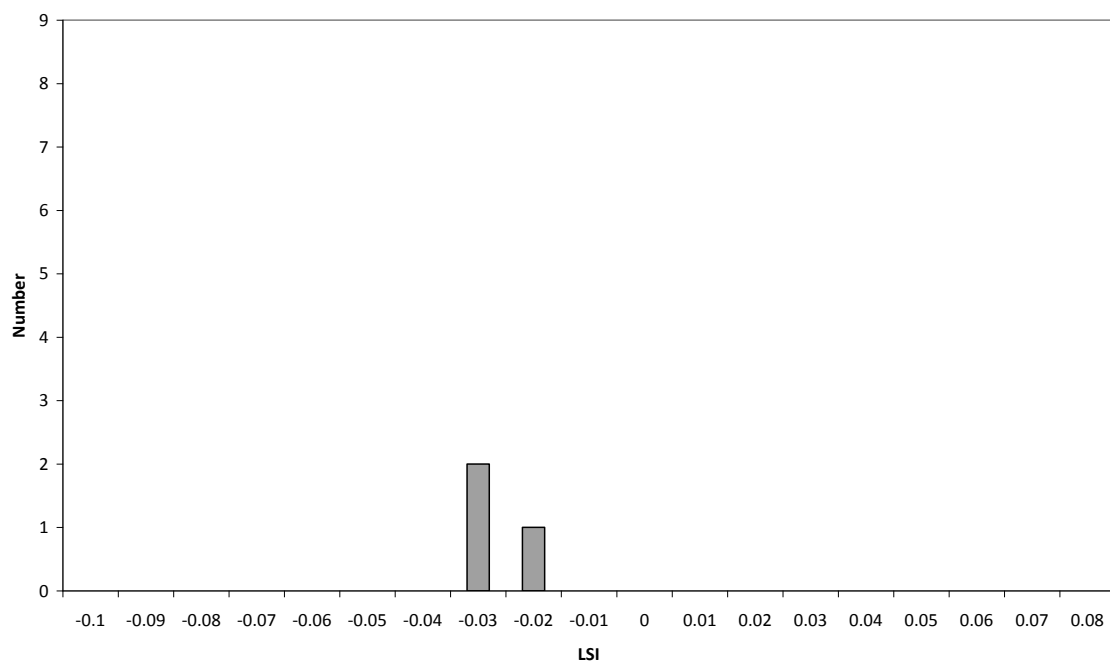


Fig 6.81: Levels A4-A3 goat length log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.03)

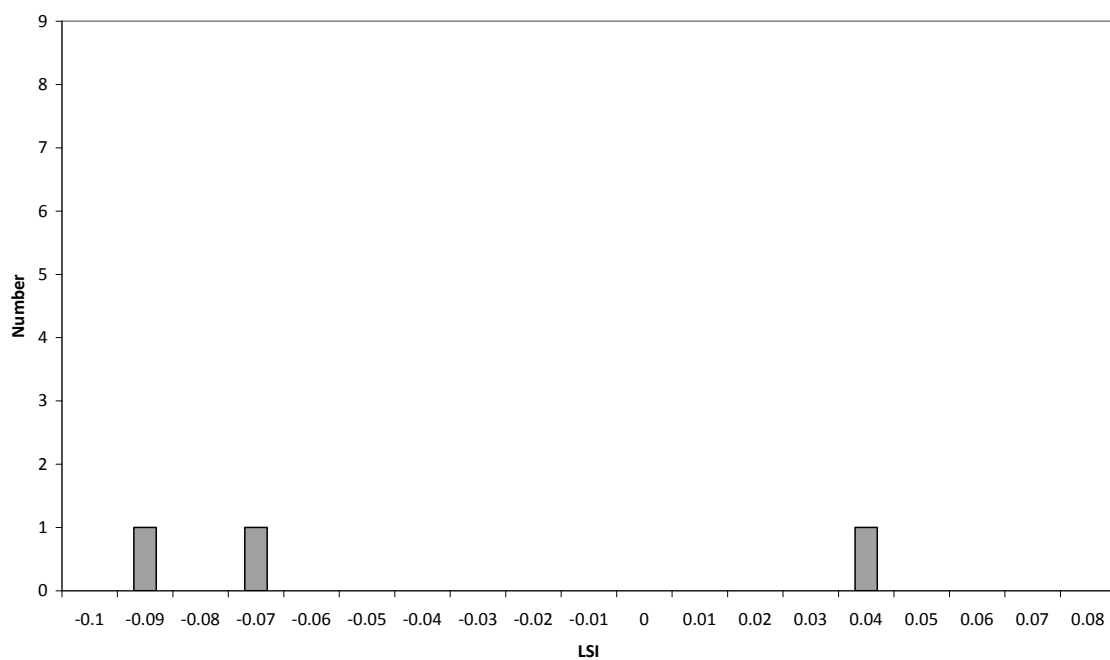


Fig 6.82: Level A2 goat length log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.04)

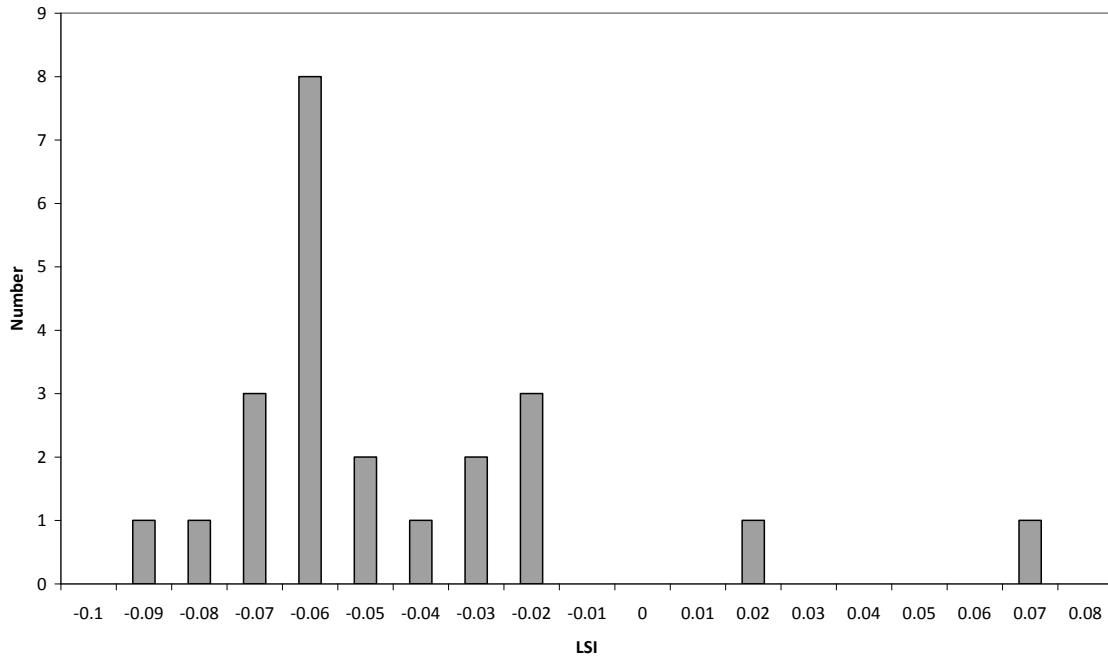


Fig 6.83: Level A1 goat length log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.05)

The sample sizes from levels A2, A4-A3, A9-A5 and A12-A10 are too small to draw any conclusions on these results alone. The sample size from A1 is much larger (fig 6.83) and shows the presence of at least two distinct groups: one whose measurements are all smaller than the standard (female), the other a far less significant group with measurements larger than the standard (male).

The sample sizes from levels B8-B4 and B3-B1 were both very small (fig 6.84 – 6.85). All that be said is that these levels show a spread of sizes but due to the small sample size no real conclusions can be drawn, apart from the possible presence of both male and female animals.

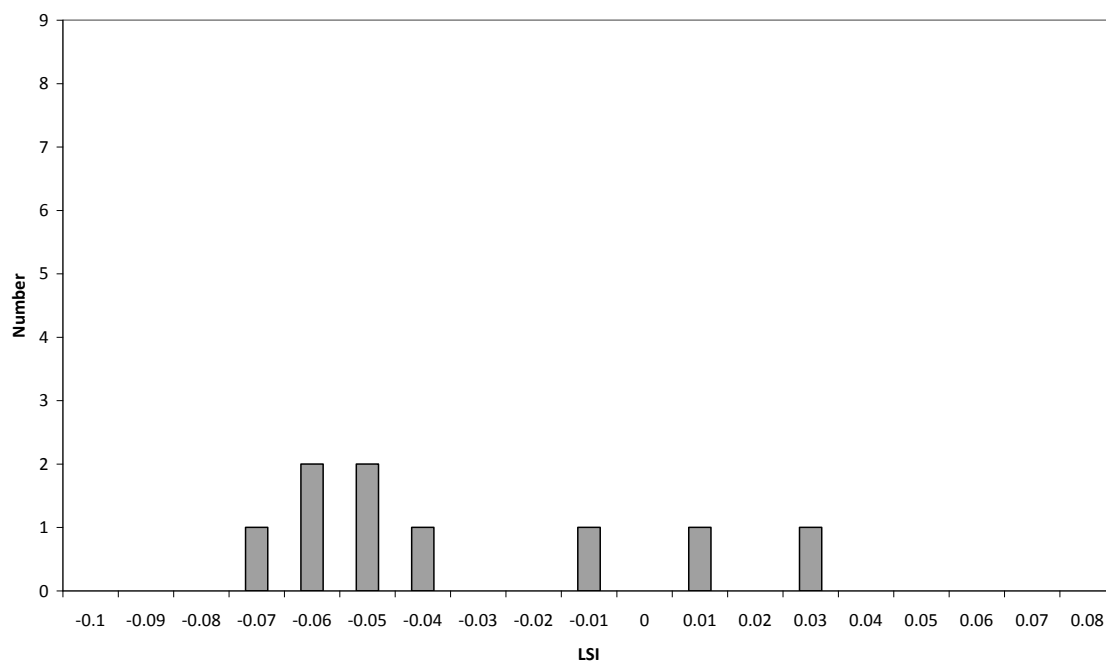


Fig 6.84: Levels B8-B4 goat length log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.05)

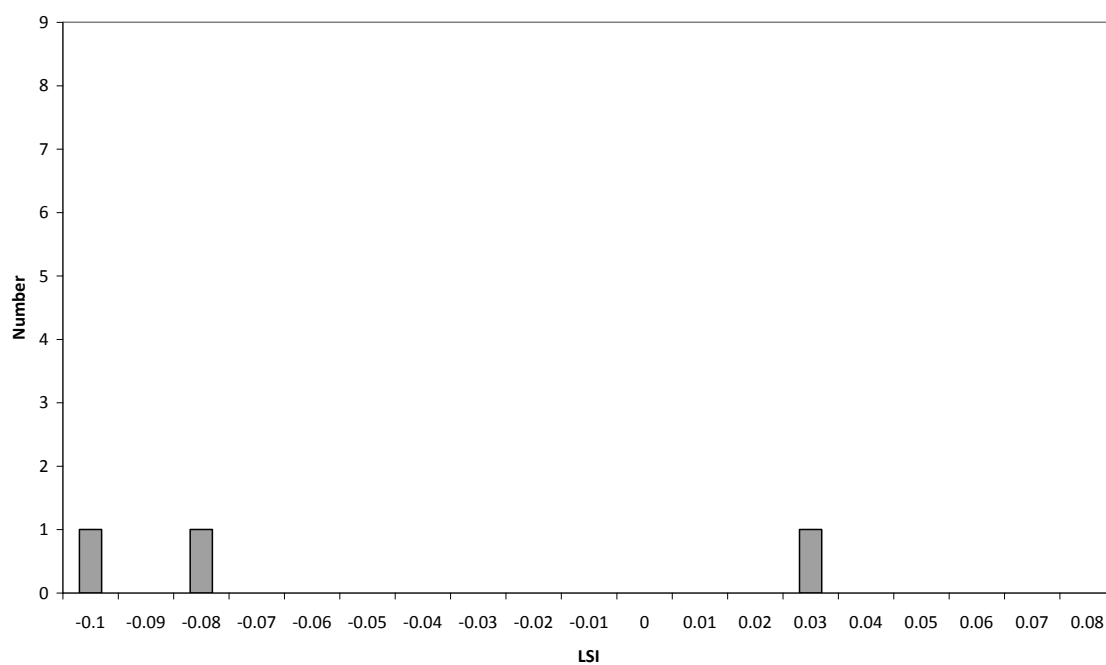


Fig 6.85: Levels B3-B1 goat length log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.03)

Level C is not considered here as no measurements from goat remains were present.

In general the majority of animals from all levels have length measurements smaller than the standard which suggests that these animals were smaller than a wild female. It is likely that the majority of goats at Tell Sabi Abyad were domestic females and there is no distinguishable change in size of the animals through time.

Unlike length measurements, the width measurements correspond more to weight than height. Figure 6.86 shows the width LSI for all levels combined. This graph is roughly bimodal with the majority of values falling below 0, probably representing domestic females and a few measurements being larger than the standard perhaps representing domestic males. The measurements are strong skewed to the left (skew=8.87) indicating a distribution of LSI values with an asymmetric tail extending toward more negative values i.e. lighter, probably female, individuals.

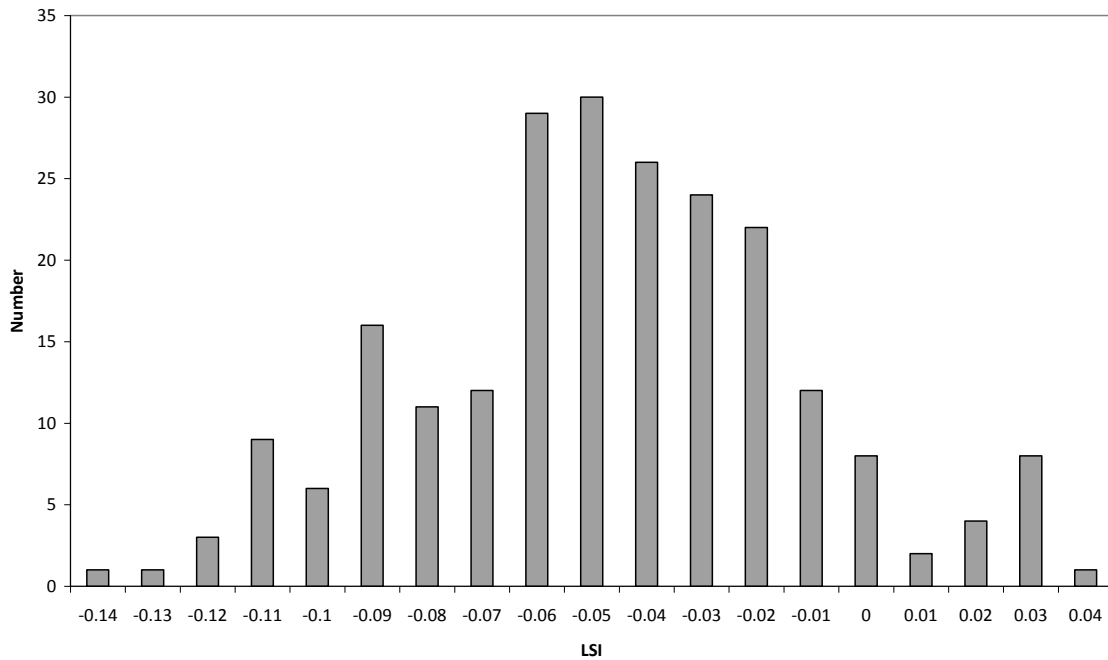


Fig 6.86: Goat width log ratio (site total): standard measurements based on modern female *Capra aegagrus*

Levels A12-A10 and A9-A5 show a larger range of LSI values but with the majority of LSI values below the standard and only one individual measurement above the standard (fig 6.87 and fig 6.88). Levels A4-A3 (fig 6.89) display LSI values roughly split into two groups, both smaller than the standard, with one individual measurement above the standard.

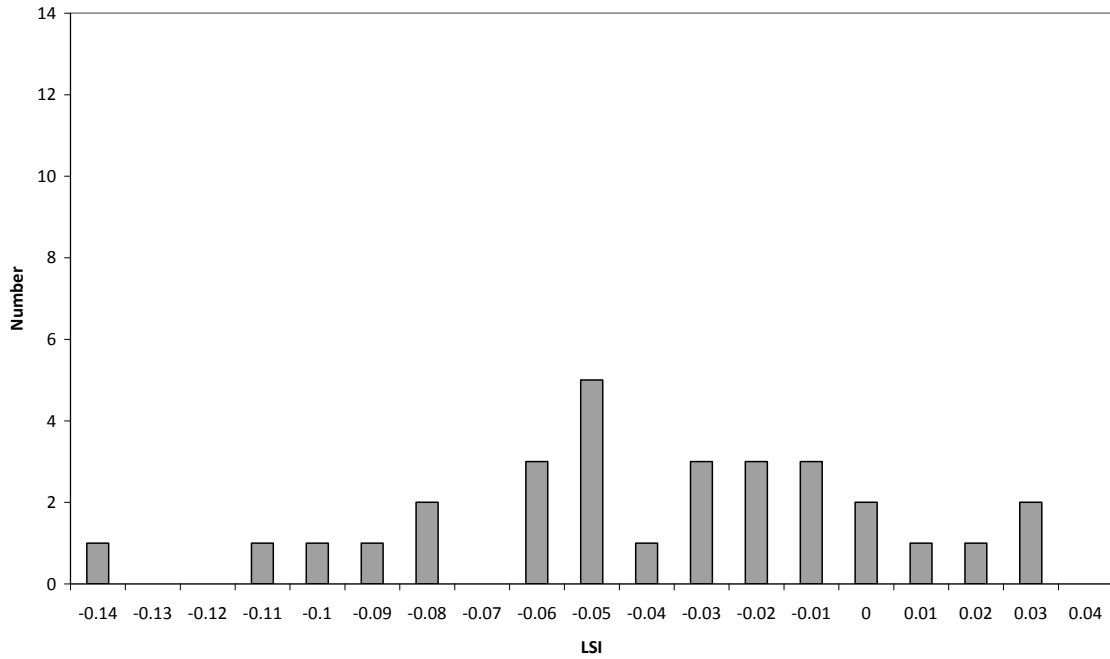


Fig 6.87: Levels A12-A10 goat width log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.04)

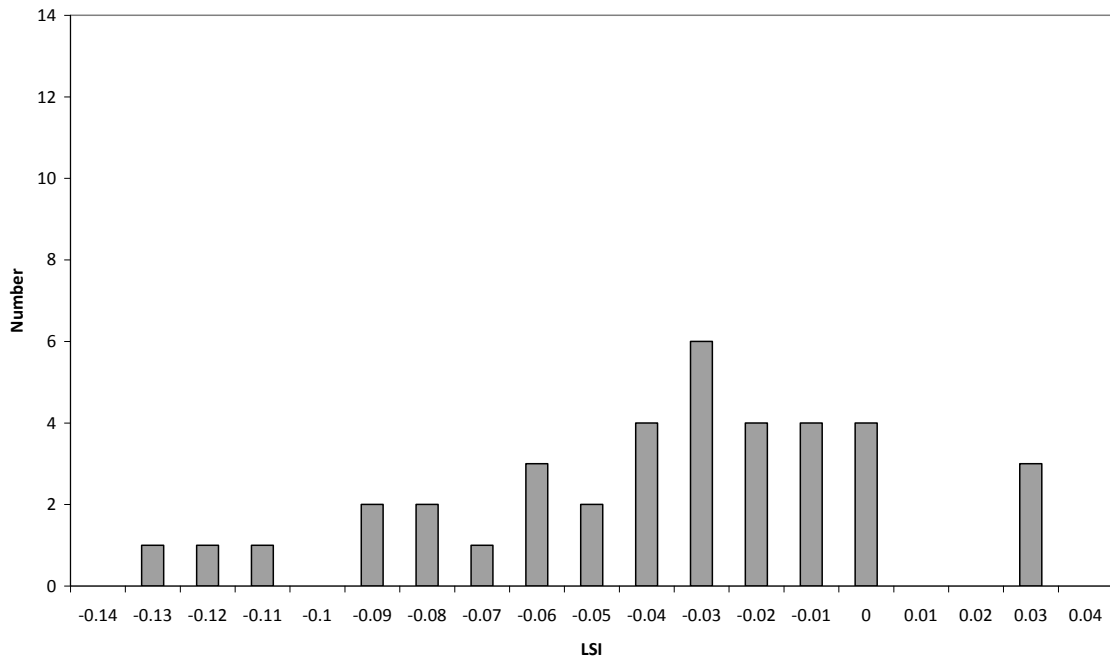


Fig 6.88: Levels A9-A5 goat width log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.06)

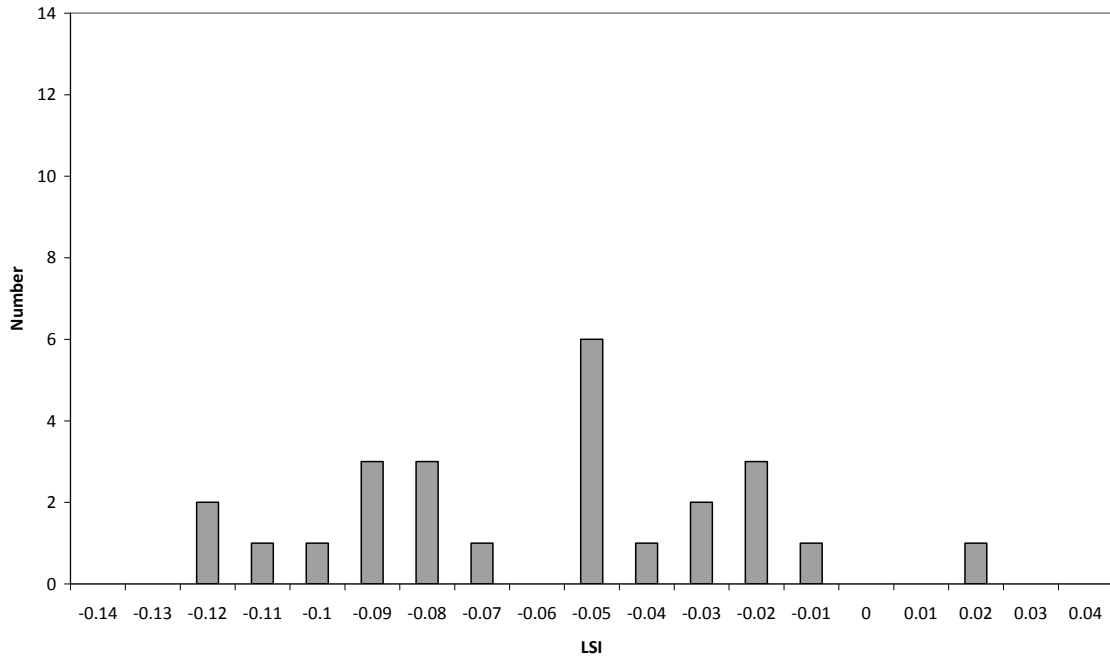


Fig 6.89: Levels A4-A3 goat width log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.06)

The samples size from level A2 is very small (fig 6.90) and all the measurements were smaller than the standard and can be assumed to be derived from domestic females.

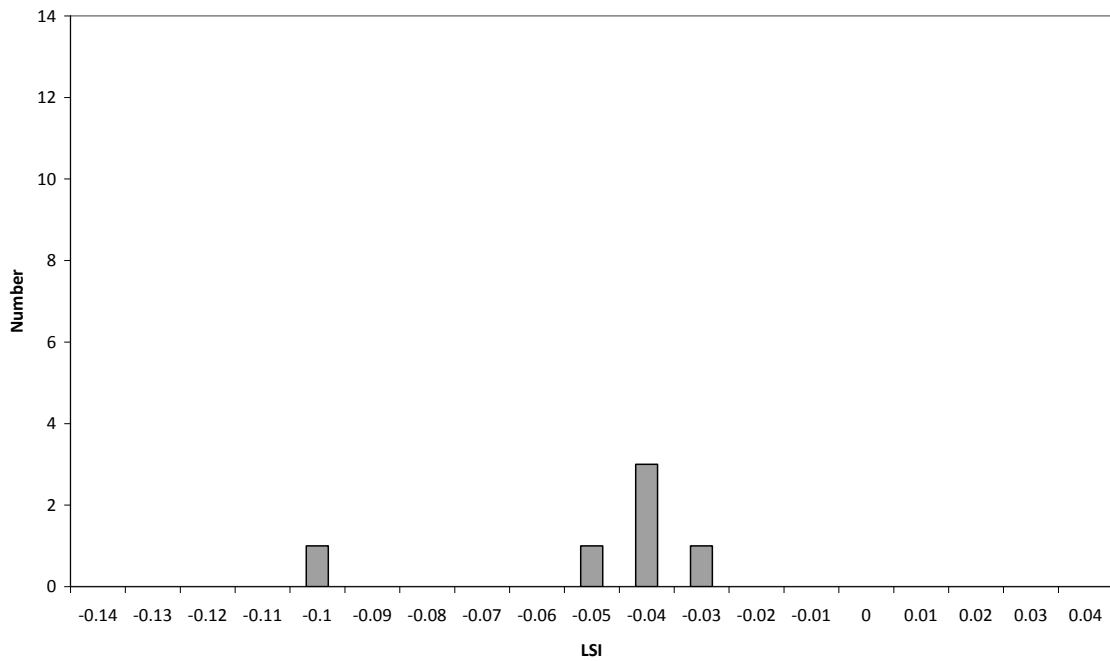


Fig 6.90: Level A2 goat width log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.07)

Level A1 is the only level with a reasonable sample of measurements (fig 6.91). This level shows a roughly binomial distribution of LSI values with the vast majority of values being below the standard and representing domestic females. Those values between 0 and 0.03 probably represent male animals.

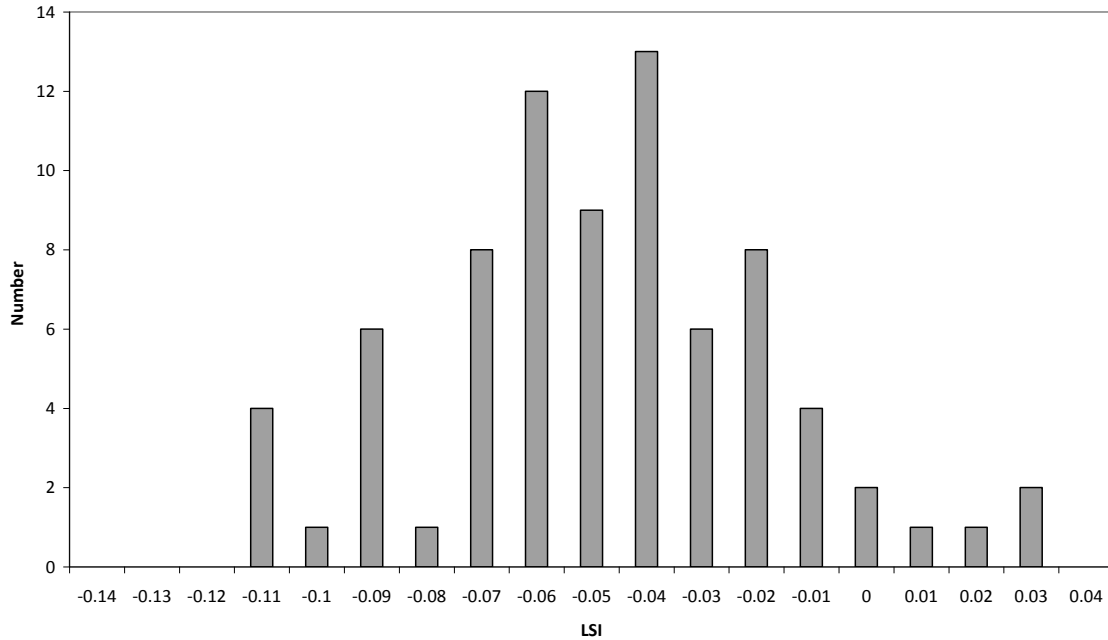


Fig 6.91: Level A1 goat width log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.05)

The sample sizes from levels B8-B4 and B3-B1 were too small to draw any real conclusions (fig 6.92 – 6.91). All that can be said is that the majority of measurements were well below the standard and probably represent domestic females, with only a few measurements larger than the standard which could represent males. There were no measurements available for the C levels.

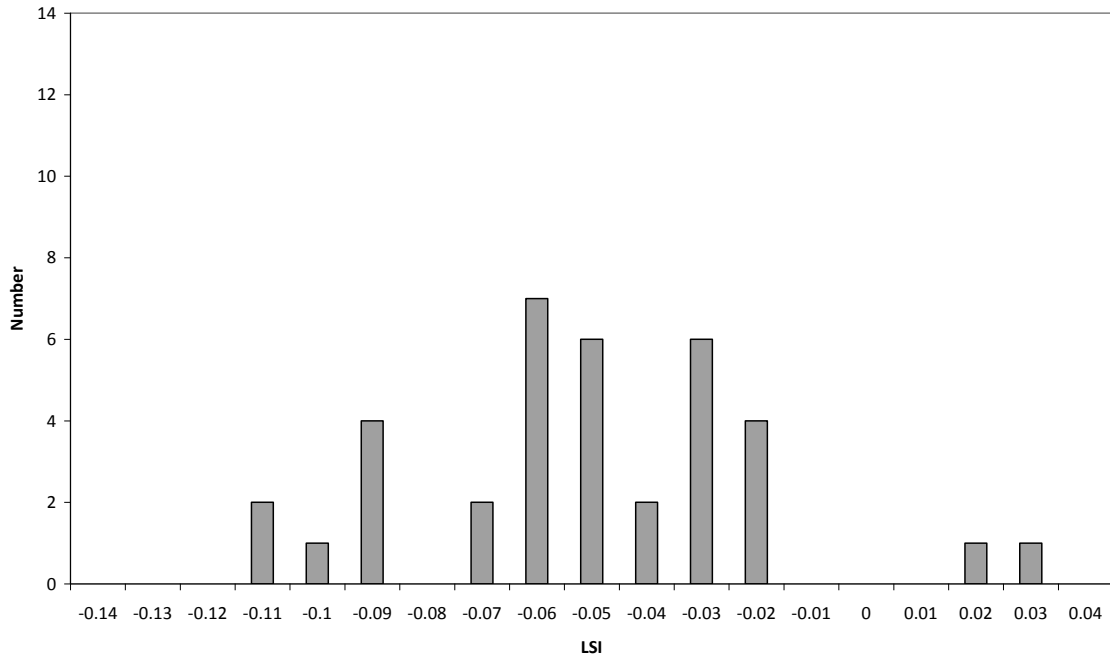


Fig 6.92: Levels B8-B4 goat width log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.05)

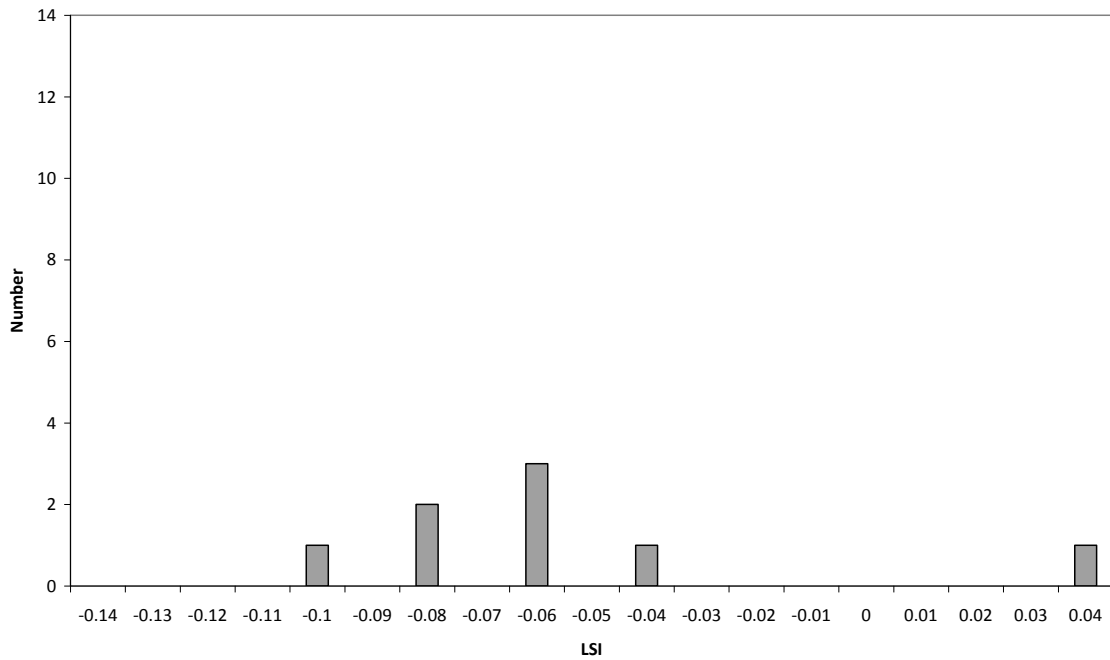


Fig 6.93: Levels B3-B1 goat width log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.05)

In general, the majority of measurements are smaller than the wild female standard in all levels and likely represent herds of domestic female goat. Those measurements larger than the standard represent heavy animals, probably domestic males. There are no changes apparent through time.

Finally the depth measurements, which also represent the weight of an animal, were analysed using the LSI method. Figure 6.94 shows the depth LSI values for all levels combined. This graph is roughly bimodal. The distribution is skewed to the right with a few very small, light individuals. The majority of LSI values fall well below the standard with only a few relatively heavy (male) individuals present. Like the width LSI values, the depth LSI values are strongly skewed to the left (skew= 8.94).

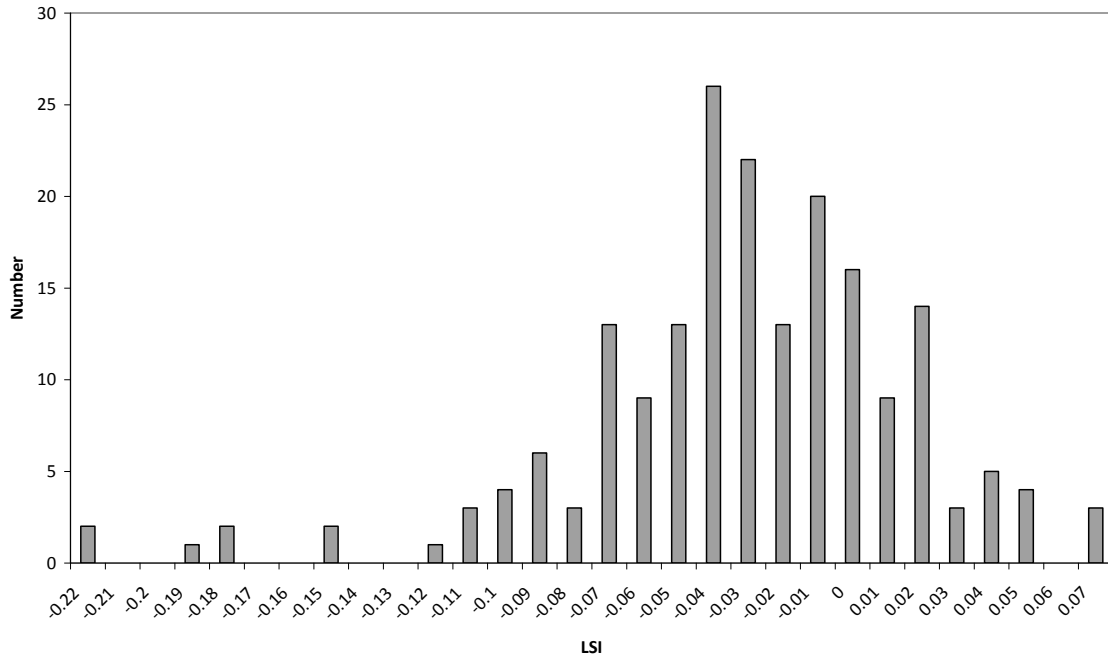


Fig 6.94: Goat depth log ratio (site total): standard measurements based on modern female *Capra aegagrus*

Levels A12-A10, A9-A9 and A4-A3 show a very similar spread of width LSI values (fig 6.95 – 6.97). With the exception of a few very small measurements the majority of LSI values fell with the range of -0.11 to 0.05 with apparently more larger individuals present in the oldest levels.

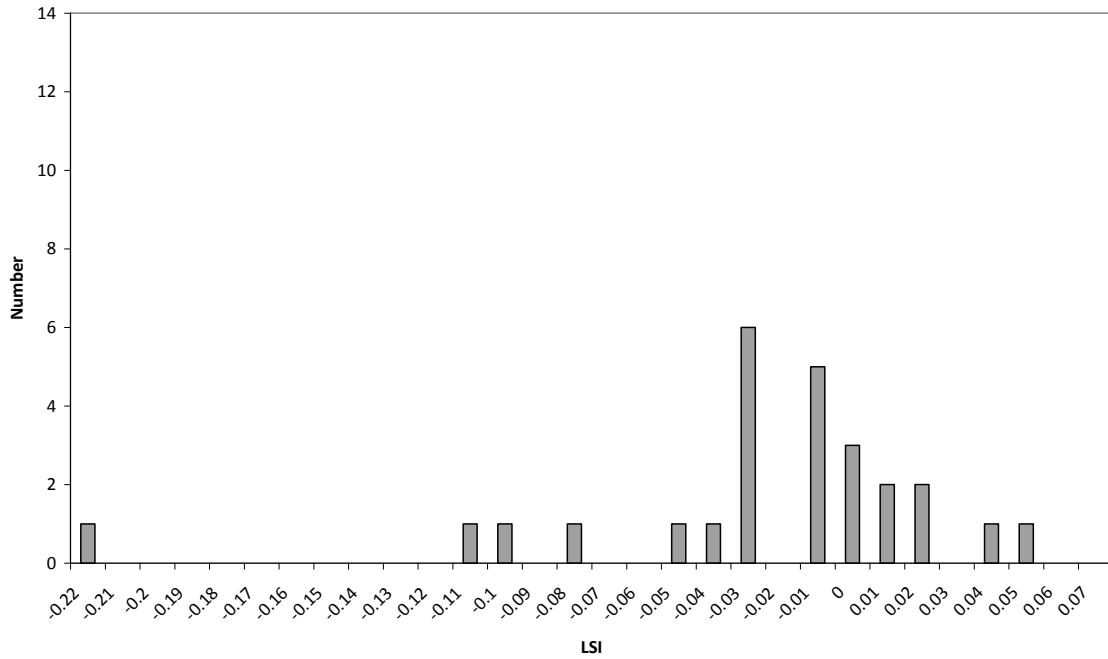


Fig 6.95: Levels A12-A11 goat depth log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.03)

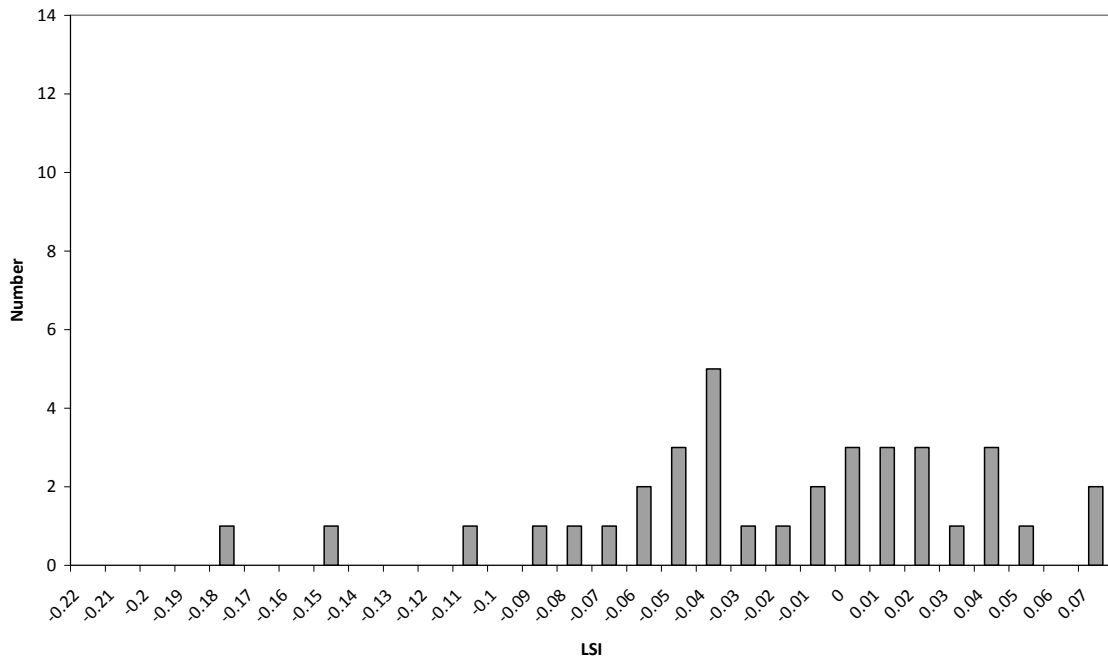


Fig 6.96: Levels A9-A5 goat depth log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.02)

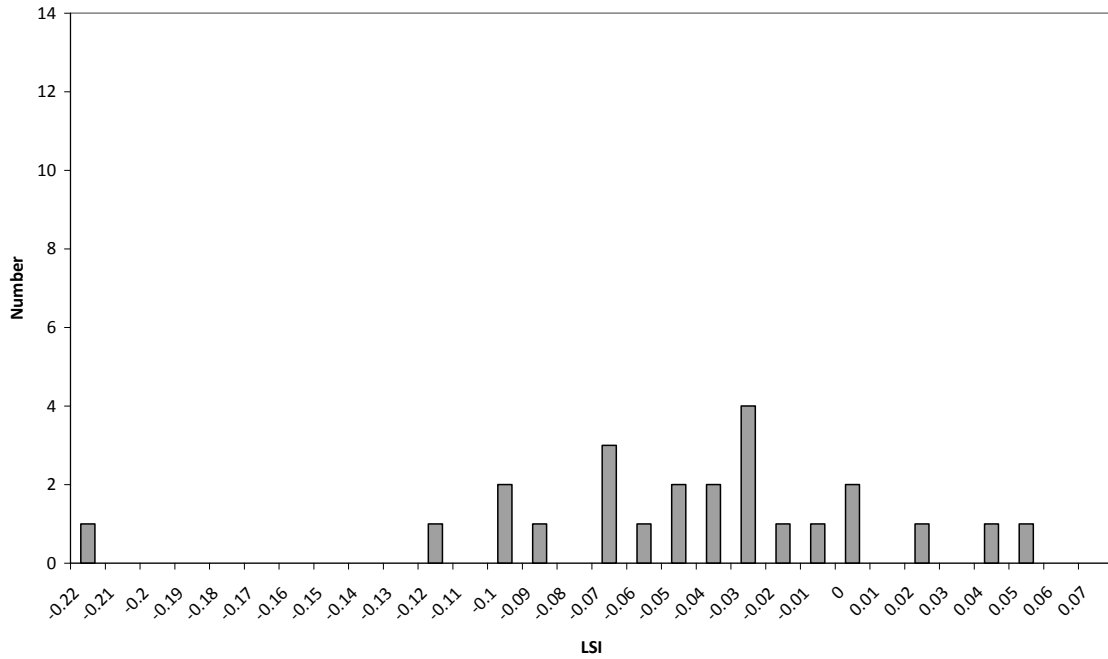


Fig 6.97: Level A4-A3 goat depth log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.05)

Level A2 has only a very small sample of measurements available, all of which were smaller than the standard (fig 6.98).

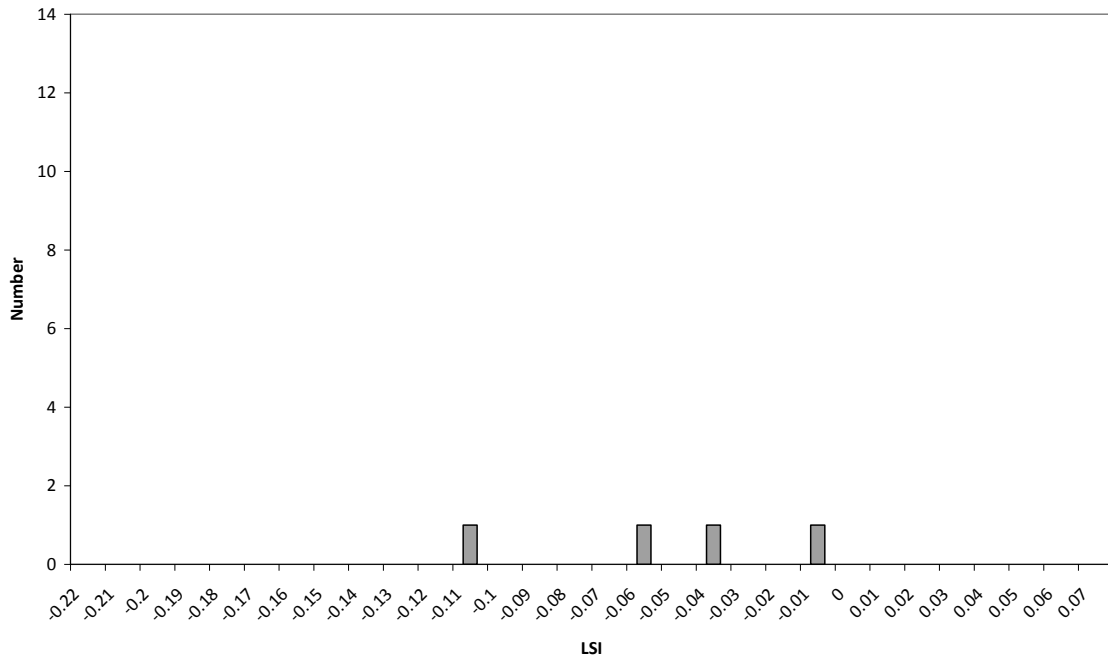


Fig 6.98: Level A2 goat depth log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.05)

The sample size from level A1 is relatively large and shows a somewhat binomial distribution of LSI values (fig 6.99). There are a few very light measurements (LSI values -0.19, -0.18 and -0.15) but the majority of values fit in the range of -0.1 to 0.03. The majority of measurements gave a LSI value below 0 and probably represent domestic females.

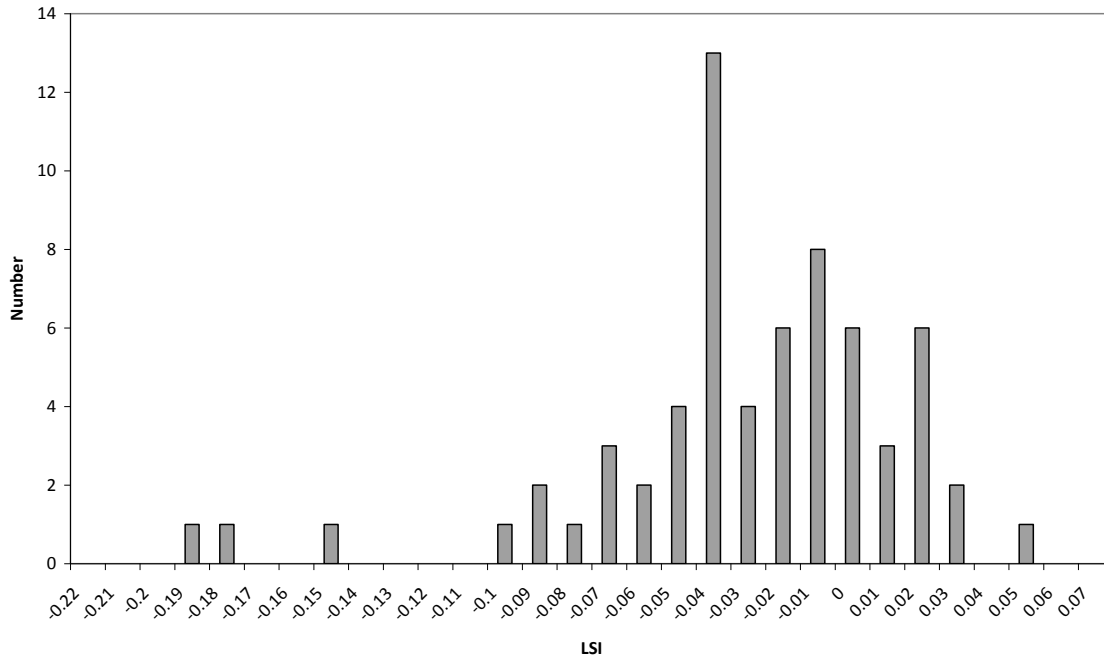


Fig 6.99: Level A1 goat depth log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.03)

The sample sizes from levels B8-B4 and B3-B1 were very small (fig 6.100 – 6.101). There is one very large measurement from level B3-B1 (LSI 0.07) which probably comes from a large, heavy male. The measurements from levels B8-B4 range from LSI values of -0.07 and 0.02. Level C had no measurements available for LSI analysis.

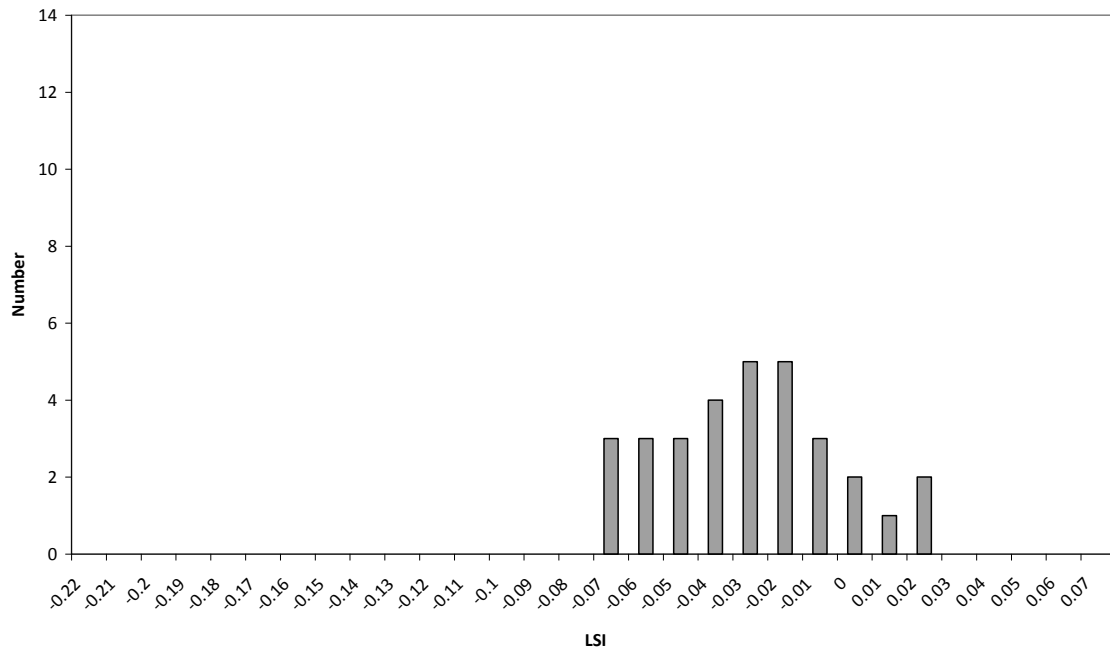


Fig 6.100: Level B8-B4 goat depth log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.03)

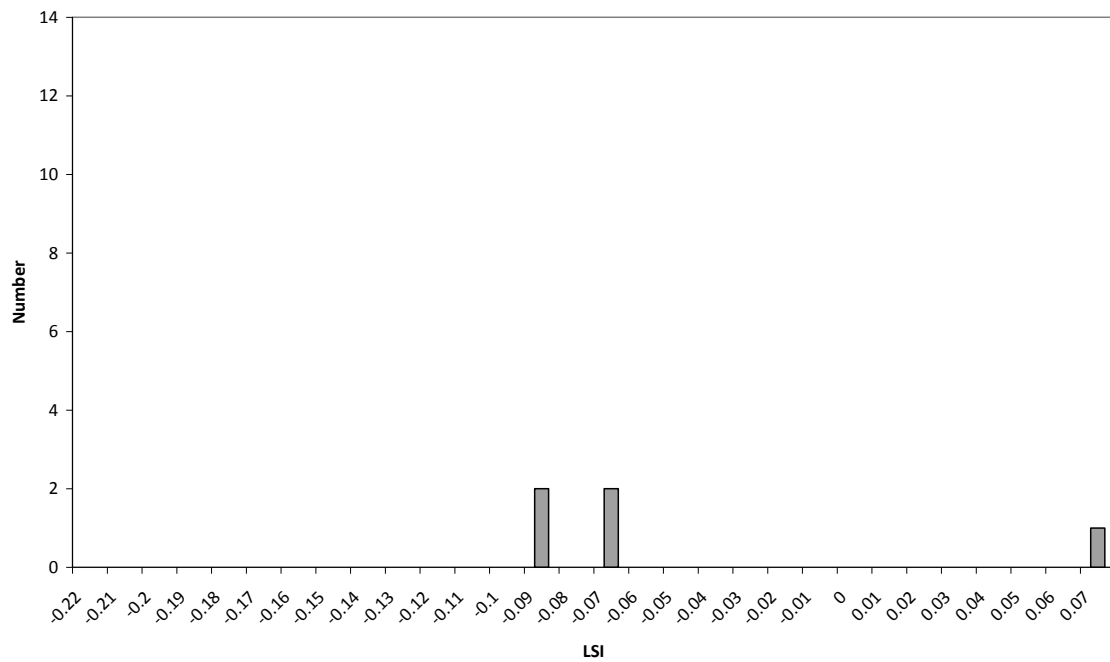


Fig 6.101: Levels B3-B1 goat depth log ratio: standard measurements based on modern female *Capra aegagrus* (mean = -0.04)

The majority of depth measurements are smaller than the standard and probably derive from domestic female goats. Those few measurements larger than the standard may represent large females or domestic

male goats. There appears to be a slight decrease in the weight of animals through time accompanied by a reduction in the size range of animals.

A similar analysis was carried out on the length, width and depth measurements of sheep remains recovered from Tell Sabi Abyad. The measurements of a modern wild female *ovis orientalis* (Buitenhuis, *per comms*; see appendix 2) were used as the standard.

Figure 6.102 shows the LSI values based on the length measurements of sheep from all levels at Tell Sabi Abyad (for a list of measurements used see appendix 2). There appears to be a slightly binomial distribution of values with the majority of values falling well below the standard. In fact, only three measurements were larger than the standard and it is safe to assume that both the male and female sheep at Tell Sabi Abyad were in general smaller than a wild female *Ovis orientalis*.

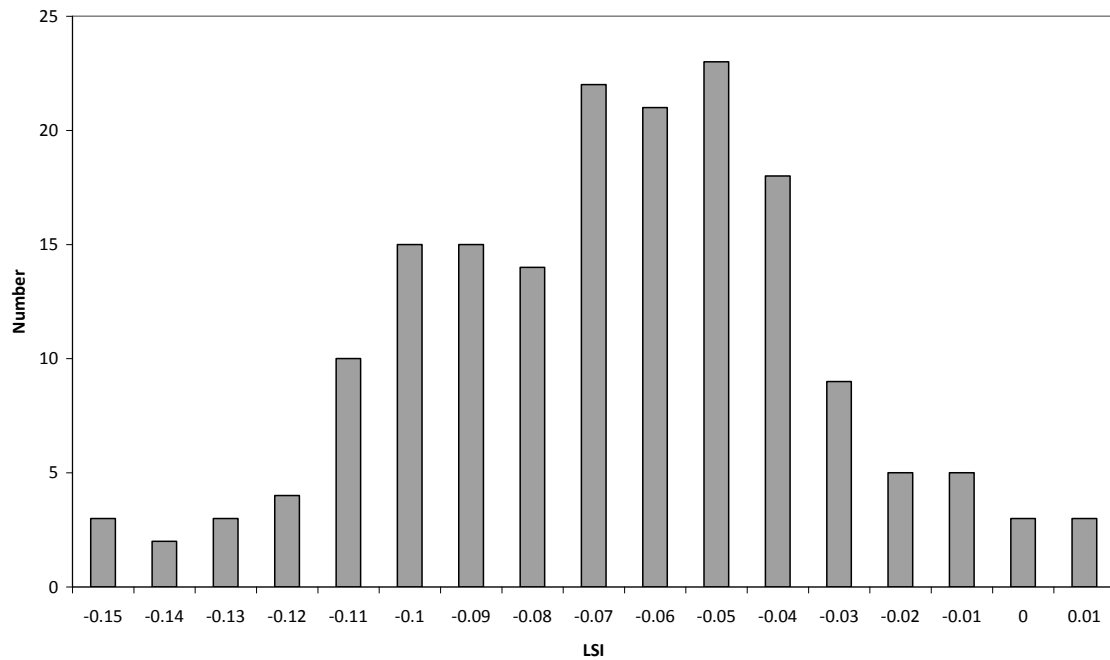


Fig 6.102: Sheep length log ratio (site total): standard measurements based on modern female *Ovis orientalis*

Levels A12-A11 shows a clear peak around -0.05 with a range of LSI values from -0.1 to 0.01 (fig 6.103). Levels A9-A5 show a spread of LSI values from -0.12 to 0 (fig 6.104). There is no skewed distribution of LSI values (skew value = -0.03).

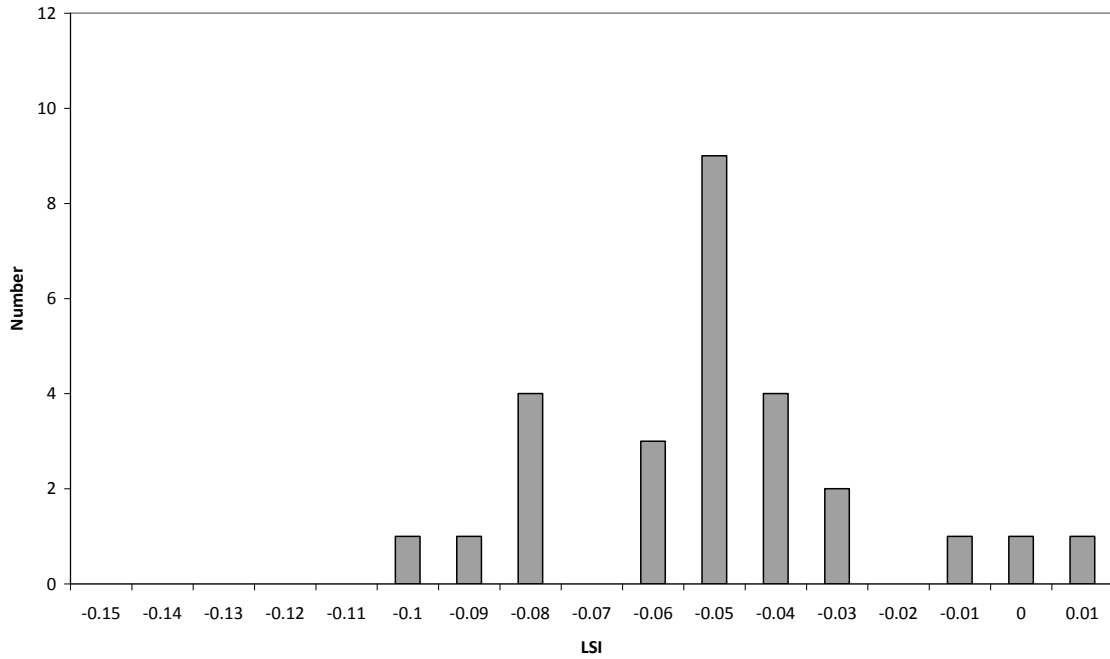


Fig 6.103: Levels A12-A10 sheep length log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.06)

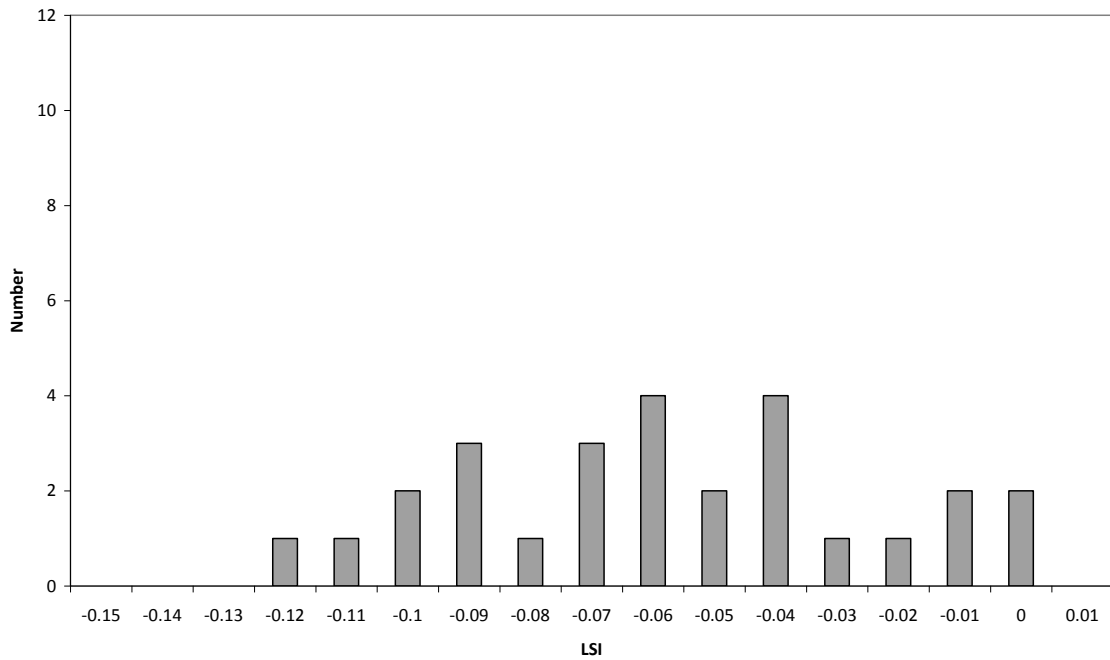


Fig 6.104: Levels A9-A5 sheep length log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.06)

The sample size from levels A4-A3 shows a range of LSI values from -0.14 to -0.03 (fig 6.105). Level A2 has too small a sample size to draw any conclusions (fig 6.106).

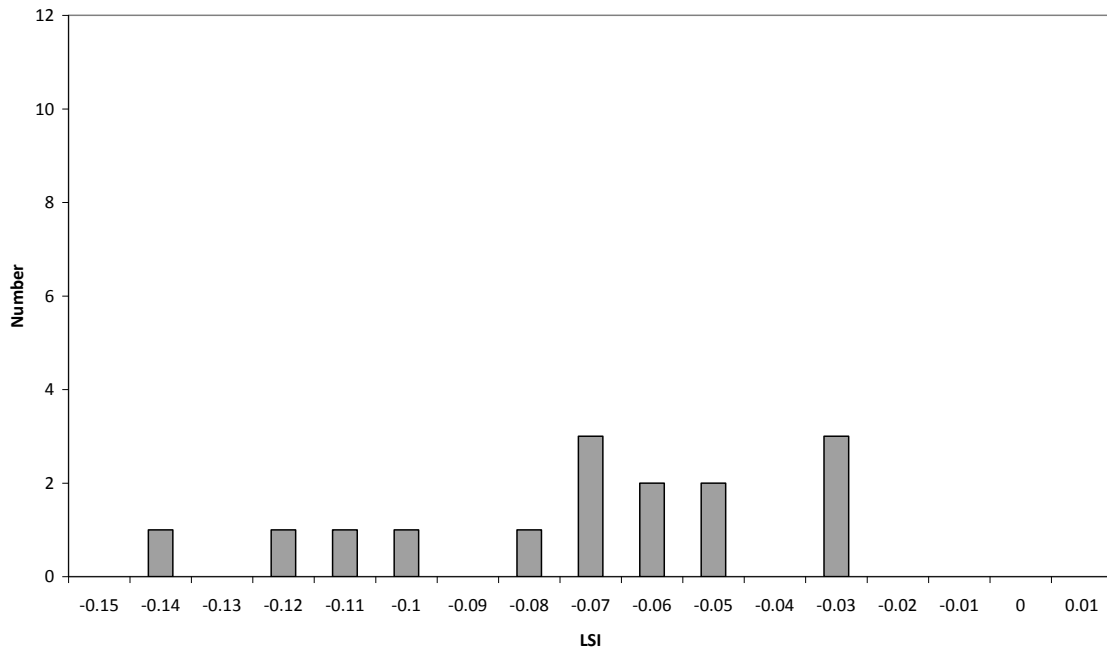


Fig 6.105: Levels A4-A3 sheep length log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.07)

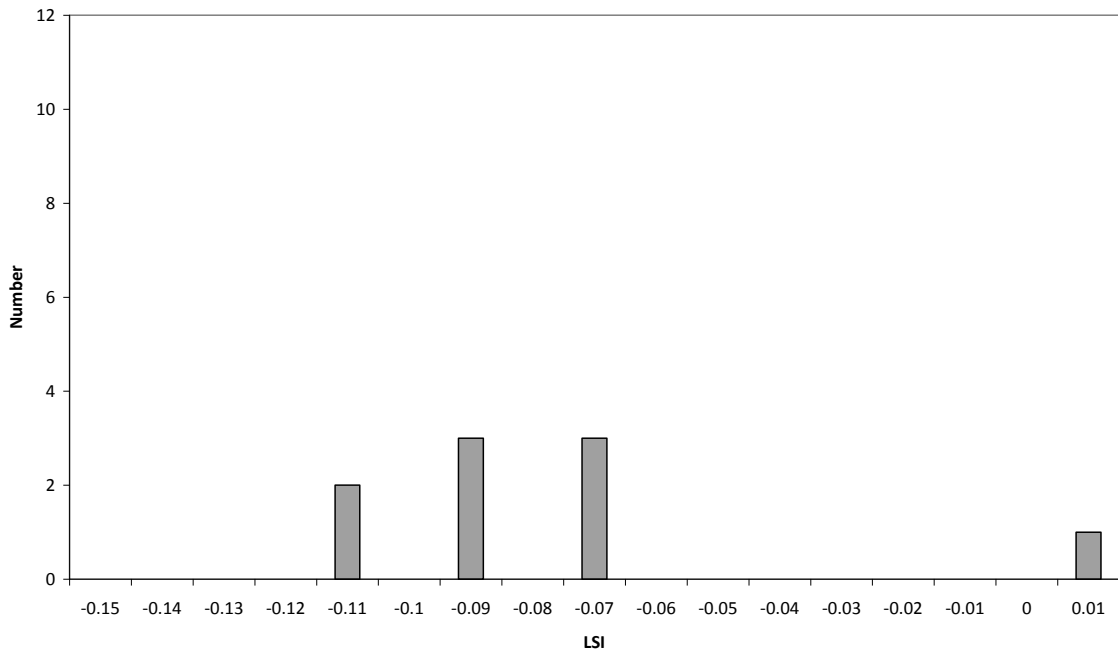


Fig 6.106: Level A2 sheep length log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.08)

As with the goat length LSI analysis, level A1 is the only level with a reasonable number of sheep length measurements available for analysis (fig 6.107). In this level there are clearly a two groups of LSI values with a large overlap around -0.07. If we assume all the sheep are domestic then it appears that there was

some sexual dimorphism in terms of size, with the group of larger values representing males and the group of lower values representing females. Levels B8-B4 provide a far smaller sample and show a large spread of LSI values, ranging from -0.15 to 0.04 (fig 6.108).

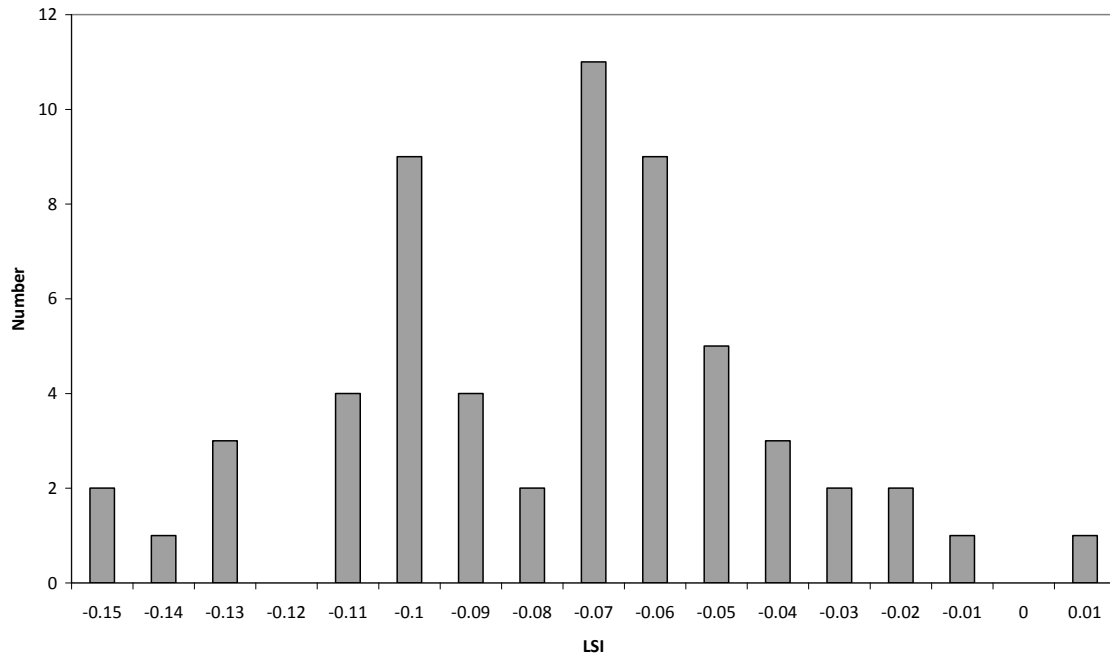


Fig 6.107: Level A1 sheep length log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.08)

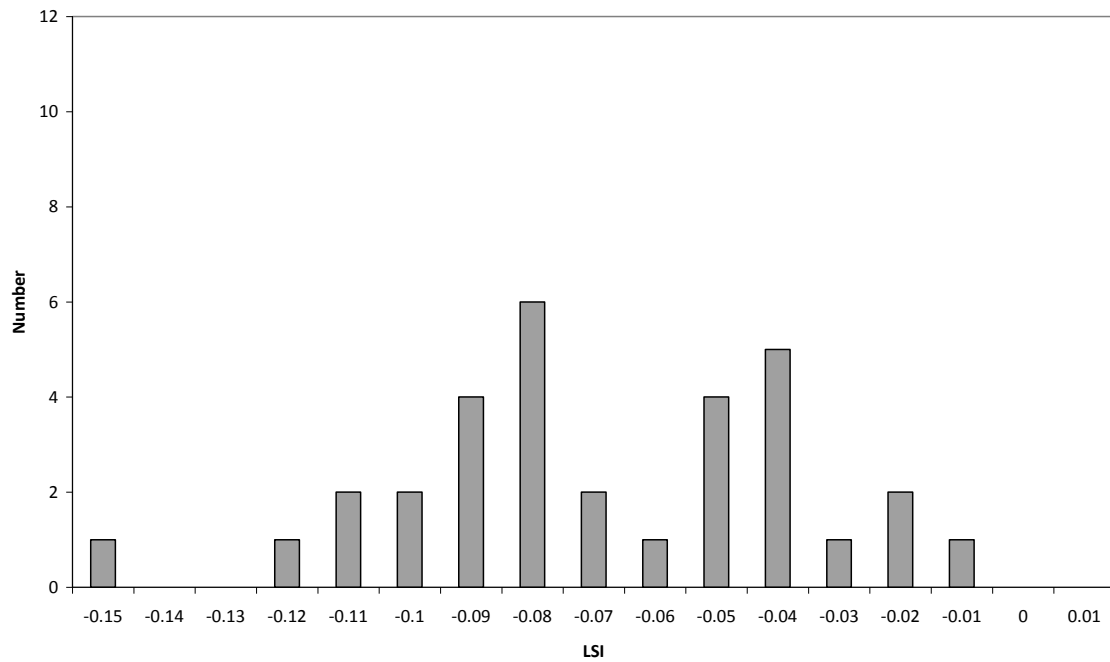


Fig 6.108: Levels B8-B4 sheep length log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.07)

The sample sizes from levels B3-B1 were very small (fig 6.109), and no conclusions can be drawn from this data set. All measurements in these levels were smaller than the standard. No sheep length measurements were available from level C.

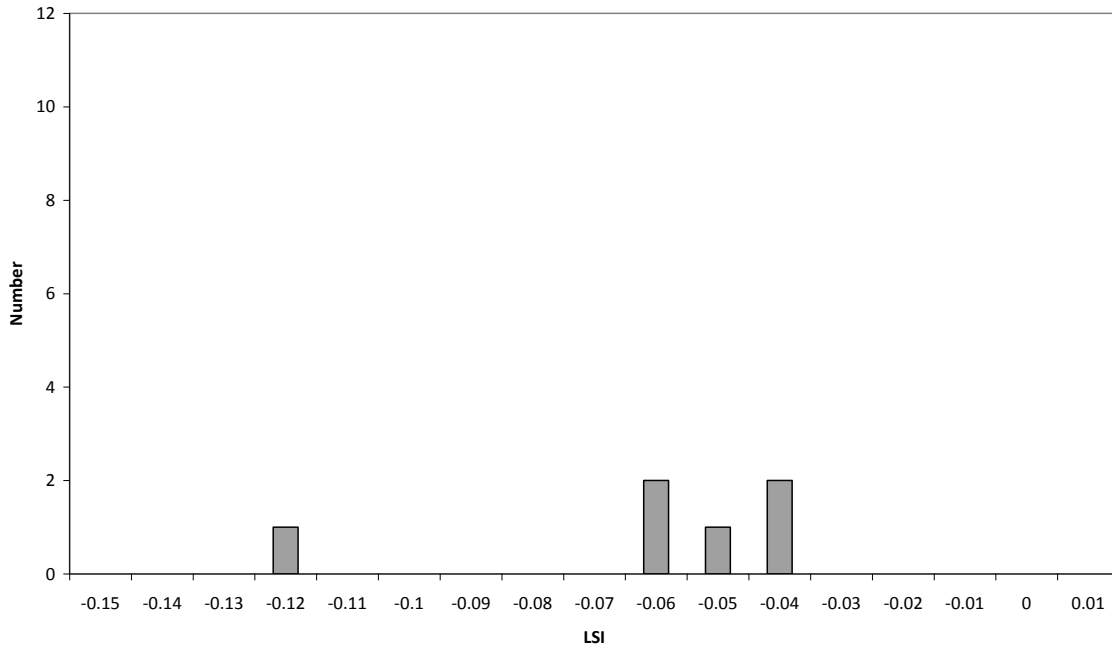


Fig 6.109: Levels B3-B1 sheep length log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.07)

The analysis of length LSI values based on the Tell Sabi Abyad sheep measurements shows no discernable changes in size of the animals through time with both male and female sheep falling below the size of the standard. The males could not be easily identified in all levels due to a lack of clear sexual dimorphism in size.

The width LSI was calculated for the sheep from all the levels combined (fig 6.110). This graph appears to be roughly binomial with the majority of values falling well below 0. Those few measurements that are larger than the standard perhaps represent domestic males. The width LSI values are slightly skewed to the left with a skew value of -1.49.

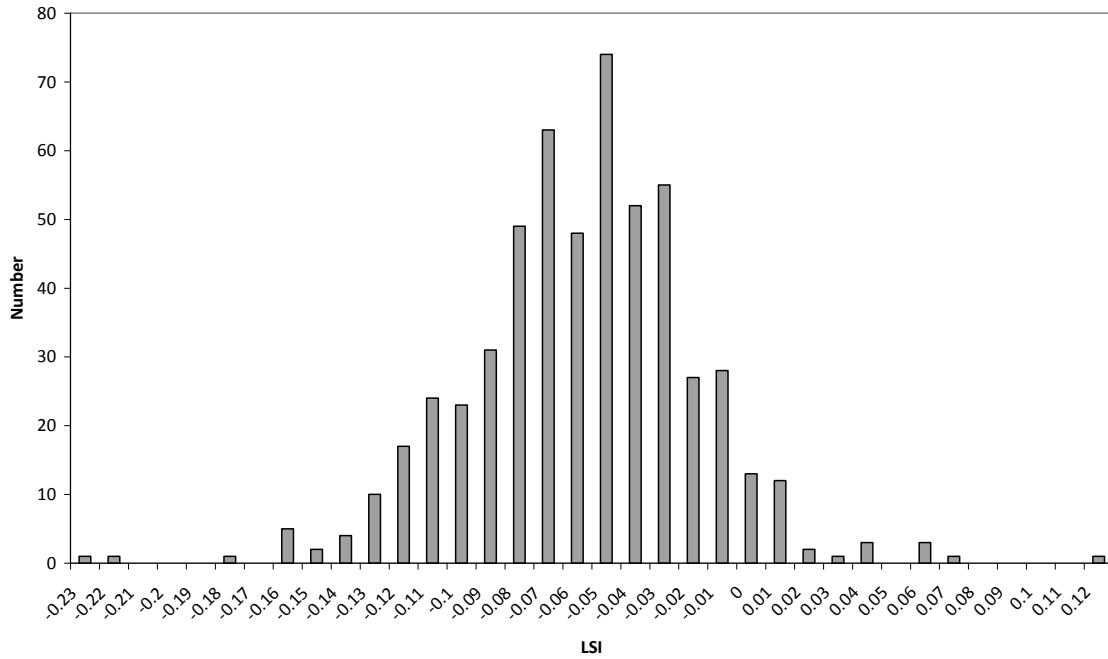


Fig 6.110: Sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis*

Levels A12-A10 (fig 6.111) have a high proportion larger measurements but the majority of LSI values still lie below zero, between -0.23 and -0.01.

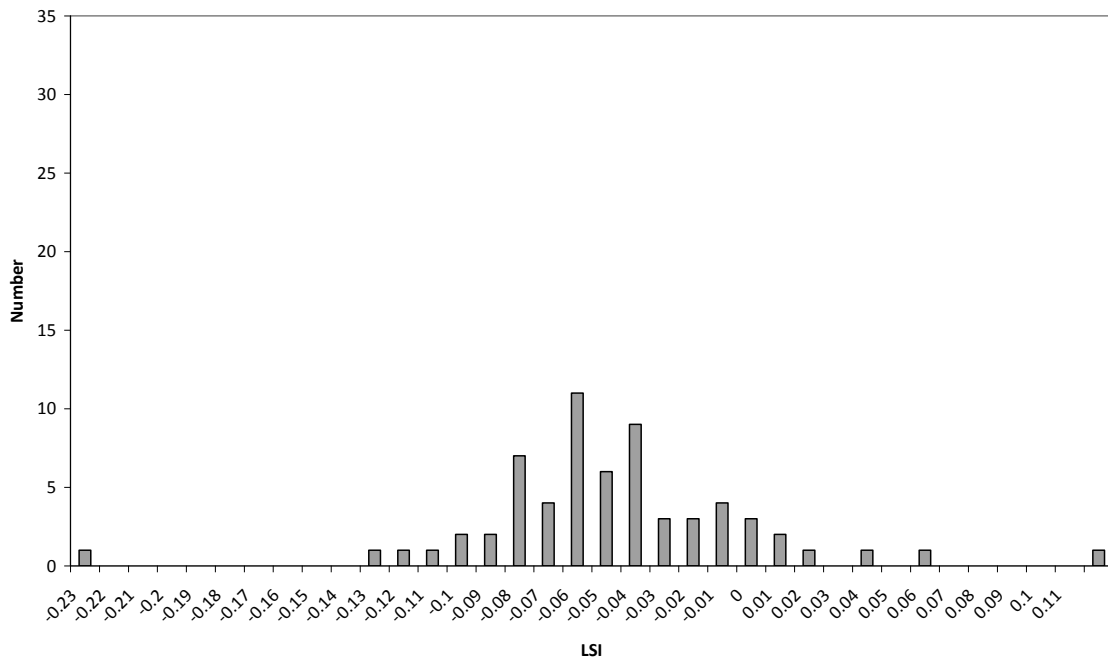


Fig 6.111: Levels A12-A10 sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.05)

Levels A9-A5 and A4-A3 have very similar ranges of LSI values (fig 6.112 and fig 6.113). There are very few larger measurements and the majority of LSI values fall between -0.12 and -0.01.

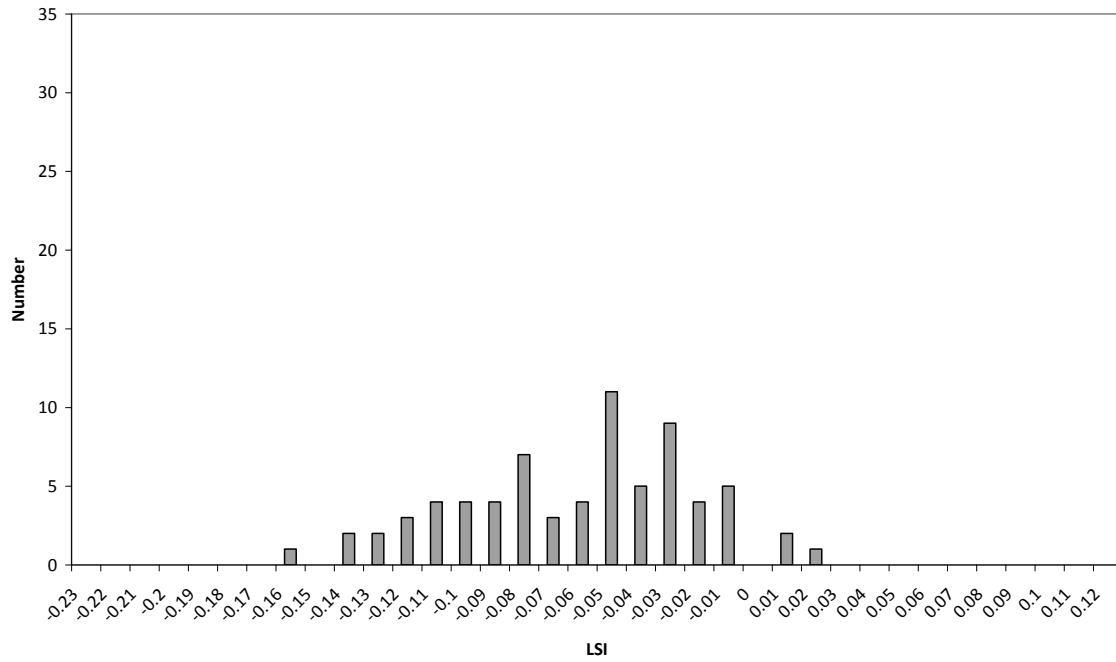


Fig 6.112: Levels A9-A5 sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.06)

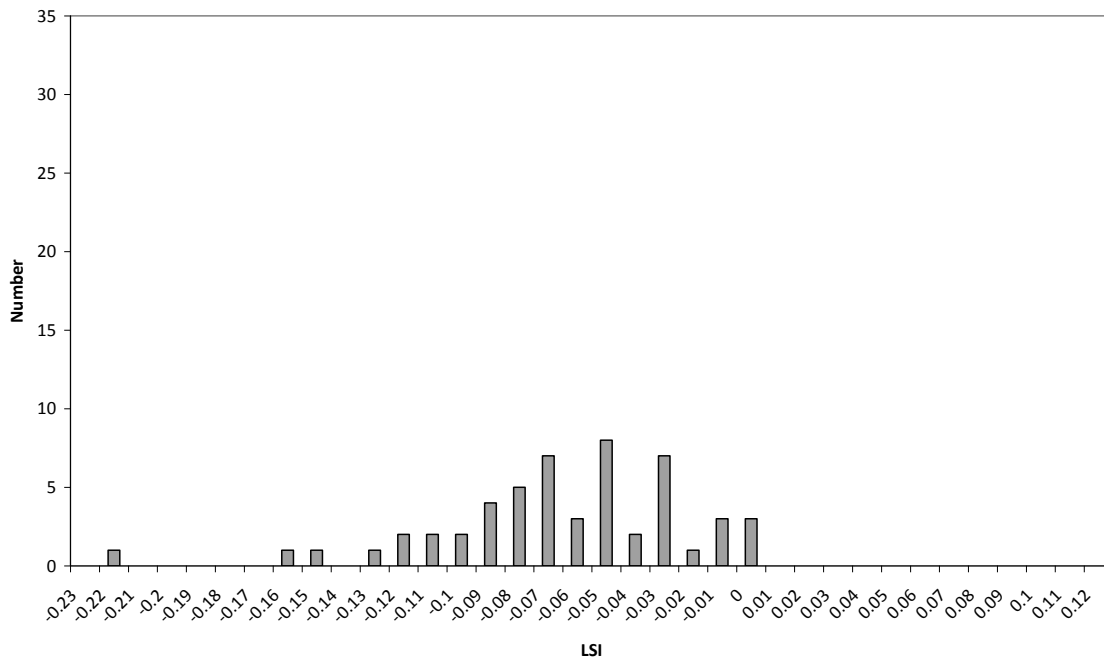


Fig 6.113: Levels A4-A3 sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.07)

The sample size from level A2 is too small to draw any accurate conclusions, although it is clear that all measurements were smaller than the standard (fig 6.114). Level A1 provides the best sample size (fig 6.115). Again, the vast majority of measurements are smaller than the standard with only a few larger measurements present. There appears to be one population present, the majority of which were female.

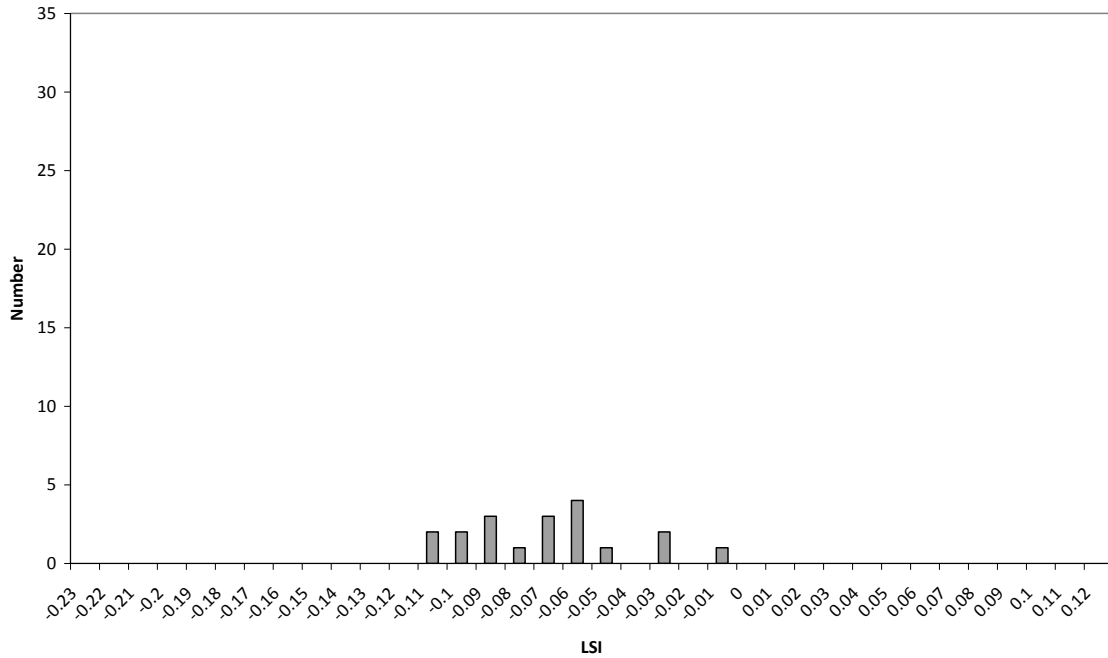


Fig 6.114: Level A2 sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = - 0.07)

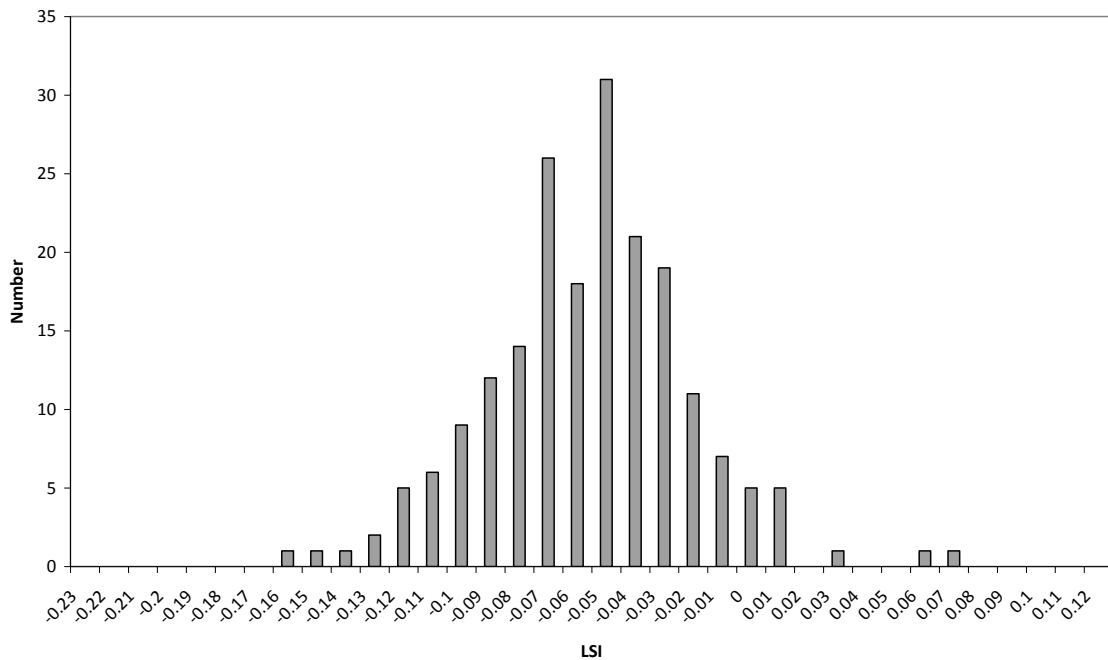


Fig 6.115: Level A1 sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = - 0.06)

The sample from levels B8-B4 is far smaller but it shows a spread of values from -0.18 to 0.04 with perhaps two groups falling either side of the LSI value of -0.06, with the majority of measurements being much smaller than the standard (fig 6.116).

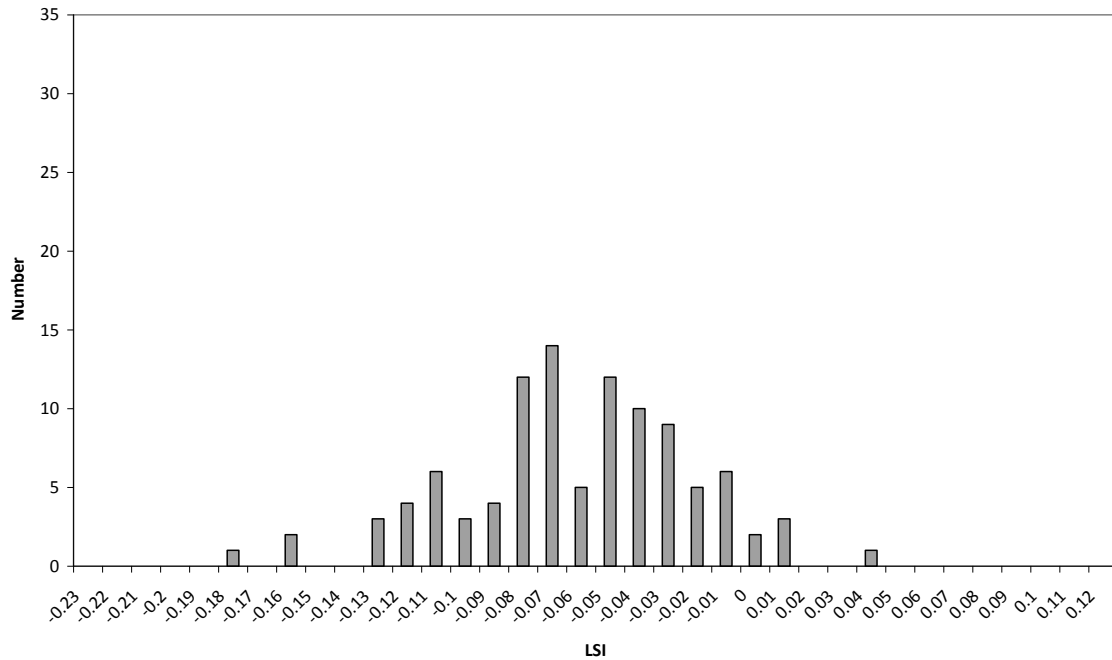


Fig 6.116: Levels B8-B4 sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = - 0.06)

The sample sizes from levels B3-B1 and C are all very small (fig 6.117 – 6.118). The majority of measurements fall below the standard with only two measurements being larger.

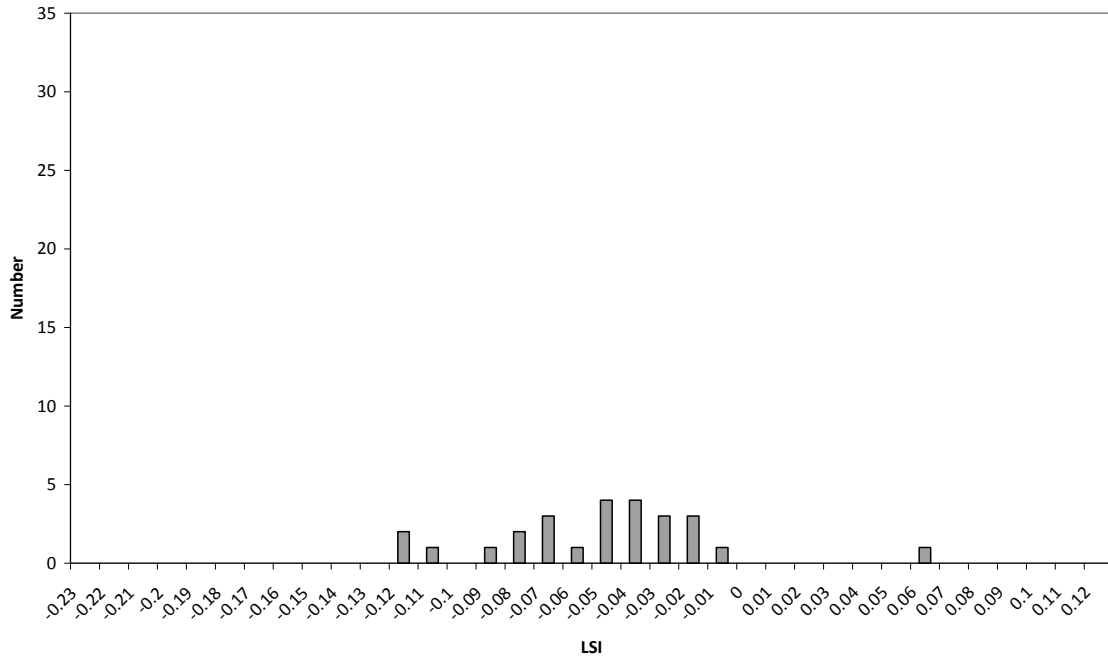


Fig 6.117: Levels B3-B1 sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.04)

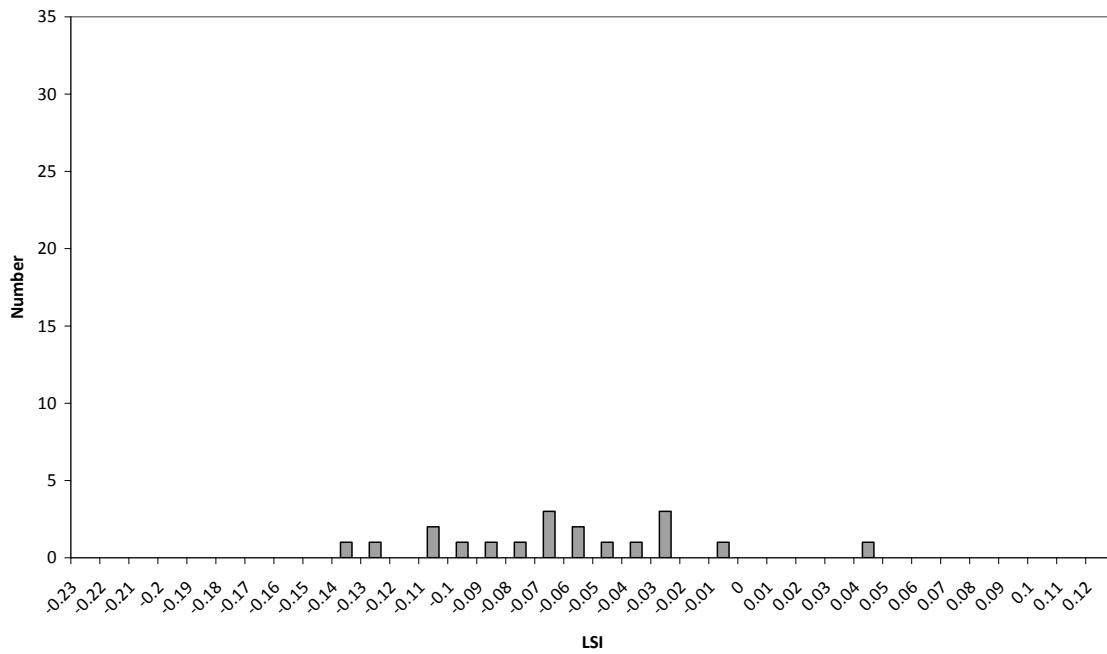


Fig 6.118: Level C sheep width log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.07)

There is no discernable change in the size of the Tell Sabi Abyad sheep based on the width measurements. The vast majority of measurements are far smaller than the standard and obviously reflect a population of

sheep far smaller than their wild ancestors. Tentatively, it can be suggested that a width LSI value of -0.06 seems to represent the boarder between the smaller females and the larger males.

Finally the sheep depth measurements were analysed. Figure 6.119 shows the depth LSI values for all levels combined. This graph is roughly binomial. The majority of LSI values fall well below the standard with only a few relatively heavy (male) individuals present. There were also some very light individuals present (perhaps representing immature females). The depth LSI values are slightly skewed to the left with a skew value of -1.62.

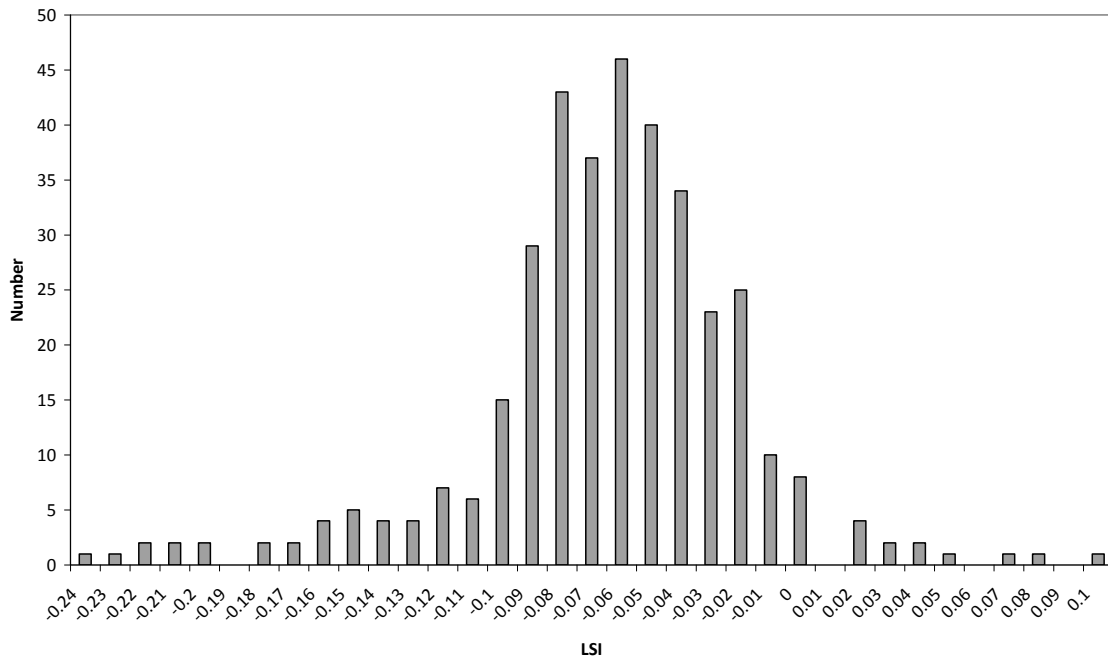


Fig 6.119: Sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis*

In levels A12-A10 there are few very small measurements (fig 6.120). The LSI values range from -0.14 to 0.1.

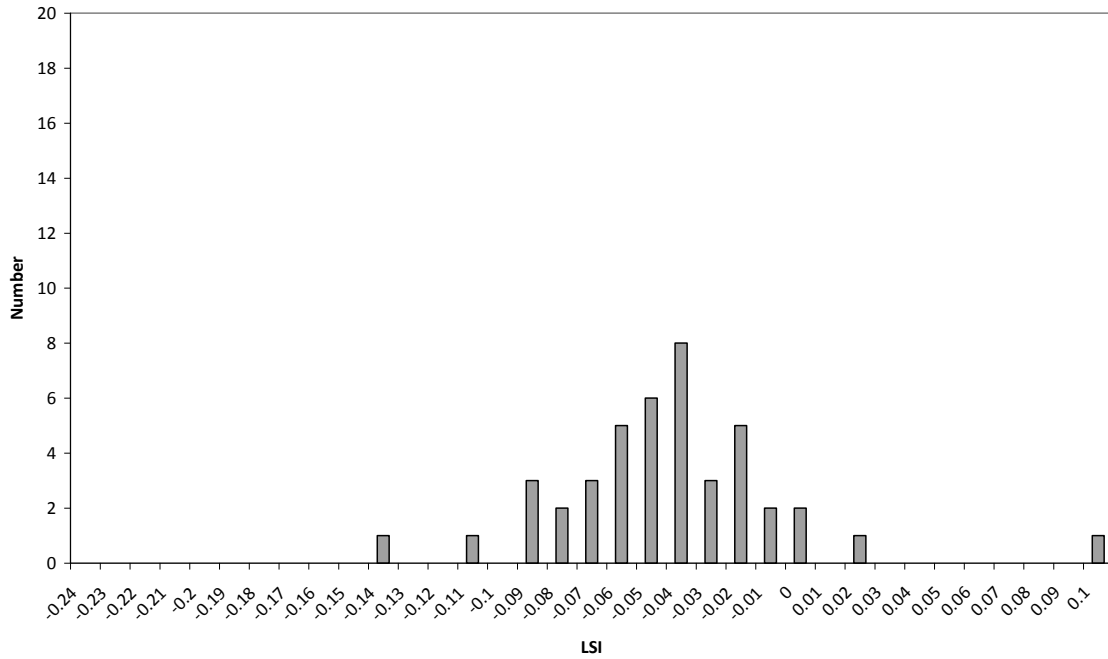


Fig 6.120: Levels A12-A10 sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.04)

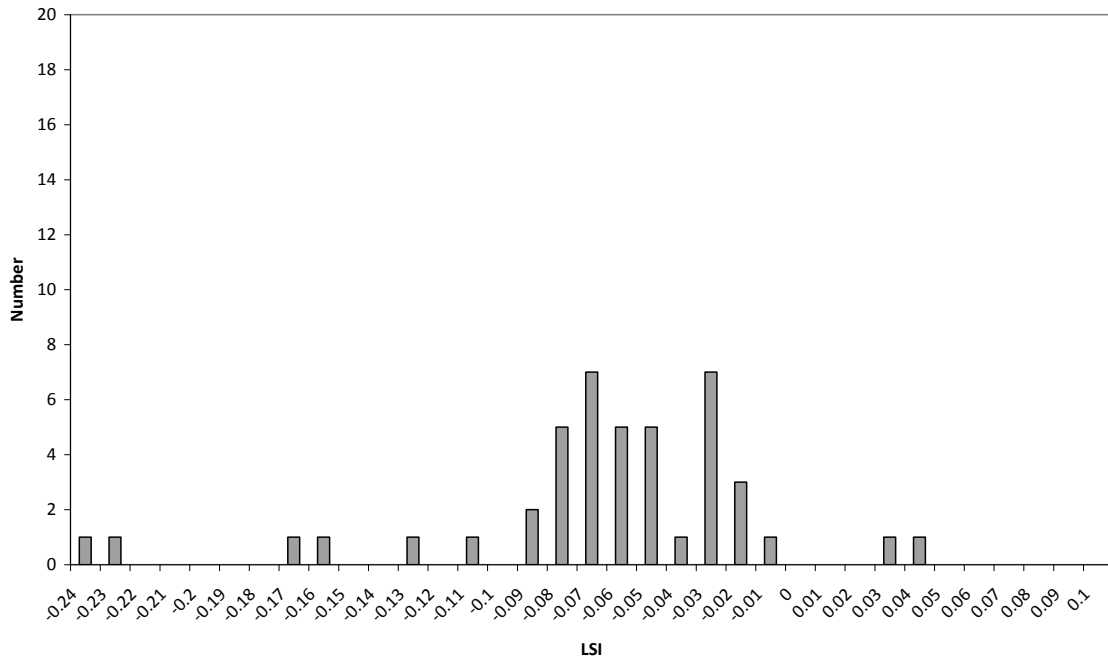


Fig 6.121: Levels A9-A5 sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.07)

Levels A9-A5 (fig 6.121) and A4-A3 (fig 6.122) have very similar data sets with the spread of LSI values being slightly larger in levels A9-A5.

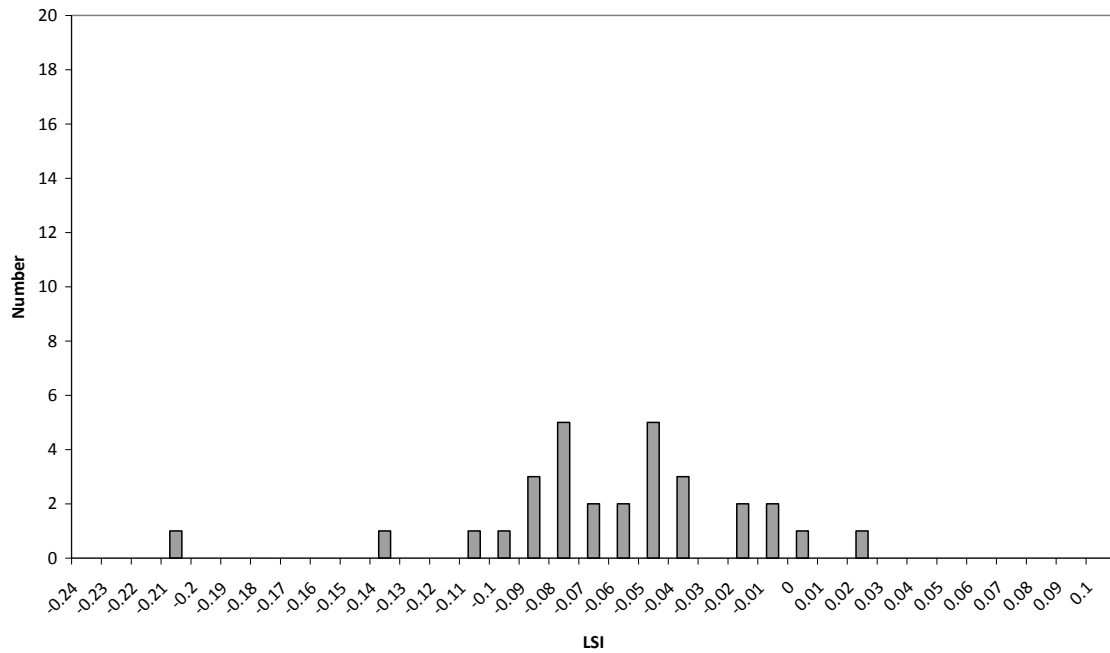


Fig 6.122: Levels A4-A3 sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.06)

The sample size from level A2 is too small to consider in detail (fig 6.123), all LSI values fell below the standard. Level A1 (fig 6.124) provides a large data set with the majority of LSI values falling below the standard and falling in the range of -0.09 to -0.02 with only a few measurement falling outside.

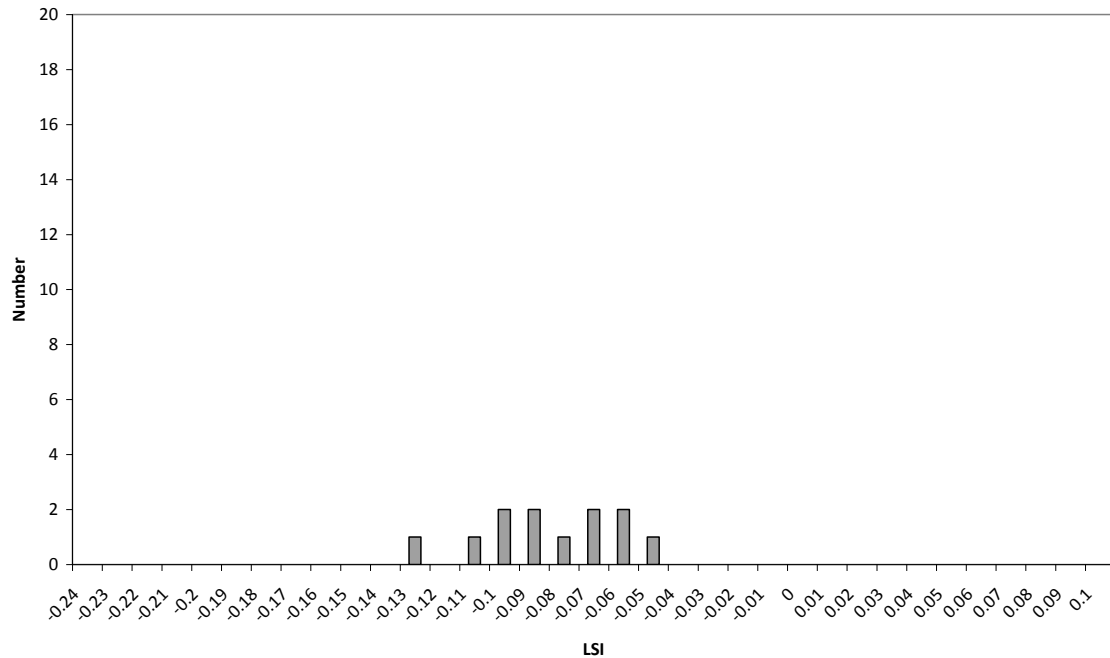


Fig 6.123: Level A2 sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.08)

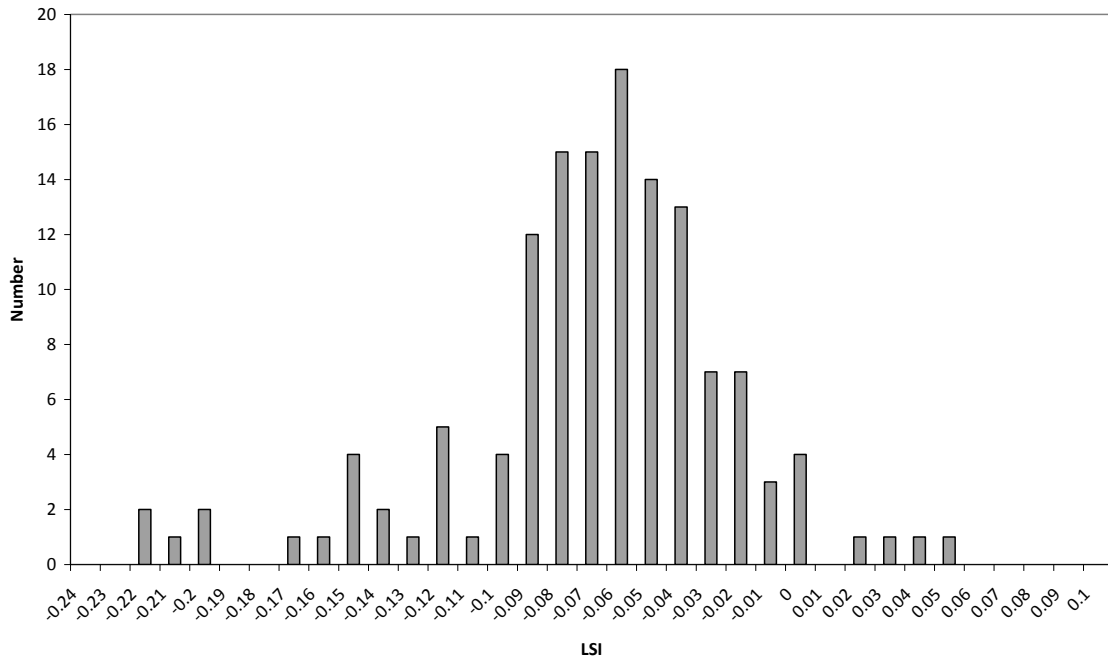


Fig 6.124: Level A1 sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.07)

The sample size from levels B8-B4 shows a cluster of LSI values between -0.12 to 0.00 with a peak at -0.08, some measurements were far larger than the standard (fig 6.125).

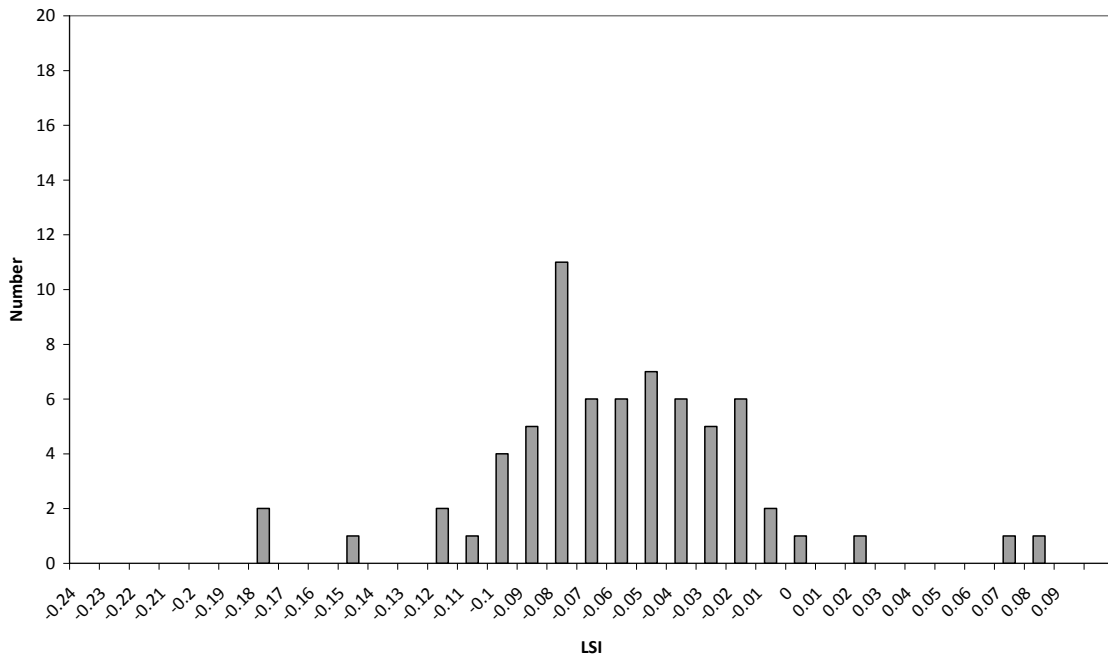


Fig 6.125: Levels B8-B4 sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.05)

Levels B3-B1 and C provided only very small sample sizes (fig 6.126 – 6.127) with all values falling below the standard.

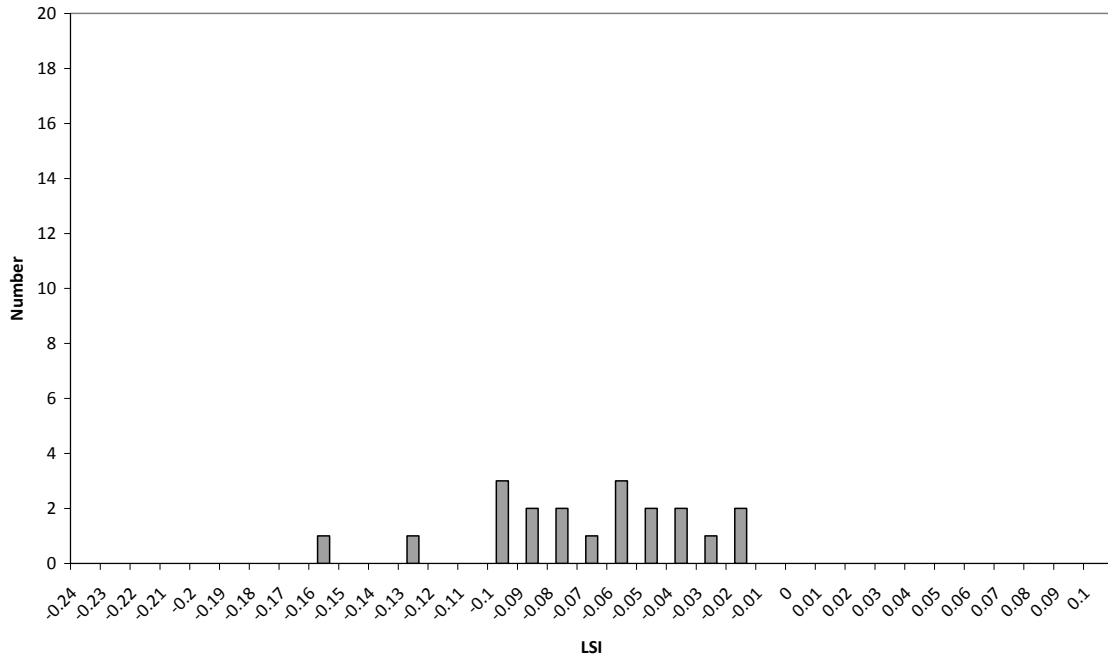


Fig 6.126: Levels B3-B1 sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.07)

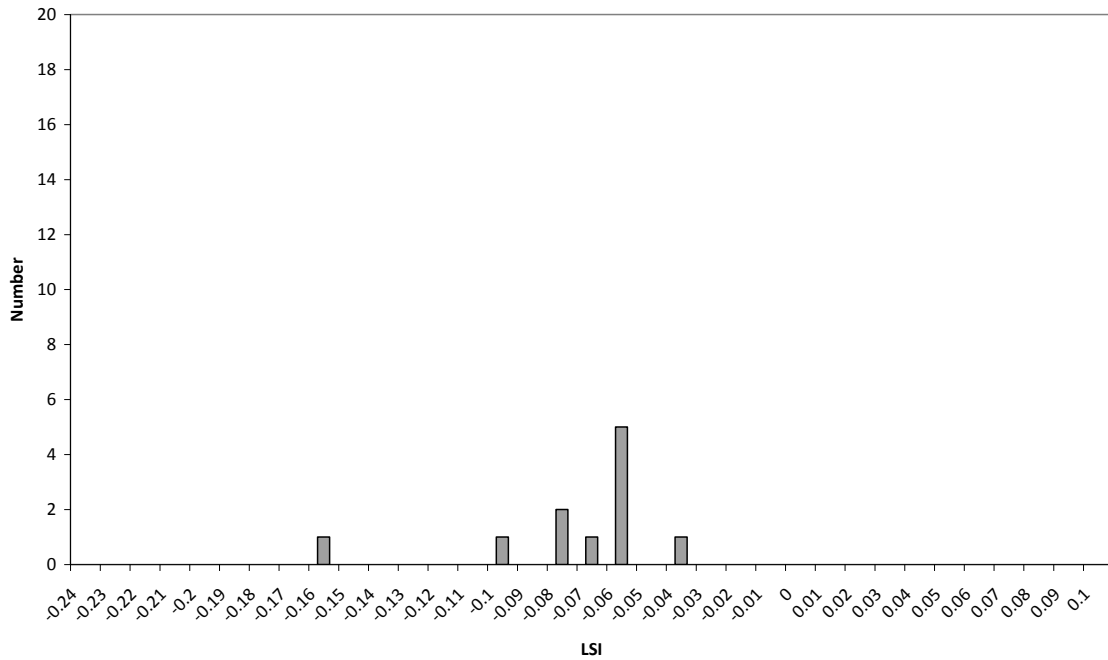


Fig 6.127: Level C sheep depth log ratio (site total): standard measurements based on modern female *Ovis orientalis* (mean = -0.08)

There does not appear to be any significant change in the general weight of animals through time. In all levels there is a similar spread of width LSI values, the vast majority of which are far smaller than the standard.

Summary

The LSI analyses of length, width and depth measurements for both sheep and goats show that the animals at Tell Sabi Abyad were far smaller than their wild progenitors. There was no clear increase or decrease in the height or weight of the animals through time. The skewed nature of the goat LSI values is evidence of sexual dimorphism with the majority of measurement coming from the smaller females. There is very little skewedness in the sheep measurements reflecting very little sexual dimorphism between the males and females.

6.3.9 Sex ratios

An analysis of the metrical data suggests a sex ratio of approximately four females to every male. This suggests the cull of some males before they reached maturity. A comparison of the BatF (distal breadth on the fusion line) of distally fused and unfused metapodials can be used to see if this was the case (fig 6.128 and 6.129). Many of the larger metacarpals were still distally unfused which may suggest that some males, which are inherently larger, were culled before they reached maturity. The picture is less clear with the metatarsals.

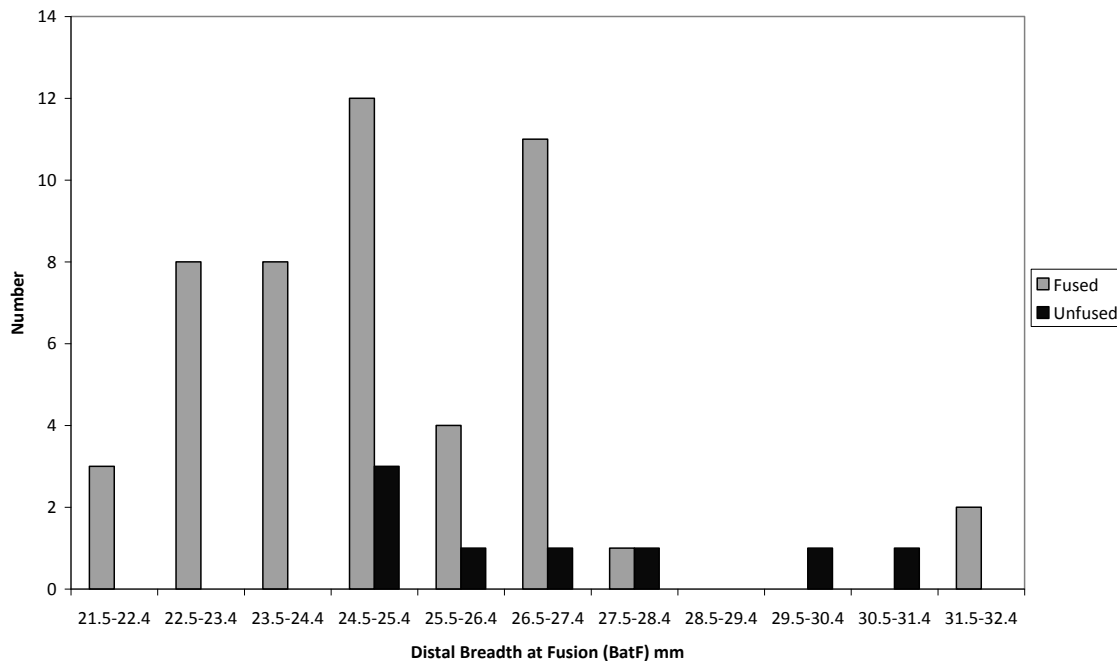


Fig 6.128: Comparison of BatF measurements of fused and unfused metacarpals (all levels)

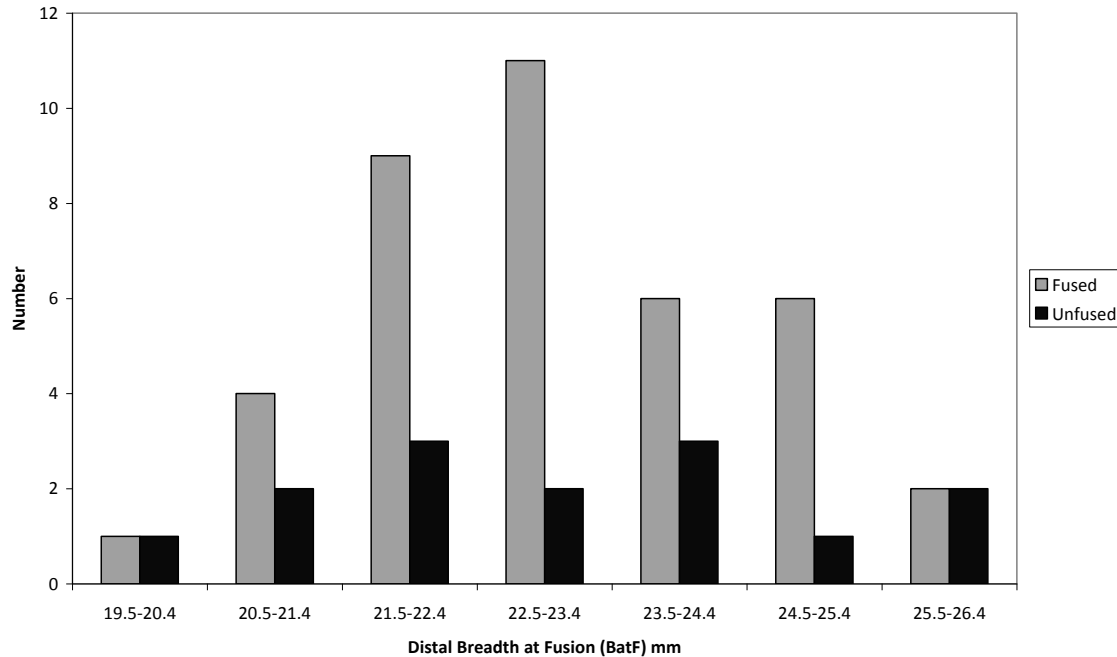


Fig 6.129: Comparison of BatF measurements of fused and unfused metatarsals (all levels)

The pelvises recorded were also sexed where possible. Only 56 pelvises had parts of the bone necessary for sexing. Out of these 29 were identified as male and 27 as female. This would give a sex ratio of one male to every female.

6.3.10 Domestication status

Both sheep and goats were domestic at Tell Sabi Abyad in the Late Neolithic. This is shown in both the mortality curves of the animals which clearly show a herd managed by humans for the production of meat and also secondary products such as milk and fibres, and in the size of the animals which were far smaller than their wild progenitors. There was no decrease in the size of the animals through time. In both the sheep and the goats at Tell Sabi Abyad both males and females were in general smaller than a wild female from the wild progenitor species. Wild goats would not be expected in the Jazirah as this is far outside their natural environment. Wild sheep could have been available locally but the inhabitants of Tell Sabi Abyad apparently chose to rely on herds of domestic sheep available. When domestic sheep and goats were brought to the site, or in the case of sheep, domesticated locally, remains unclear but it obviously happened earlier than the oldest levels analysed here. Herds of both sheep and goats were present at Tell Sabi Abyad from at least 6900 BC. These animals likely formed a mixed herd and the forms of animal husbandry used were well established and did not change much through time. The main change was that of an apparent shift to herd security and secondary product exploitation which began around level A2/A1.

6.3.10 Conclusions

Sheep and goats were the most common species in all levels and they dominated the assemblage in terms of numbers making up 60-80% of the assemblage in each level. Their importance in terms of the weight of meat they would have provided is less pronounced, making up only 30-60% of the weight of bone recovered in each level. Ovicaprids were most important in levels A1 to B4 but in general there was a slight decrease in the relative importance of ovicaprids through time, probably due to the increase in bos numbers. The sheep and goats at Tell Sabi Abyad were probably kept in a mixed herd, as they are today in the Jazirah, with about three times as many sheep as goats and with a herd composition of approximately 80% females to 20% males. The sheep and goats were domestic in all levels. All parts of the carcasses of these animals were found on site suggesting that the whole animal was butchered on site. The good meat

bearing bones of the fore and hind limbs were most common. There did not appear to be any differences in the proportions of skeletal parts found in each level. Neither was there any difference between the contexts. This was to be expected as apparently the three main contexts – open areas, pits and room fills (see above) – all contained secondary or even tertiary deposits of rubbish. Butchery marks were most commonly caused through carcass disarticulation and skinning. The mortality profiles show that there were several changes in ovicaprid management and husbandry practices through time. There was a shift in the main culling age from two years of age in the oldest levels to three or four years of age in the youngest levels. There was also a slight increase in the number of neonates through time. This suggests a shift from prime meat production to keeping animals for secondary product exploitation. Nevertheless, the main aim of the animal husbandry was herd security in all levels. Both sheep and goats appear to have been managed and exploited in the same way.

6.4 Sus

6.4.1 *Sus* proportions

Sus were found in all levels and make up 7.5% of the assemblage in terms of numbers and 7.4% in terms of bone weight. *Sus* are the second most common species (after ovicaprids) in the A levels but are relegated to third place in the B levels after an increase in *bos* proportions. In terms of the number of *sus* bone fragments, *sus* are most important in levels A12-A10 (c. 17%) after which their importance decreases dramatically, practically disappearing from the assemblage by levels B8-B4 (fig 6.130). There is then a revival in numbers in levels B3-B1 and C, but they do not reach the popularity seen in levels A12-A10.

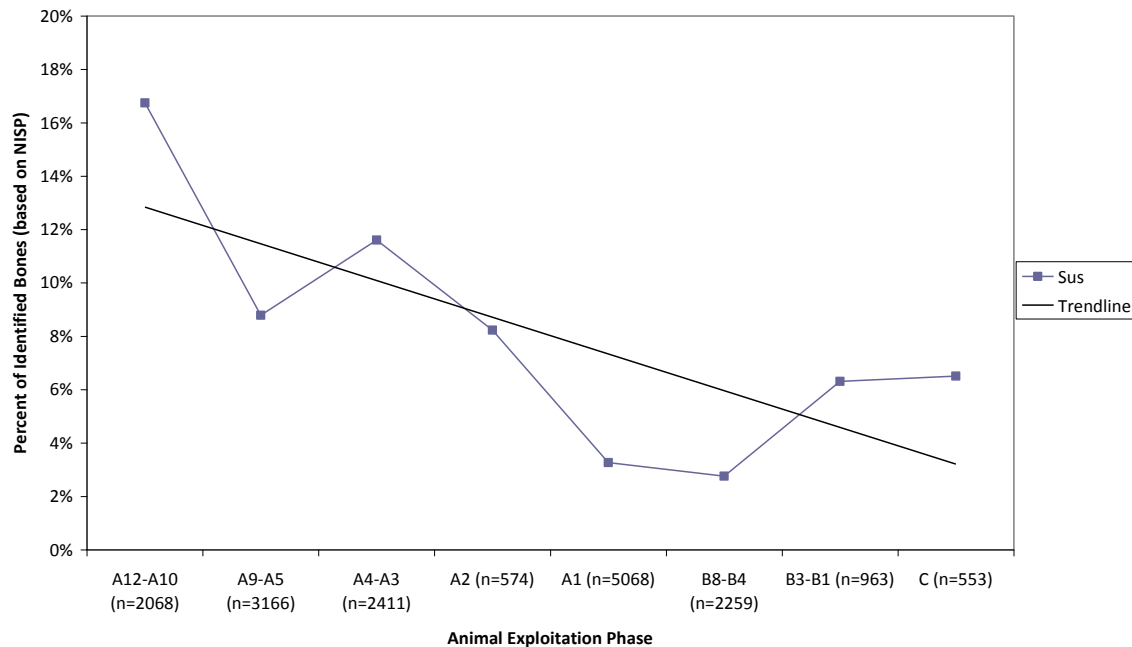


Fig 6.130: *Sus* species proportions by animal exploitation phase (NISP)

A similar picture is painted when looking at the weight of *sus* remains recovered from each animal exploitation phase (fig 6.131). Adding a trend line highlights the decline of this species.

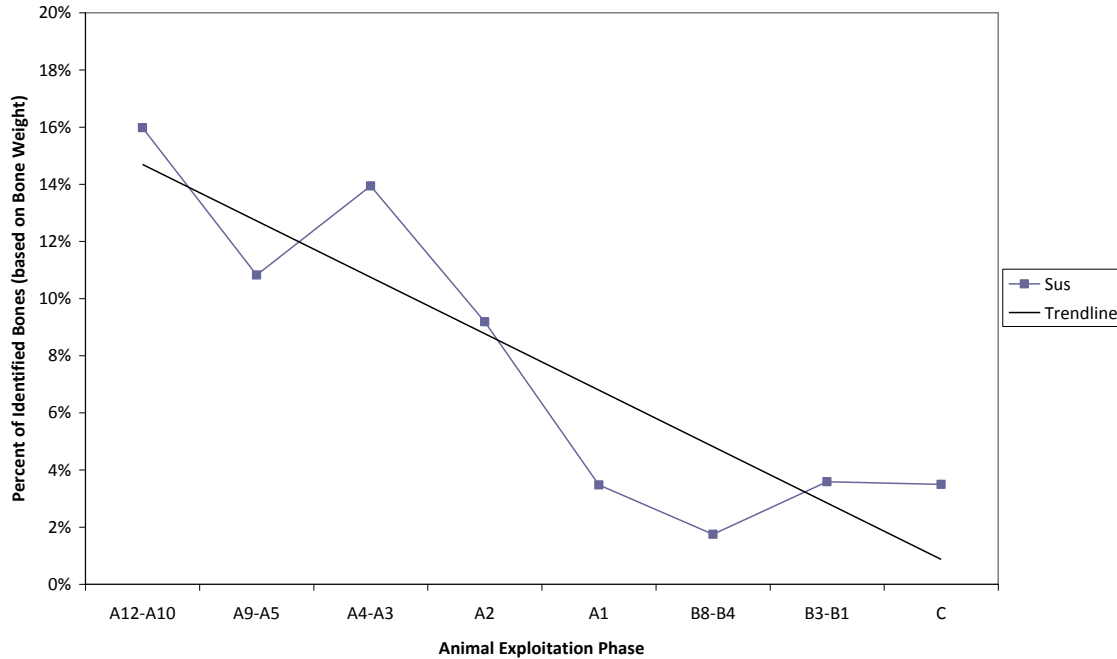


Figure 6.131: *Sus* species proportions by animal exploitation phase (Bone Weight)

6.4.2 Body part distribution

Body part distribution was calculated using both the NISP and MNI (the Minimum Number of Individuals, which was used to compensate for the bias of naturally more common bone elements in the skeleton) by both level (fig 6.132 – fig 6.137) and for open areas (fig 6.138), pits (fig 6.139) and room fills (fig 6.140). Vertebrae (with the exception of the first two vertebrae the axis and atlas) and ribs were excluded because of the difficulties associated in identifying the elements to species.

Levels A12-A10, A9-A5 and A4-A3 are all very similar in terms of the body part proportions recovered (fig 6.132 – 6.134). In these levels the sacrum and femur are generally missing and the most common elements are the mandible, scapula, radius and ulna.

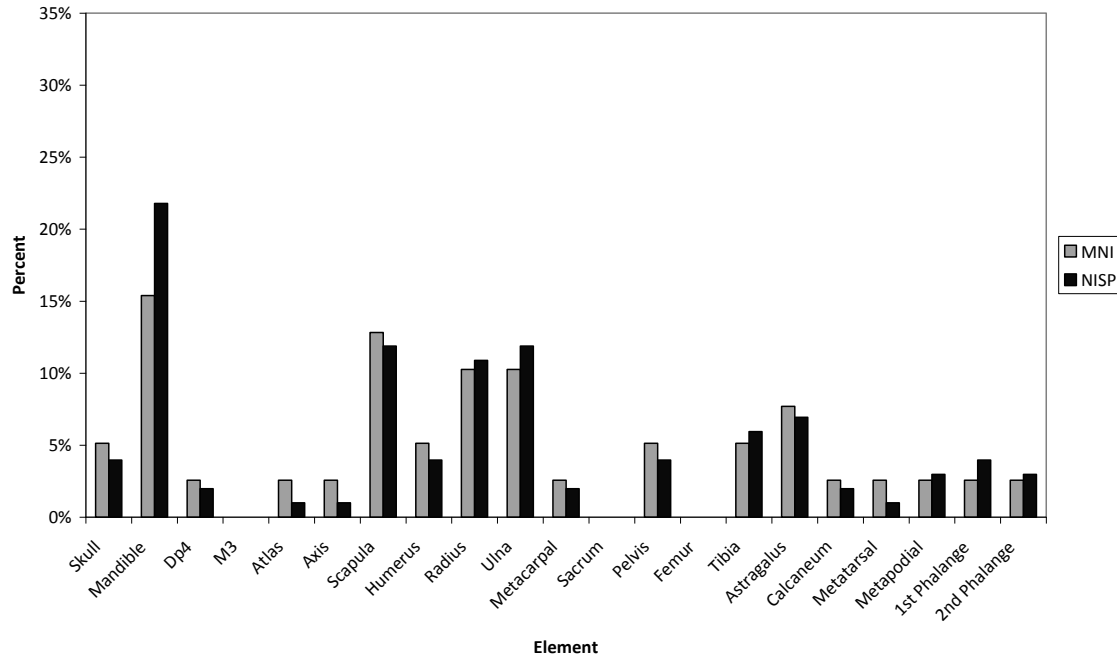


Fig 6.132: Levels A12-A10 sus body part proportions

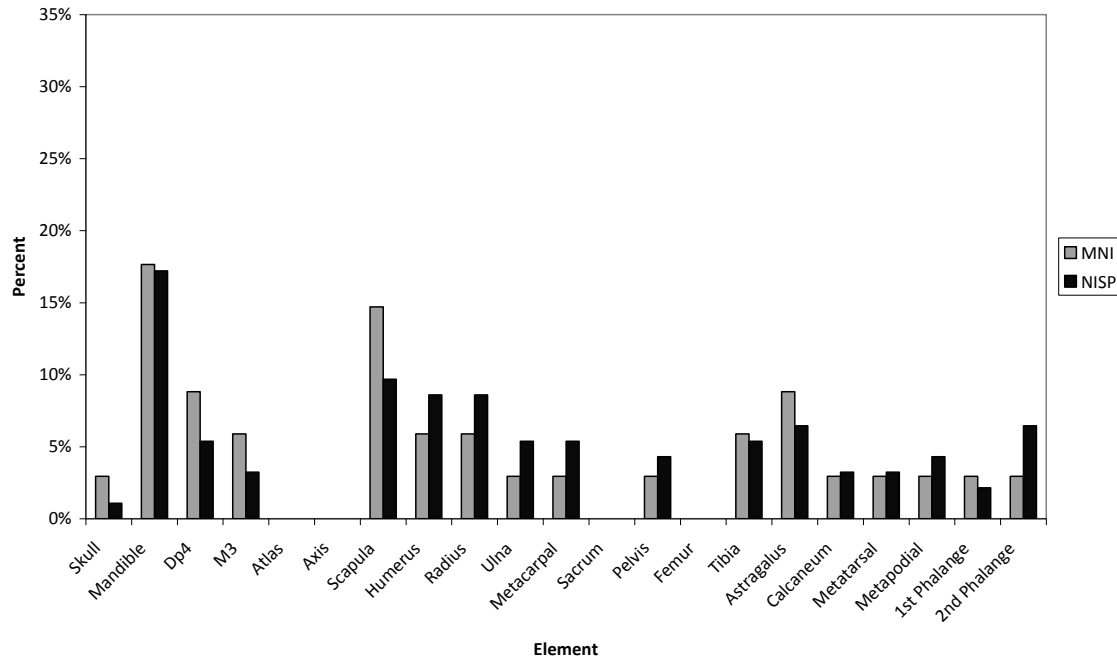


Fig 6.133: Levels A9-A5 sus body part proportions

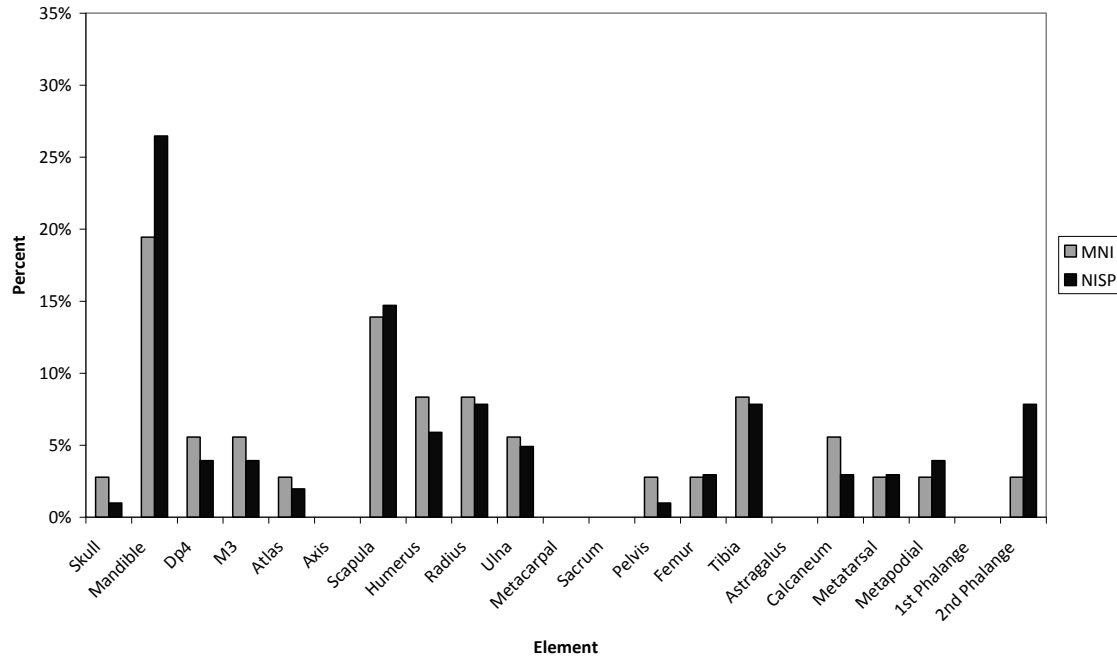


Fig 6.134: Levels A4-A3 sus body part proportions

In level A2 many parts of the carcasses were missing including the skull, sacrum, lower fore limbs, hind limbs and feet (fig 6.135). The most common element recovered was the mandible. In level A1 the neck, sacrum and femur were missing but in general most areas of the carcass were recovered, with the most common body parts being the forelimb (scapula, humerus, radius and ulna) and mandible (fig 6.136).

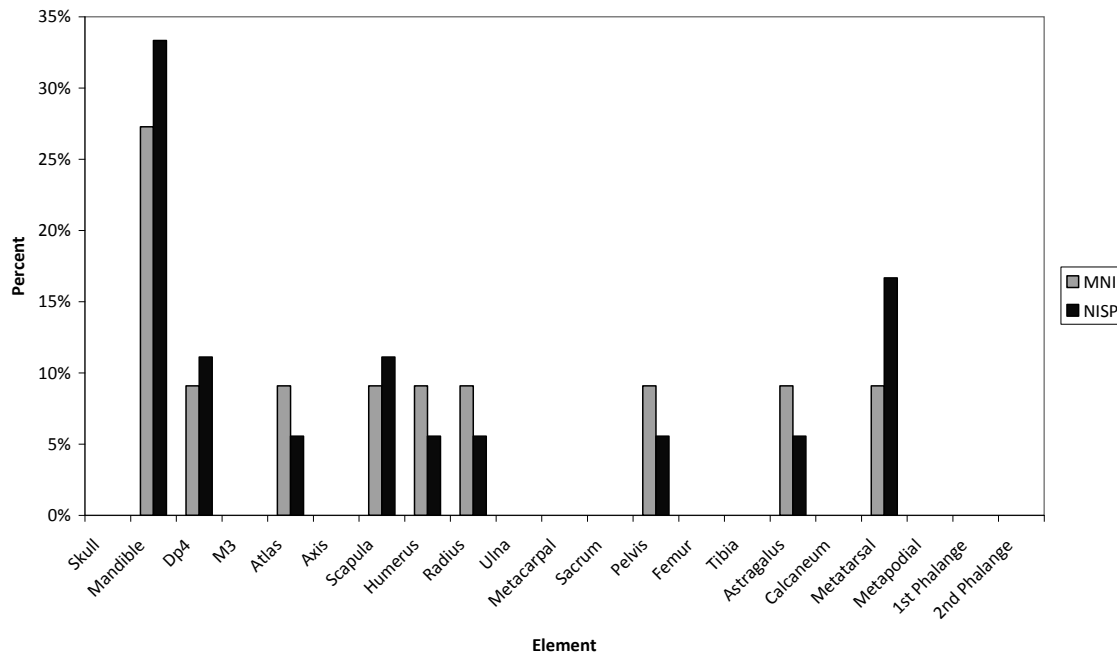


Fig 6.135: Level A2 sus body part proportions

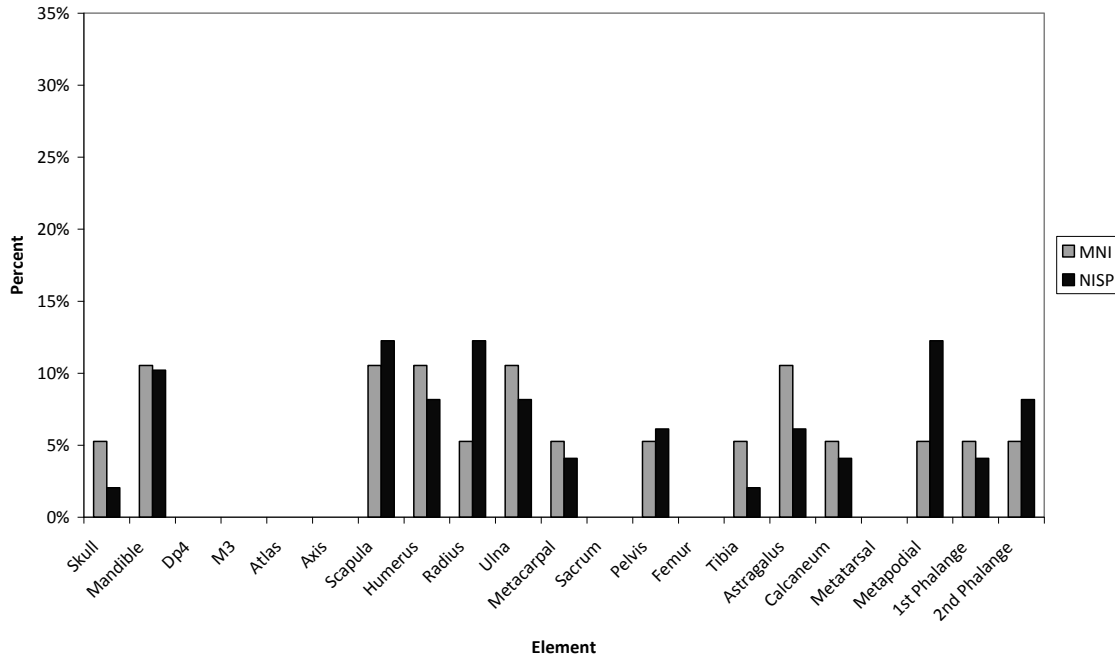


Fig 6.136: Level A1 sus body part proportions

The sample sizes for levels B8-B4 and B3-B1 were very small so these levels were combined (fig 6.137). Some parts of the carcass were not present in the B levels with areas of the body such as the skull, neck, pelvis, sacrum and metapodials conspicuously absent from the assemblage.

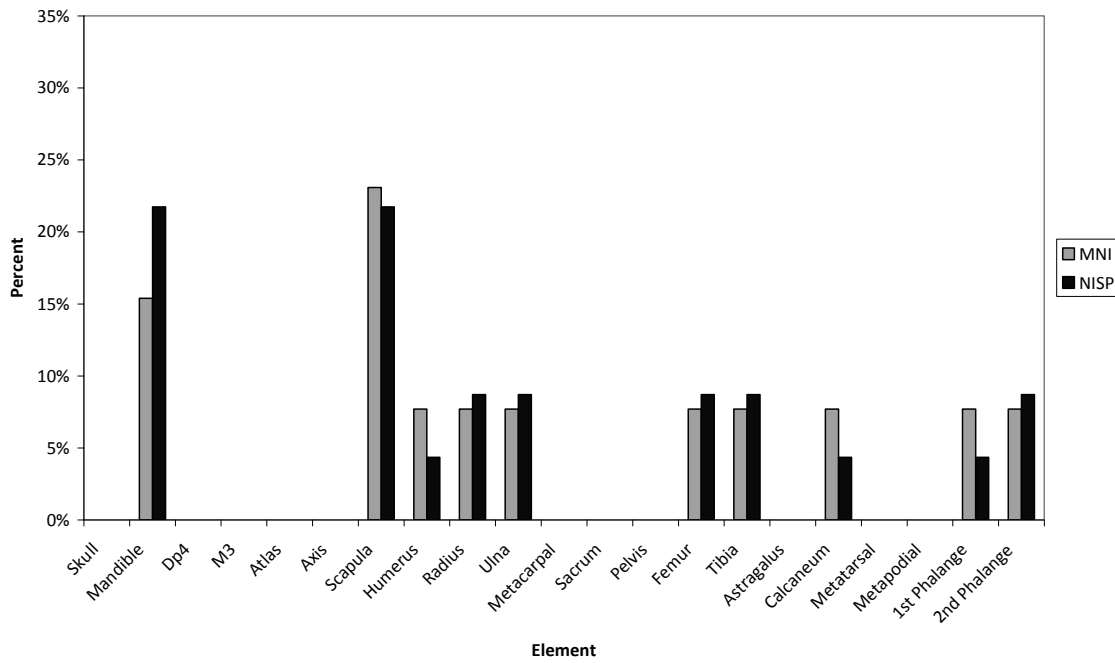


Fig 6.137: Levels B8-B1 sus body part proportions

The sus assemblage in level C consisted mostly of tooth fragments with just two scapula, one radius, one 2nd phalanx and a skull fragment. As there was such a small sample size a body part distribution graph was not drawn.

In all levels there are areas of the body missing from the sus assemblage. This is particularly the case in the C and B levels where many elements are missing. This suggests that whole carcasses were not processed on the site. In the older levels, A12 to A3, most areas of the skeleton are present with the most common parts being the mandible and elements of the forelimb. Whole carcasses were probably processed on site in these levels but not in levels B8 to C.

There appears to be little difference between the body part proportions recovered in open areas (fig 6.138), pits (fig 6.139) and room fills (fig 6.140) with the most common skeletal parts being the mandible and elements of the forelimb. Mandibles are particularly common in pits and second phalanges in room fills. Open areas had most parts of the skeleton present.

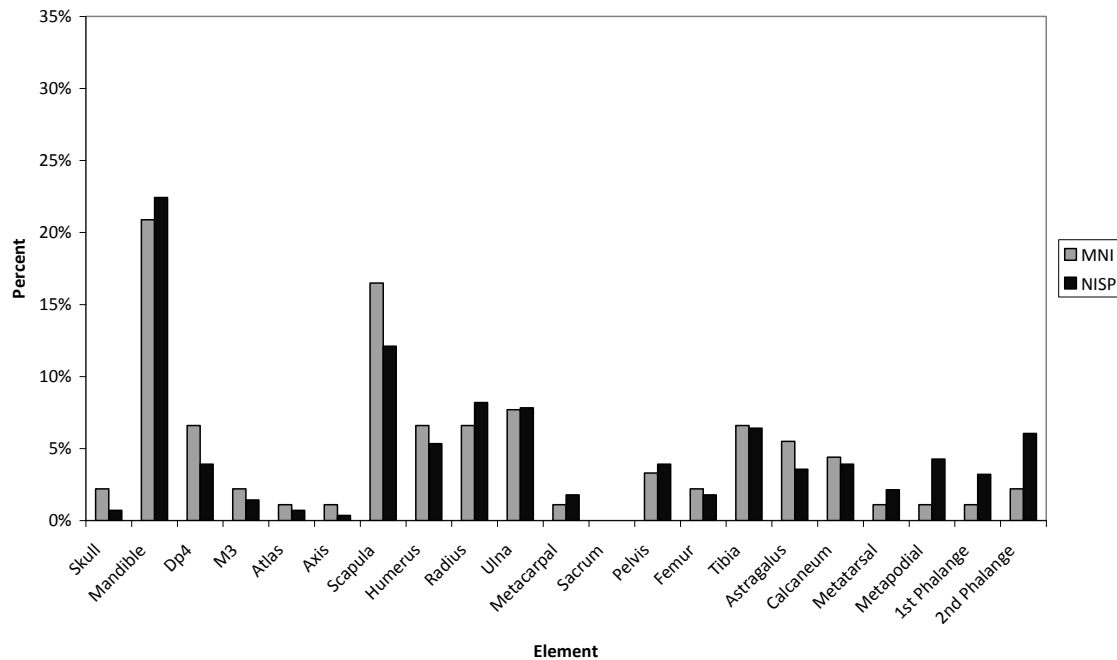


Fig 6.138: Open area sus body part proportions

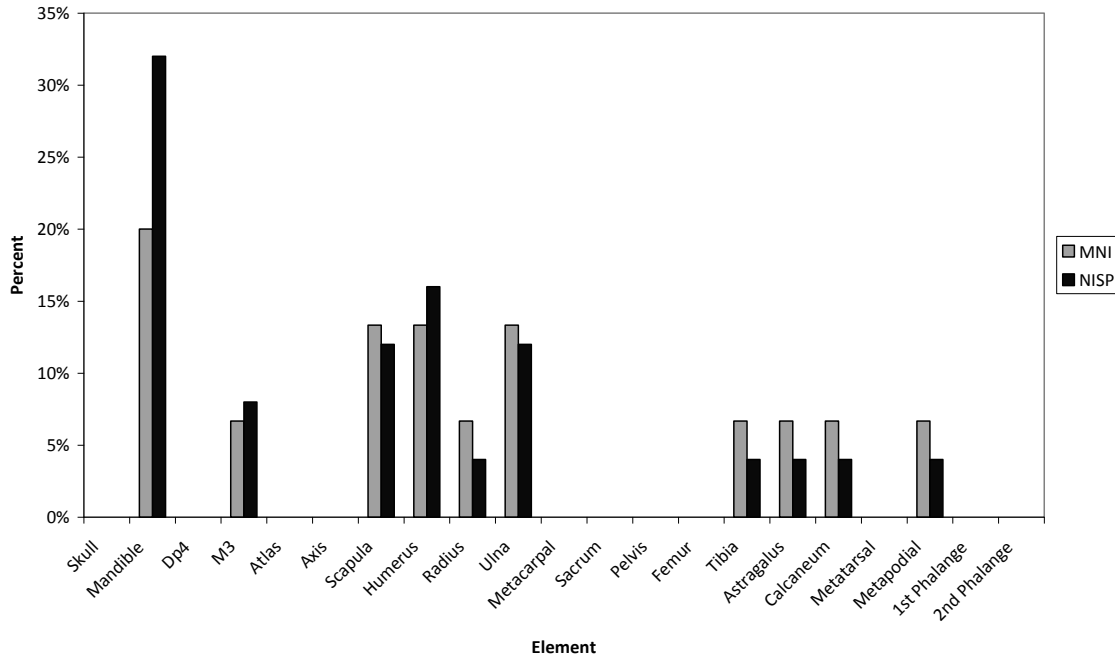


Fig 6.139: Pit sus body part proportions

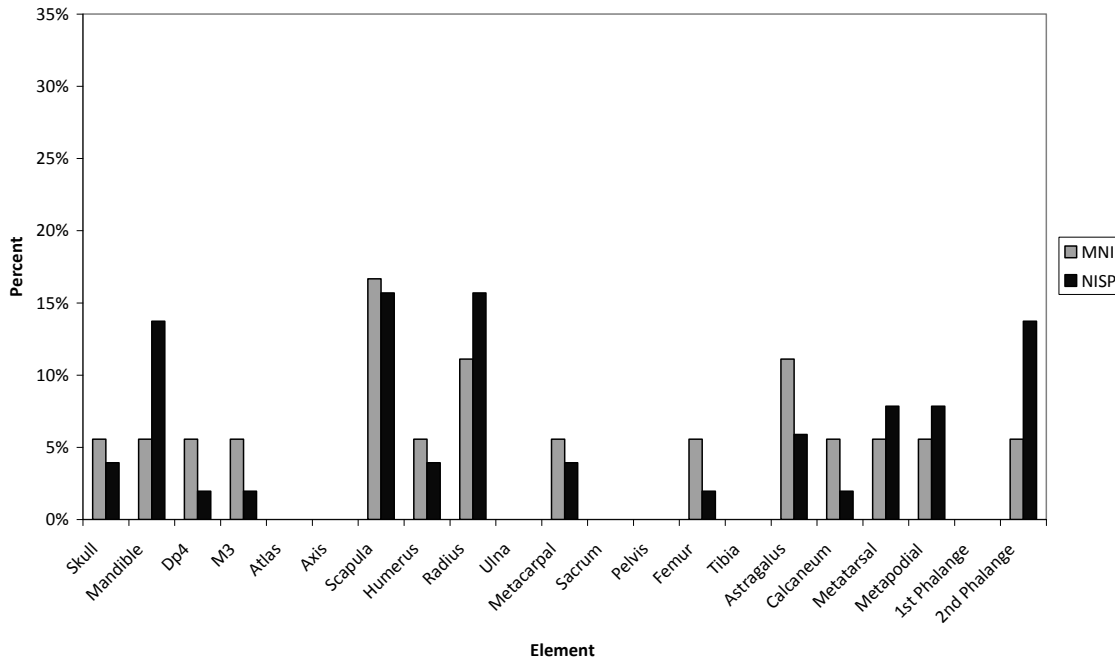


Fig 6.140: Room fill sus body part proportions

In the C and B levels many areas of the body were missing. In levels A12-A3 most areas of the body were present. No clear patterns emerged when comparing the different contexts. In general it appears as if whole sus carcasses were processed on the site in the oldest levels only.

6.4.3 Butchery

Only ten sus bones showed signs of butchery. These marks were all cut marks located at sites in the skeleton which are typical of disarticulation and skinning (fig 6.141).

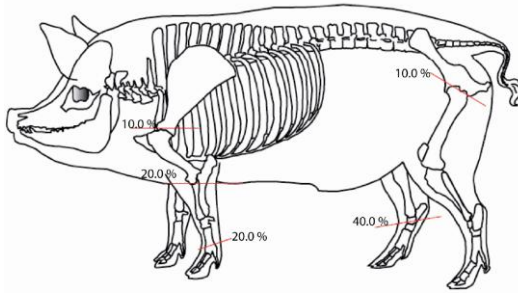


Fig 6.141: Location of butchery marks on the sus skeleton

6.4.4 Age profiles

Age profiles were calculated using both postcranial fusion (fig 6.142 – 6.145) and mandibular toothwear (fig 6.146). Unfortunately there were not enough sus remains from phases B8-B4, B3-B1, or C to construct any form of mortality curve. Only phases A12-A10, A9-A5, A4-A3, A2, and A1 will be considered here.

The fusion status of the postcranial elements was analysed first. In levels A12-A10 (fig 6.142) 80% of sus lived to 24 months with only 30% reaching 30 months. No animals lived beyond 36 months of age. A similar pattern is seen in levels A9-A5 (fig 6.143)

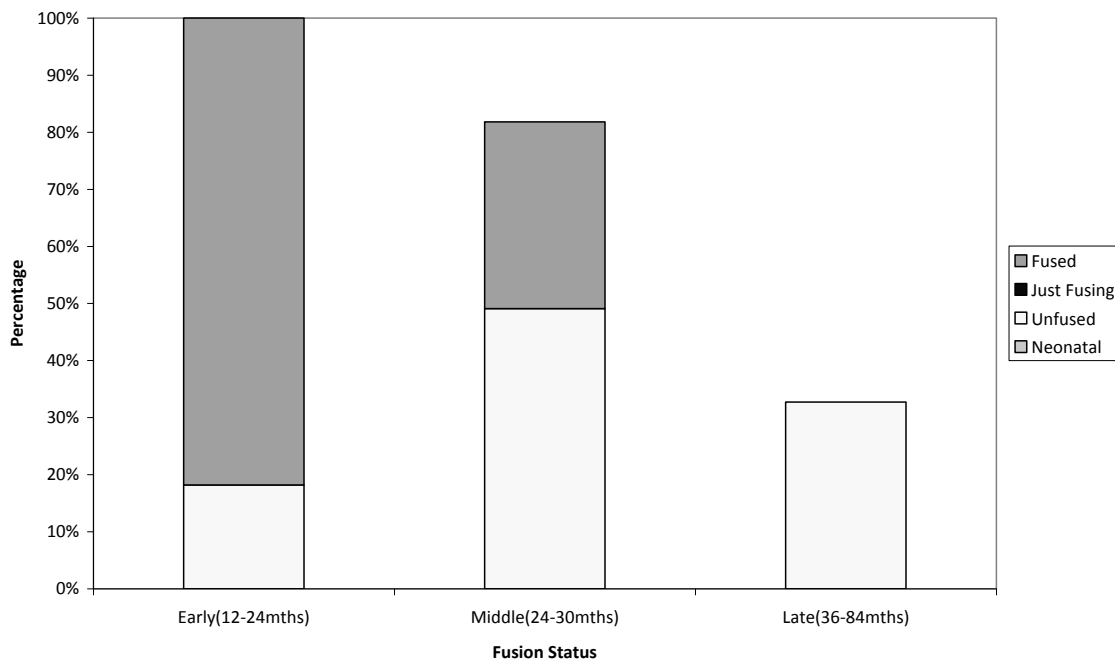


Fig 6.142: Levels A12-A10 sus age profiles from bone fusion

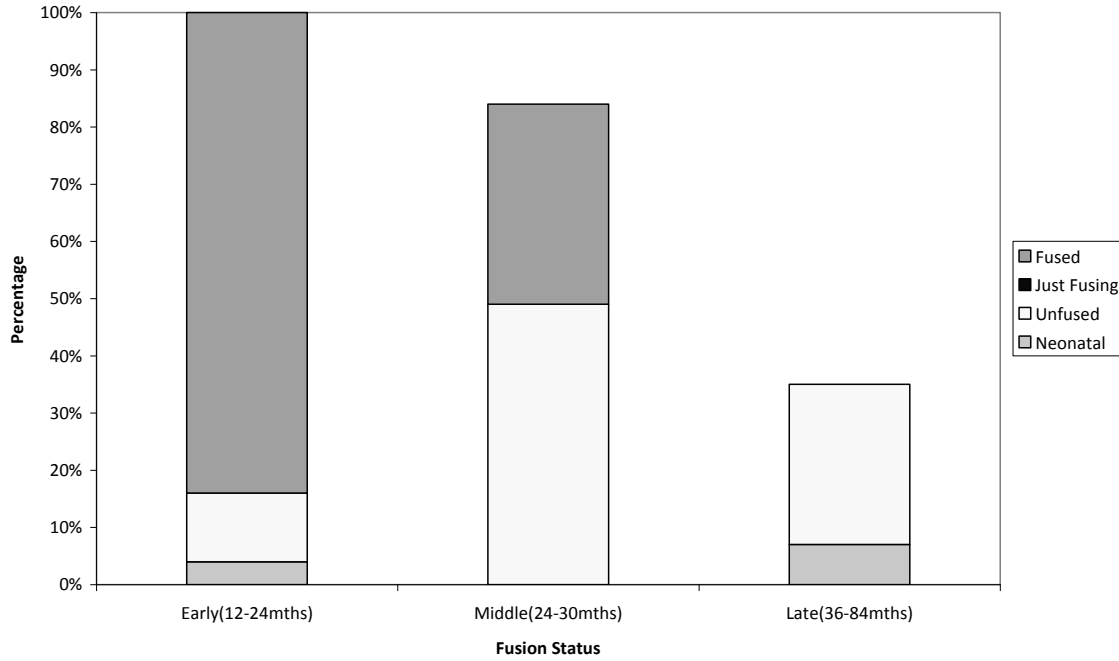


Fig 6.143: Levels A9-A5 sus age profiles from bone fusion

In levels A4-A3 75% of sus lived up to 24 months with 45% living up to 30 months (fig 6.144). No animals lived beyond 36 months of age and the main culling period was between the ages of two and three years.

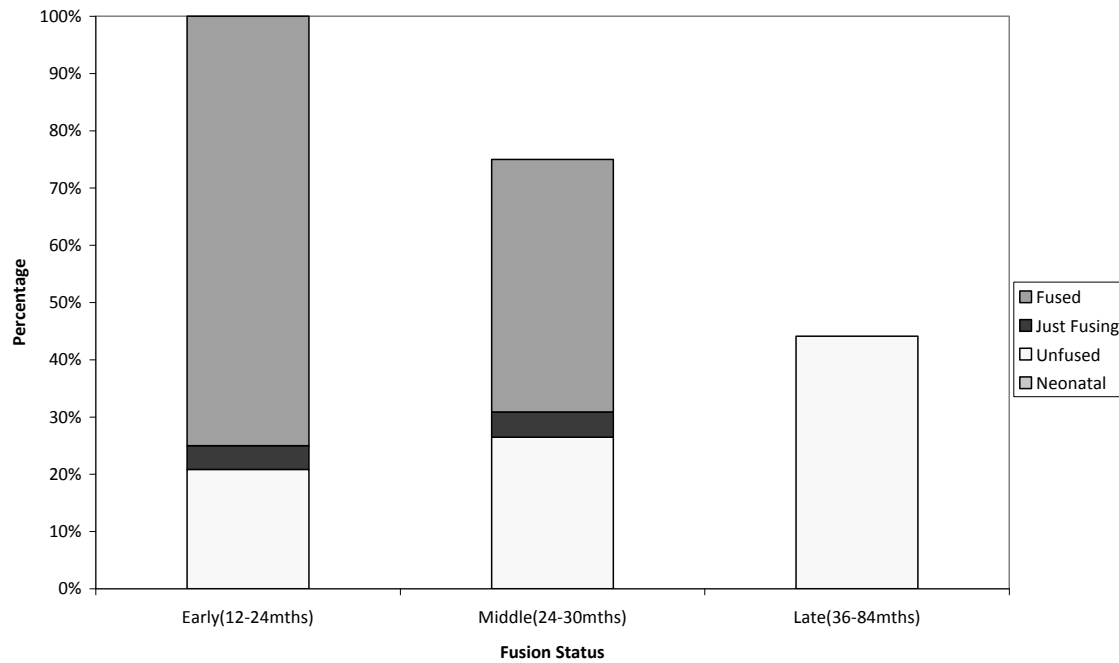


Fig 6.144: Levels A4-A3 sus age profiles from bone fusion

The fusion data from levels A2 and A1 were combined to create a larger data set as the sample size from each level was too small to deal with separately (fig 6.145). In these levels 80% of the population reached c. 24 months of age with 30% reaching up to 30 months of age. No animals survived up to 36 months. The main culling age appears to be between the ages of two and three years.

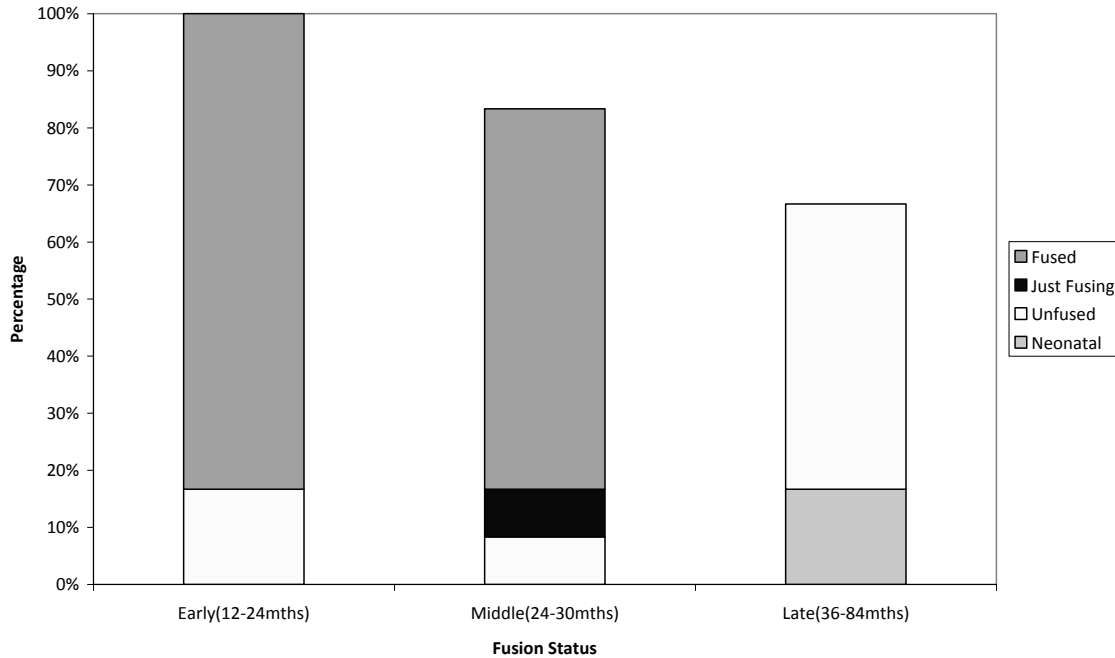


Fig 6.145: Levels A2 and A1 sus age profiles from bone fusion

In all levels the sus were culled between the ages of two and three years. Neonatal remains were only recorded in levels A9-A5, A2 and A1.

As sample sizes are very small for tooth wear analysis, the levels were combined into two groups: A12-A5 and A4-A1 (fig 6.146). In levels A4-A1 only 50% of the sus lived long enough to become juveniles, 30% to become subadult and 10% to reach full adulthood. In levels A12-A5 the survival rate is even lower with only 40% of animals becoming juveniles, 15% to subadult and 5% adulthood.

Both the mortality profiles from postcranial bone fusion and from toothwear show a similar pattern of sus animal husbandry, that being one of prime meat production only. Only a few adults were kept for reproduction while the rest of the sus were culled before they reached sexual maturity. This is a typical pattern of domestic pig exploitation for optimal meat production, with very few very young animals culled. Through time there appears to be a shift to keeping slightly more older individuals, but the main culling age remains the same.

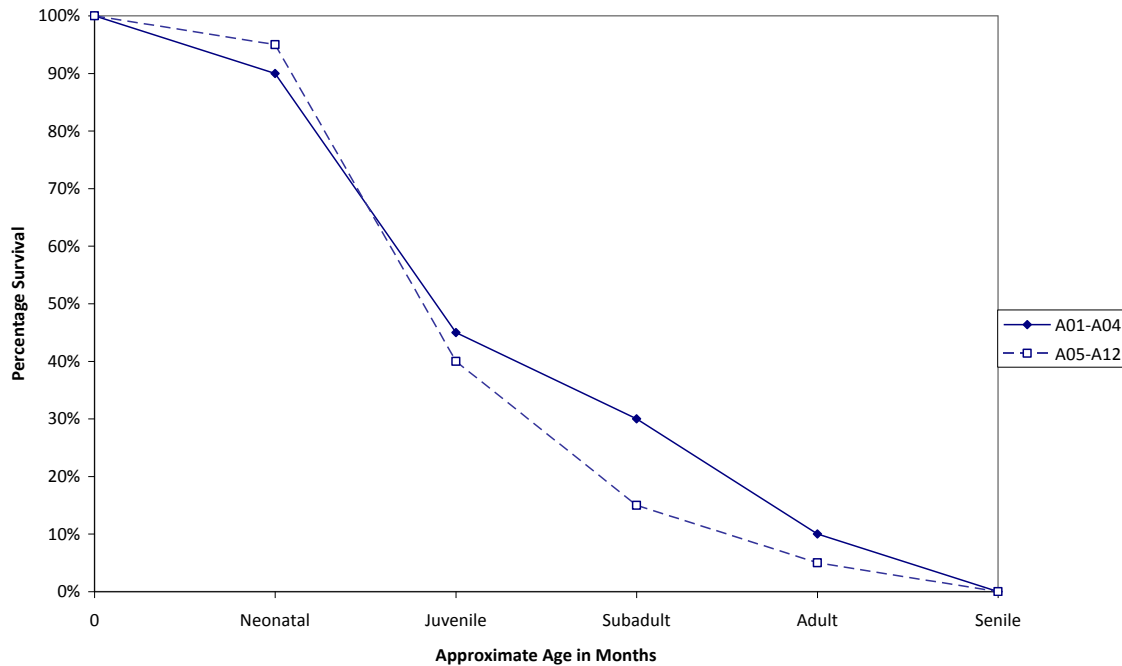


Fig 6.146: *Sus* mortality curve based on toothwear

6.4.5 Pathology

Only one sus bone showed signs of pathology, a 2nd phalanx showing signs of malformation perhaps due to either a healed break or old infection.

6.4.6 Metrical analysis

During the recording of the Tell Sabi Abyad material measurements were taken where possible. For a full list of the measurements taken see appendix 3.

As the number of individual measurements by species and element by level are so small all length, width and depth were grouped and analysed using the LSI technique (see chapter 5) by animal exploitation phase (fig 6.147 – 6.158). A full list of all sus measurements and a list of the measurements used in the LSI analysis are listed in appendices 3 and 4. The measurements from a female *Sus scrofa* from the site of Çayönü (Hongo and Meadow, 2000: 140) in Turkey were used as the standard. In some ways this is not the ideal standard to use, as although these wild boar are from a similar time period and a Near Eastern subspecies, they are also derived from a very different geographical area and environment than the sus at Tell Sabi Abyad. The sus at Çayönü were in their ideal habitat and are likely to be far larger than the sus living in the arid desert steppe of the Jazirah, an environment which is generally unsuitable for sus.

Even with the measurements from all levels grouped together, the sample of length measurements was very small with only 11 measurements available (fig 6.147). The majority of the measurements were smaller than the standard. Three measurements were larger than the standard and must have come from very large individuals and are likely to be wild and/or male.

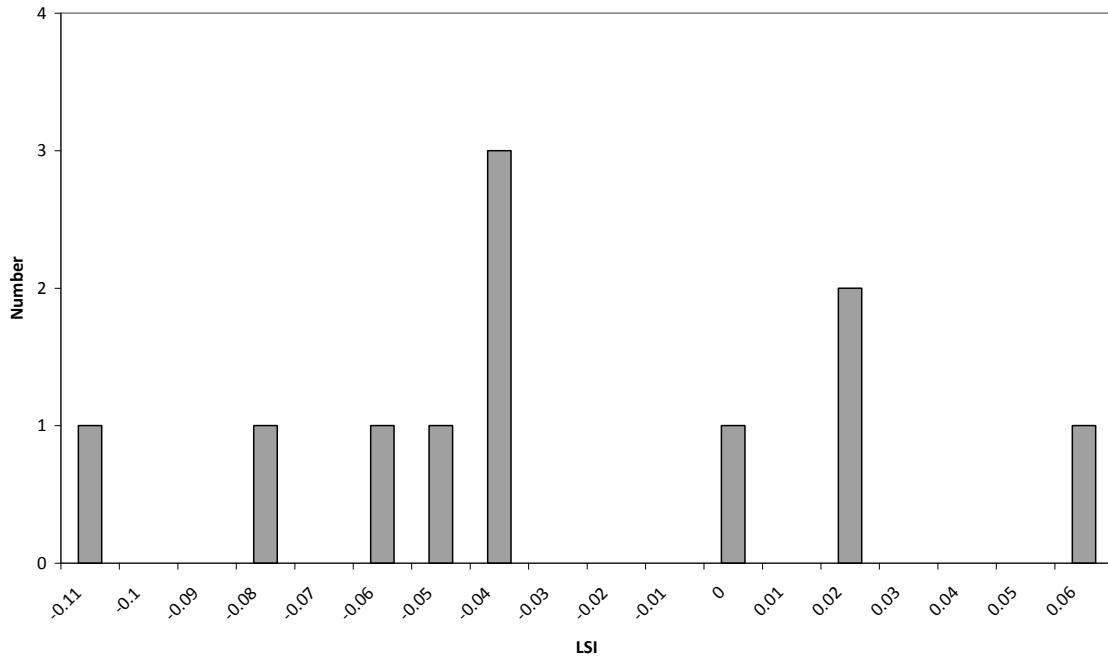


Fig 6.147: *Sus* length log ratio (site total): standard measurements based on female *Sus scrofa* (Çayönü)

The width LSI was calculated for the sus from all the levels combined (fig 6.148). The distribution of LSI values is roughly binomial, suggesting a single population. The majority of measurements were below the standard and are likely to be domestic sows. Those few measurements larger than the standard are possibly males.

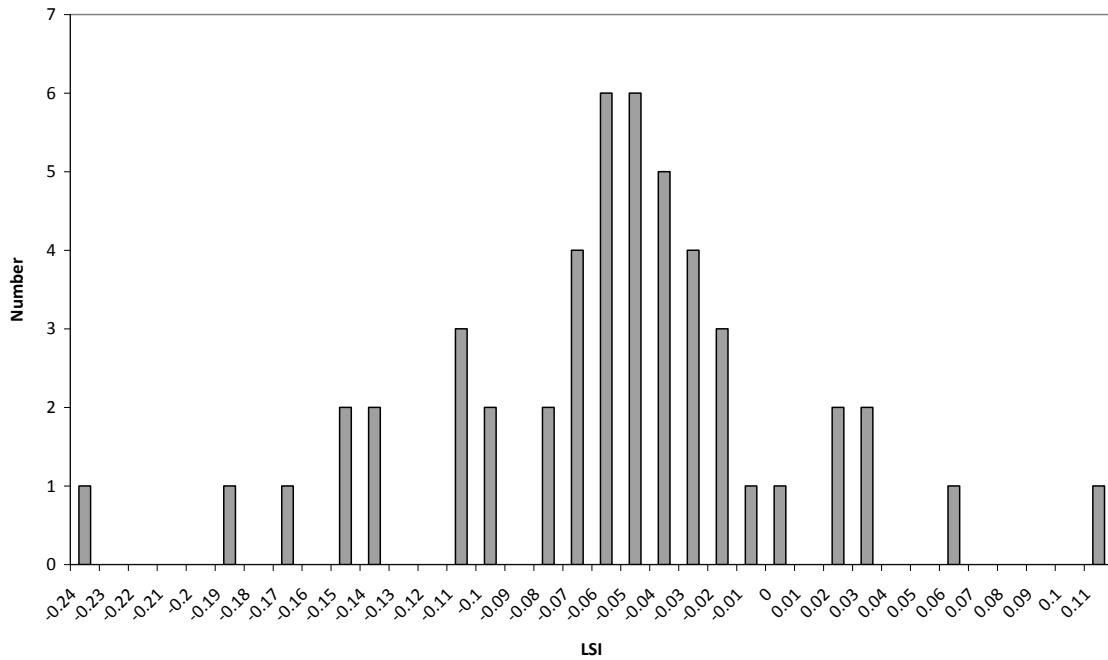


Fig 6.148: *Sus* width log ratio (site total): standard measurements based on female *Sus scrofa* (Çayönü)

In levels A12-A10 there are no measurements larger than the standard and several very small measurements (fig 6.149). A very narrow range of width LSI values was seen in levels A9-A5 with two measurements larger than the standard (fig 6.150).

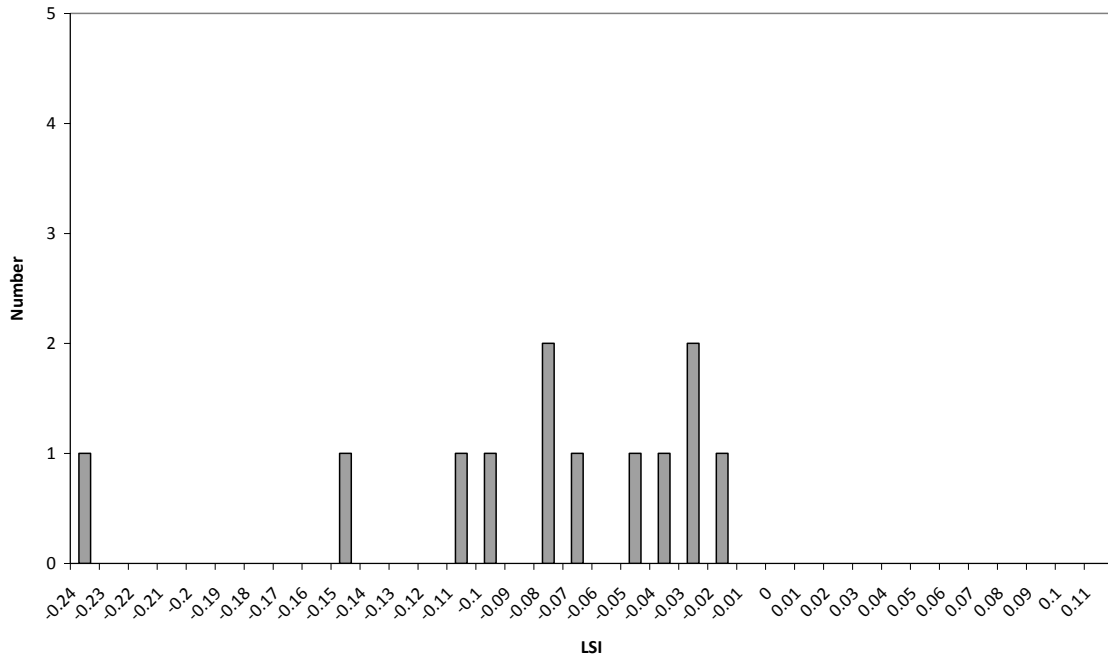


Fig 6.149: Levels A12-A10 sus width log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.08)

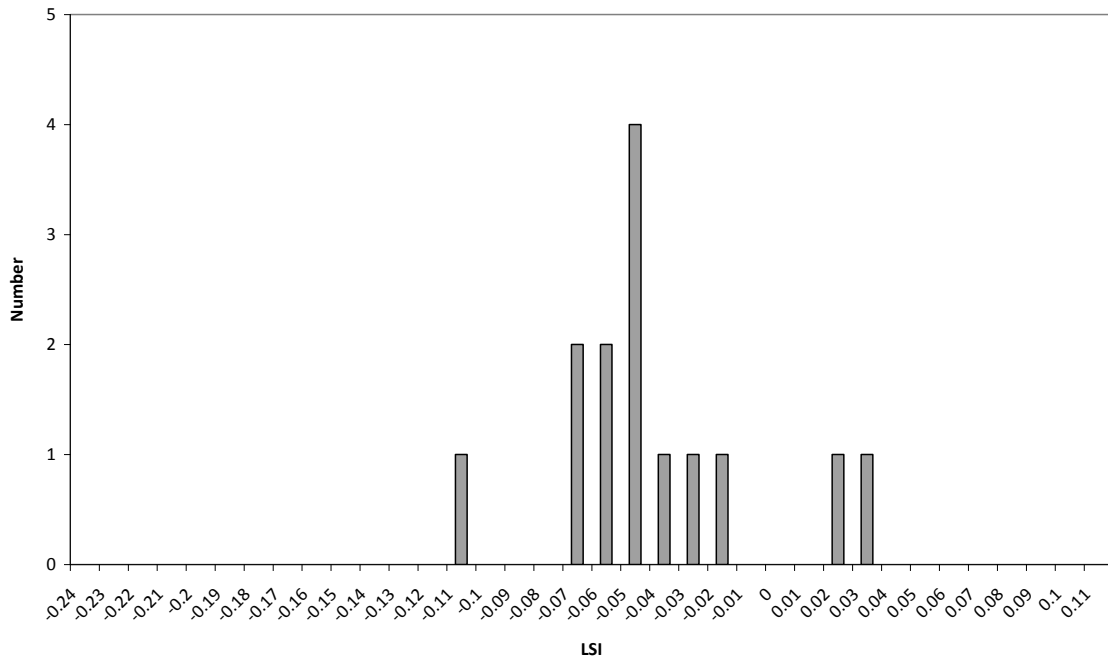


Fig 6.150: Levels A9-A5 sus width log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.04)

In levels A4-A3 all measurements were smaller than the standard with the exception of one measurement which was equal to the standard (fig 6.151).

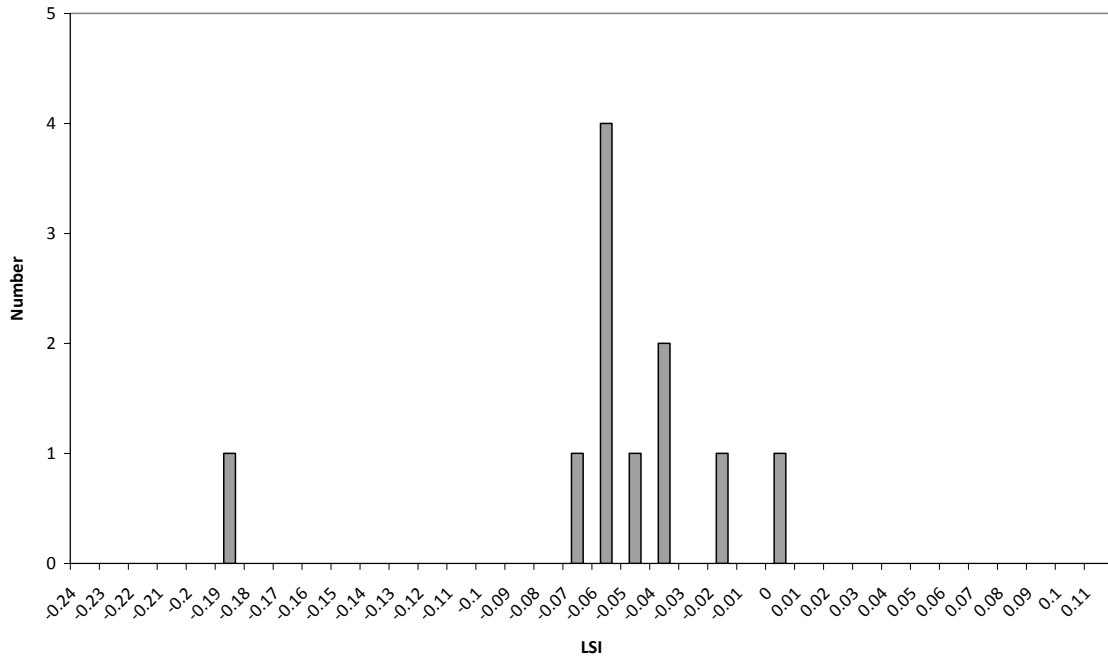


Fig 6.151: Levels A4-A3 sus width log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.06)

The sample sizes for levels A2 and A1 were very small so the width measurements from these phases were grouped (fig 6.152). In these levels there was a large spread of LSI values ranging from -0.17 to 0.11 suggesting a mix of very small domestic females and some far larger, perhaps wild and/or male, individuals.

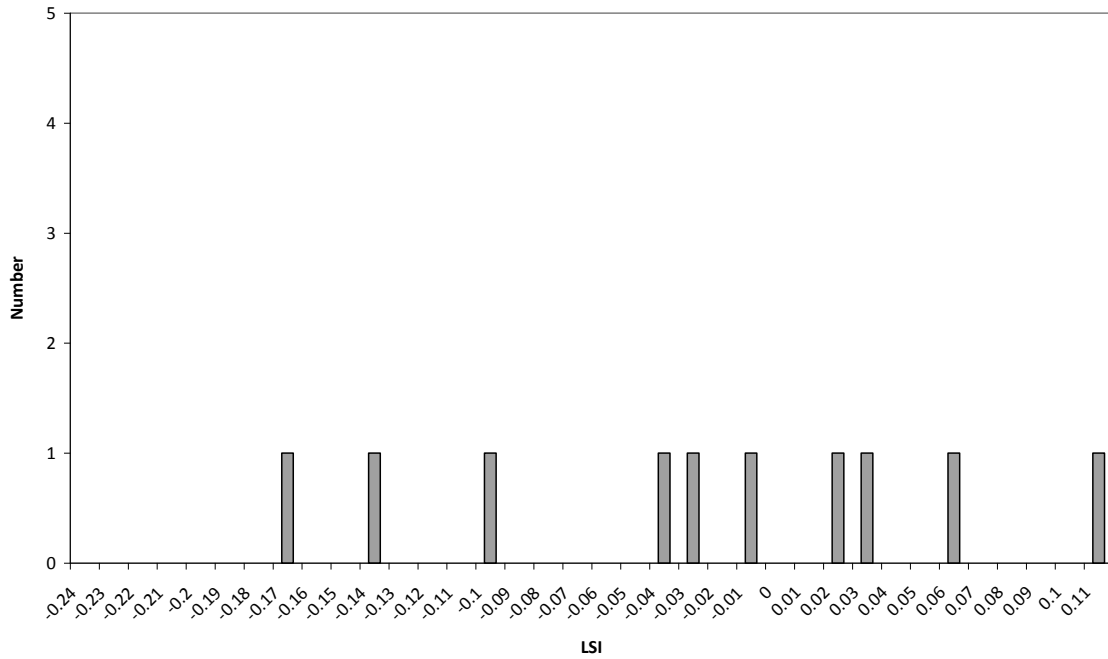


Fig 6.152: Levels A2 and A1 sus width log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.03)

Only three sus width measurements were available from levels B8-B1 and C combined (fig 6.153). All these measurements were far smaller than the standard.

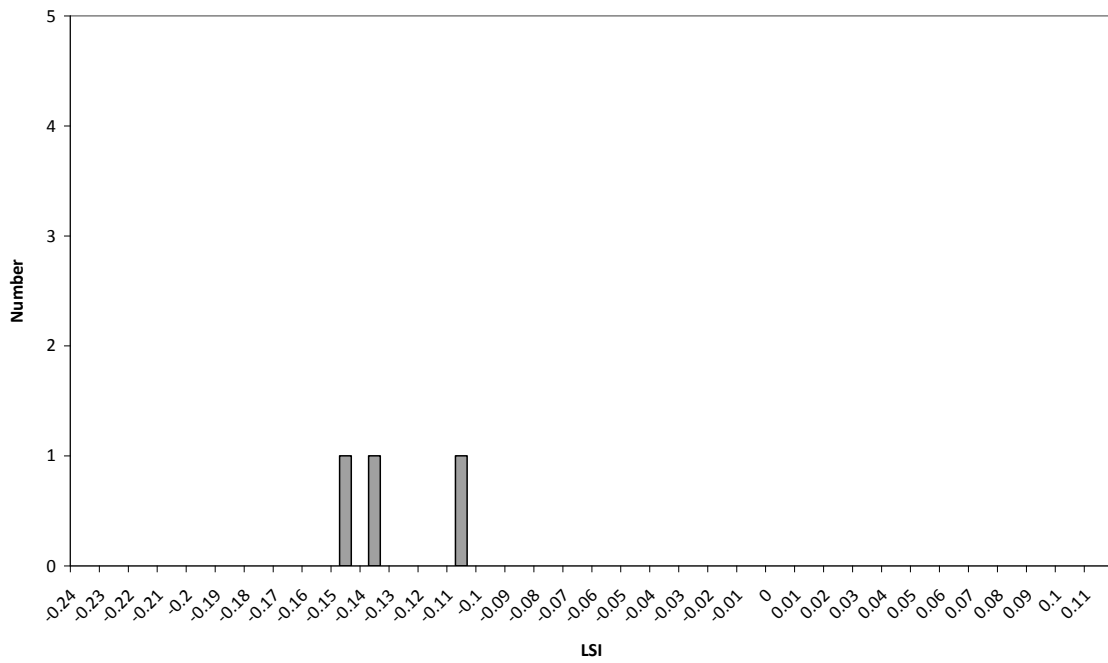


Fig 6.153: Levels B8-B1 and C sus width log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.13)

The majority of width measurements from all levels were smaller than the standard suggesting a population of domestic female pigs. There were some measurements larger than the standard, probably derived from male and/or wild individuals. With such small sample sizes it is difficult to detect any changes through time, looking at the data available though there does seem to be a trend towards more heavier individuals in the levels A2 and A1.

The depth LSI was calculated for the sus from all the levels combined (fig 6.154). Most measurements were far smaller than the standard with LSI values ranging from -0.19 to 0.08 with the majority of values falling between -0.07 to -0.01. The majority of measurements below the standard are likely to be derived from domestic sows. Those few measurements larger than the standard are possibly from male and/or wild individuals.

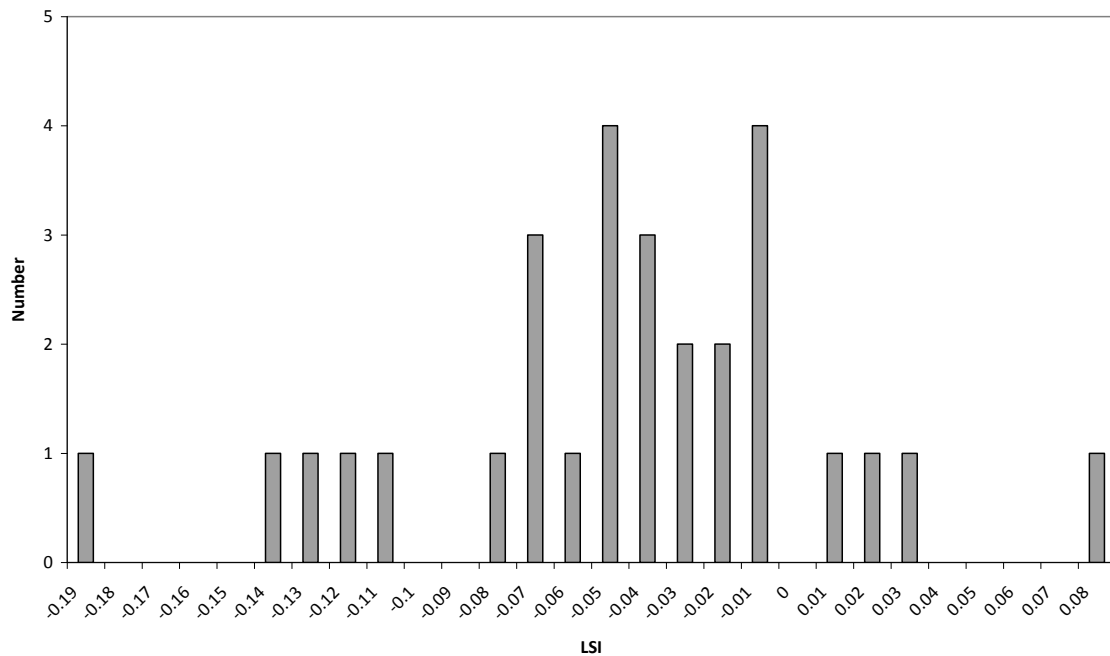


Fig 6.154: *Sus* depth log ratio (site total): standard measurements based on female *Sus scrofa* (Çayönü)

In levels A12-A10 and A9-A5 there is a much narrower range of LSI values with all measurements being smaller than the standard (fig 6.155 and fig 6.156).

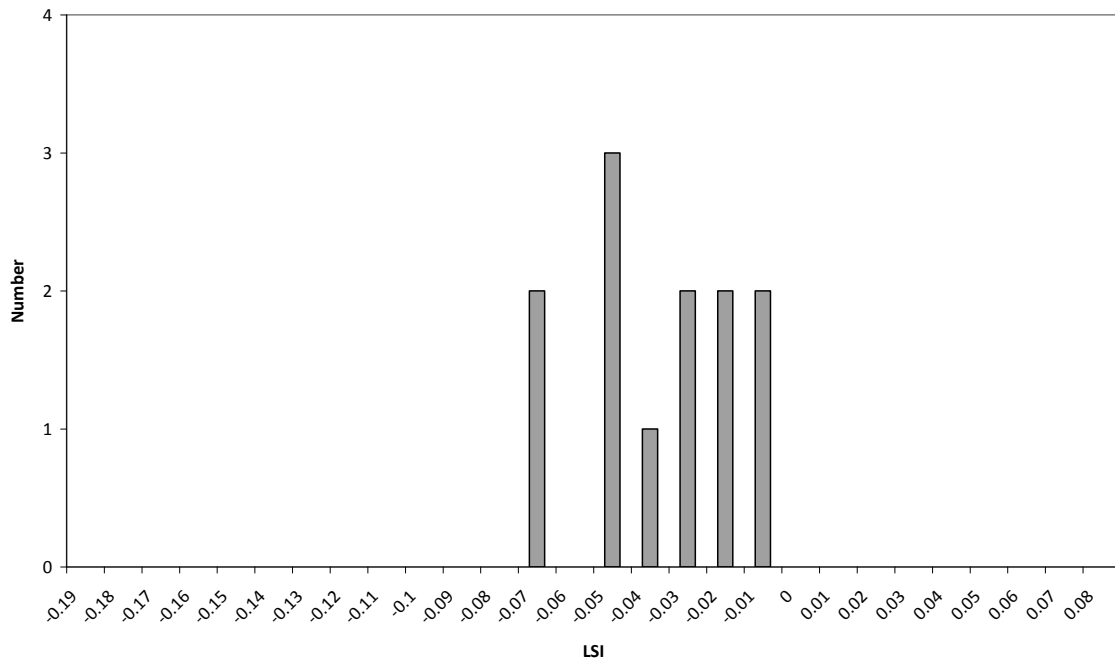


Fig 6.155: Levels A12-A10 sus depth log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.04)

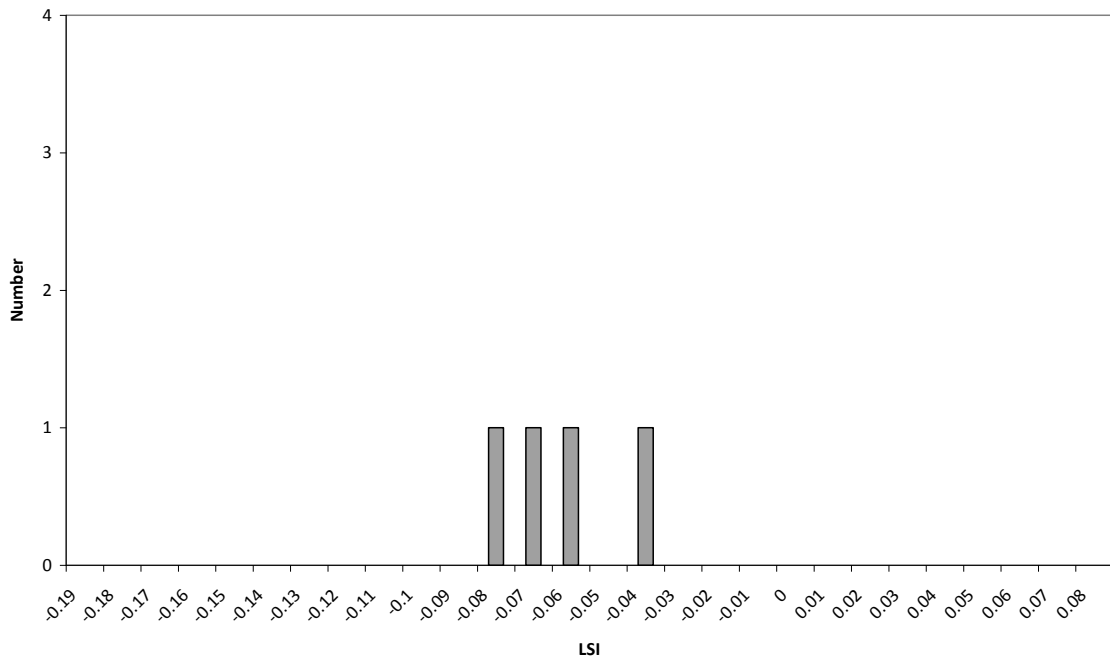


Fig 6.156: Levels A9-A5 sus depth log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.06)

In levels A4-A3 there is quite a spread of LSI measurements with most measurement falling below the standard (fig 6.157).

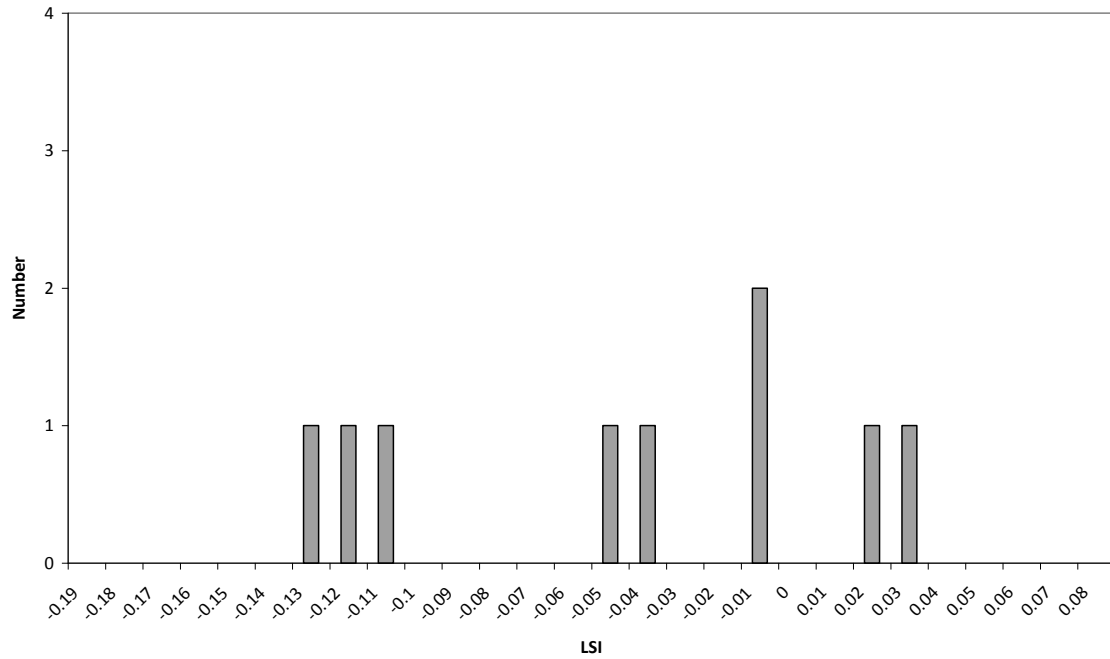


Fig 6.157: Levels A4-A3 sus depth log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.05)

The sample sizes for levels A2 and A1 were very small so the width measurements from these levels were grouped (fig 6.158). In these levels there was a large spread of LSI values ranging from -0.19 to 0.08 suggesting a mix of very small domestic females and some larger, perhaps wild and/or male, individuals. No depth measurements were available from levels B8-B1 or C.

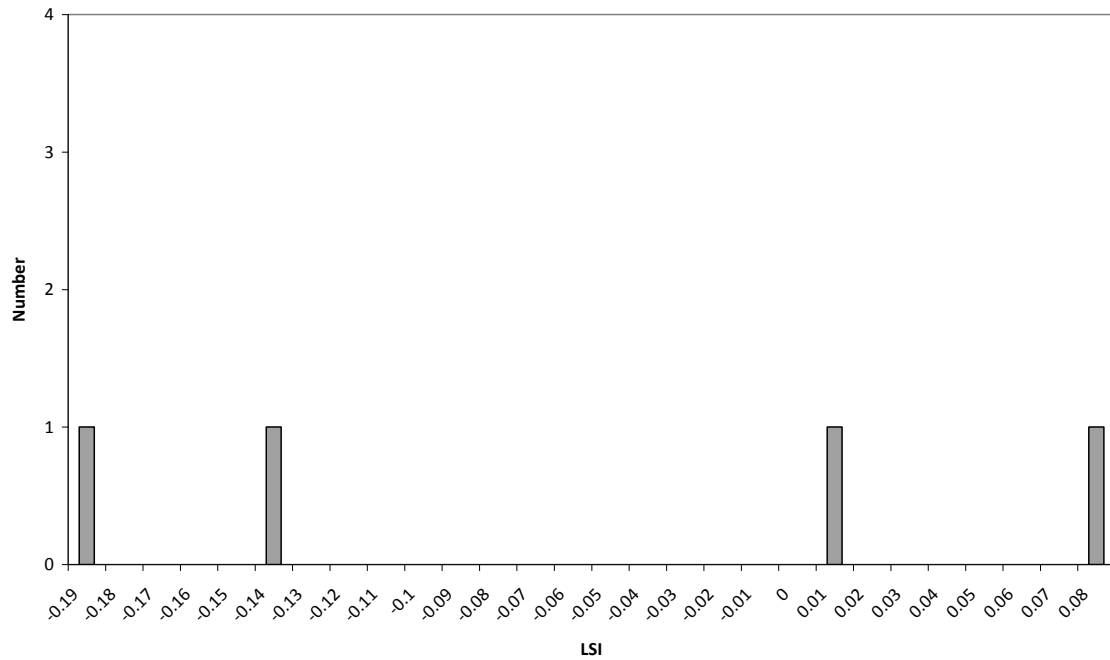


Fig 6.158: Levels A2 and A1 sus depth log ratio: standard measurements based on female *Sus scrofa* (Çayönü) (mean = -0.06)

The majority of depth measurements were smaller than the standard and probably represent domestic female sus. The few measurements that were larger than the standard were found in the younger levels, A4-A3, A2 and A1. Through time there seems to be an increase in the number of larger measurements and an increase in the range of LSI values. The large LSI values do not derive from the same bone.

Most of the Tell Sabi Abyad length, width and depth measurements from all levels were smaller than the standard suggesting a population of domestic female pigs. There were some measurements larger than the standard, probably derived from male and/or wild individuals. Through time there was an increase in the number of larger animals present, perhaps implying an increase in the presence of wild boar and/or males. That the increasing presence of larger animals occurs before the sus proportions in the assemblage decrease could suggest that domestic pig husbandry was failing or being abandoned and that hunting of wild boar was increasing.

6.4.7 Domestication status

The sus appear to be domestic in the oldest levels (A12-A10) where they are bred for their meat with mortality profiles showing a typical pattern of domestic pig exploitation. The metrical data backed this up with most measurements being far smaller than the standard of a wild female *Sus scrofa*. An increase in the proportions of older animals and wild boar sized sus in the younger phases suggests a reversion to hunting wild boar.

6.4.8 Conclusions

Domestic pigs were most common in levels A12-A10 after which they decrease in numbers until they practically disappear from the assemblage by level A1. In levels A12-A3 the sus were apparently domestic pigs herded for their meat with the main cull occurring between two and three years of age and carcasses being processed on site. By level A1 not only are there far less sus present but there are more larger, wild boar sized, animals present. Not all body parts from these animals are present on the site. This evidence suggests an increase in the hunting of wild boar with the decline of domestic pig husbandry. As the vast majority of sus appear to be domestic they will from now simply be referred to as pigs.

6.5 Bos

6.5.1 Bos proportions

Bos were found in all levels and make up 7.5% of the assemblage in terms of numbers and 29.3% in terms of bone weight. Bos was the second most common species in the C (13.4% of the NISP) and B (17.0% of the NISP) levels and the third most common species in the A levels (5.3% of the NISP). Bos are far more important in terms of meat weight (fig 6.160) than they are in terms of numbers (fig 6.159). Through time there is an increase in the proportion of bos with the increase starting after level A2 with a dip at level A1 (fig 6.159 and fig 6.160). Adding a trend line to figures 6.159 and 6.160 highlights the increasing importance of bos through the animal exploitation phases.

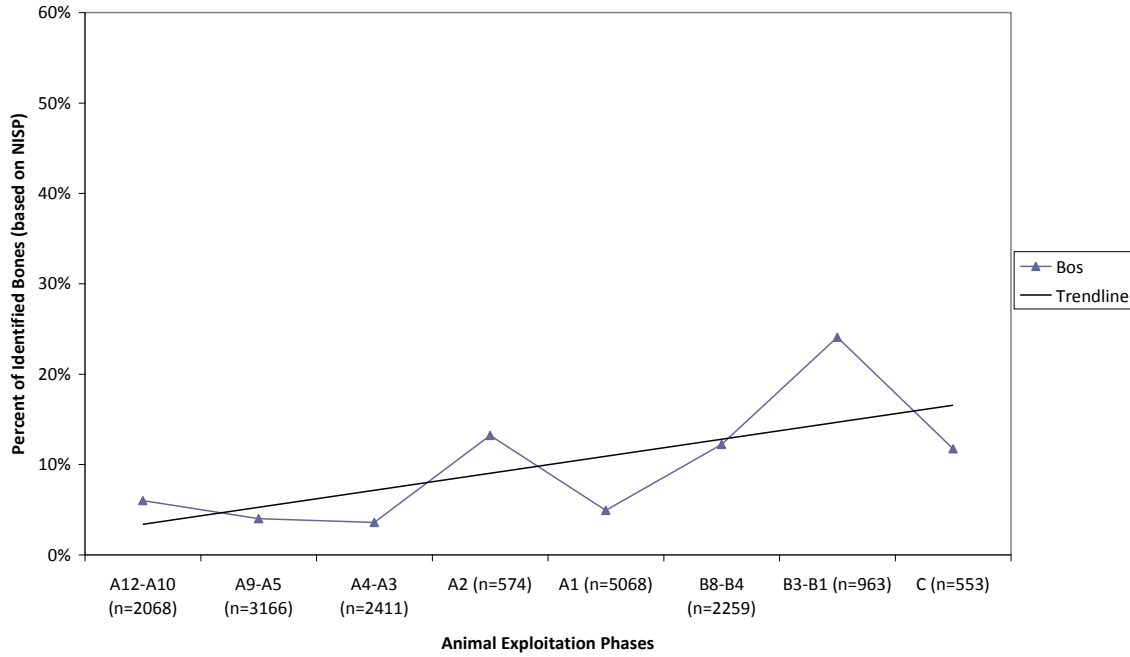


Fig 6.159: Bos species proportions by animal exploitation phase (NISP)

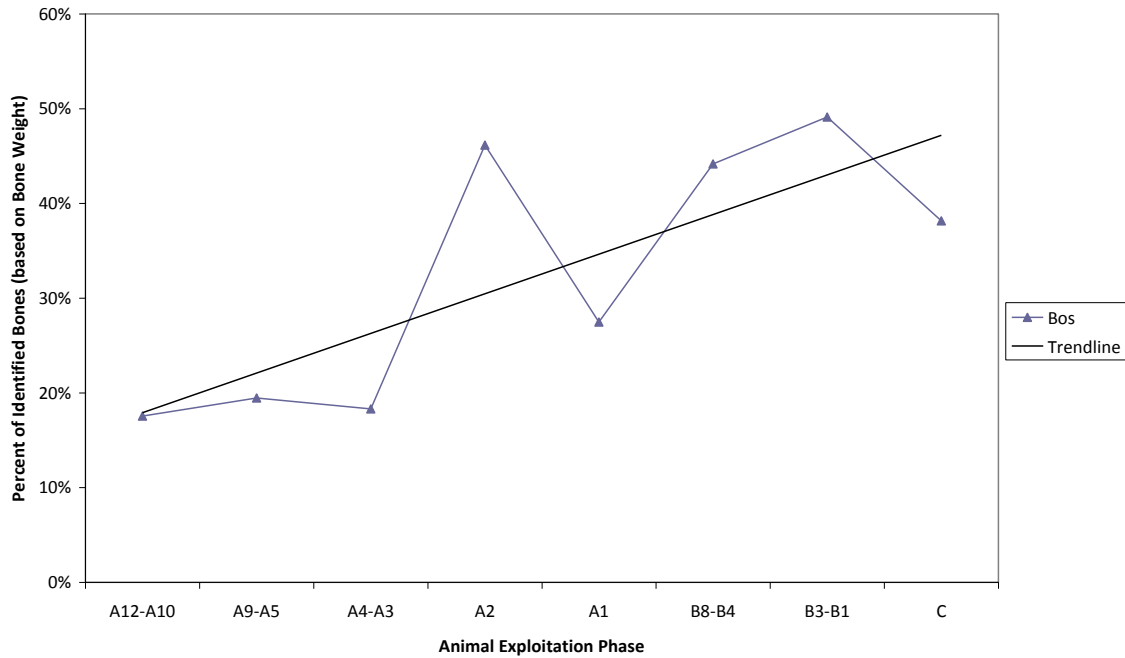


Fig 6.160: Bos species proportions by animal exploitation phase (Bone Weight)

6.5.2 Body part distribution

Body part distribution was calculated using both the NISP and MNI (the Minimum Number of Individuals which was used to compensate for the bias of naturally more common bone elements in the skeleton) by both level (fig 6.161 – fig 6.168) and for open areas (fig 6.169), pits (fig 6.170) and room fills (fig 6.171).

Vertebrae (with the exception of the first two vertebrae the axis and atlas) and ribs were excluded because of the difficulties associated in identifying the elements to species.

The body part proportions in levels A12-A10 and A9-A5 are very similar with phalanges being the most common elements (fig 6.161 and 6.162).

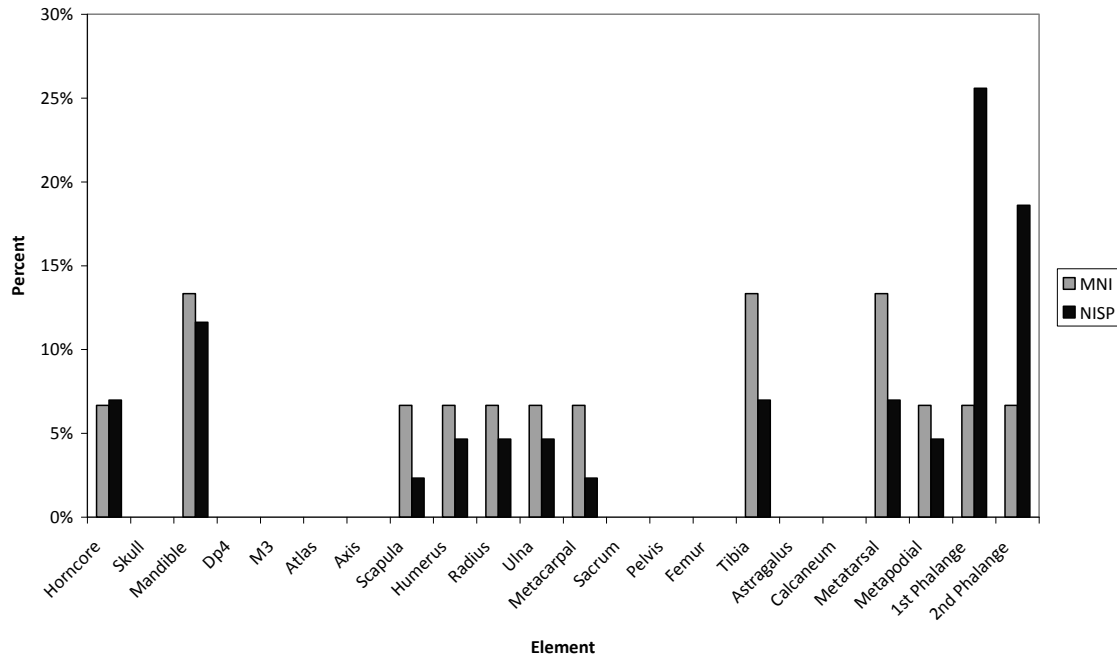


Fig 6.161: Levels A12-A10 bos body part proportions

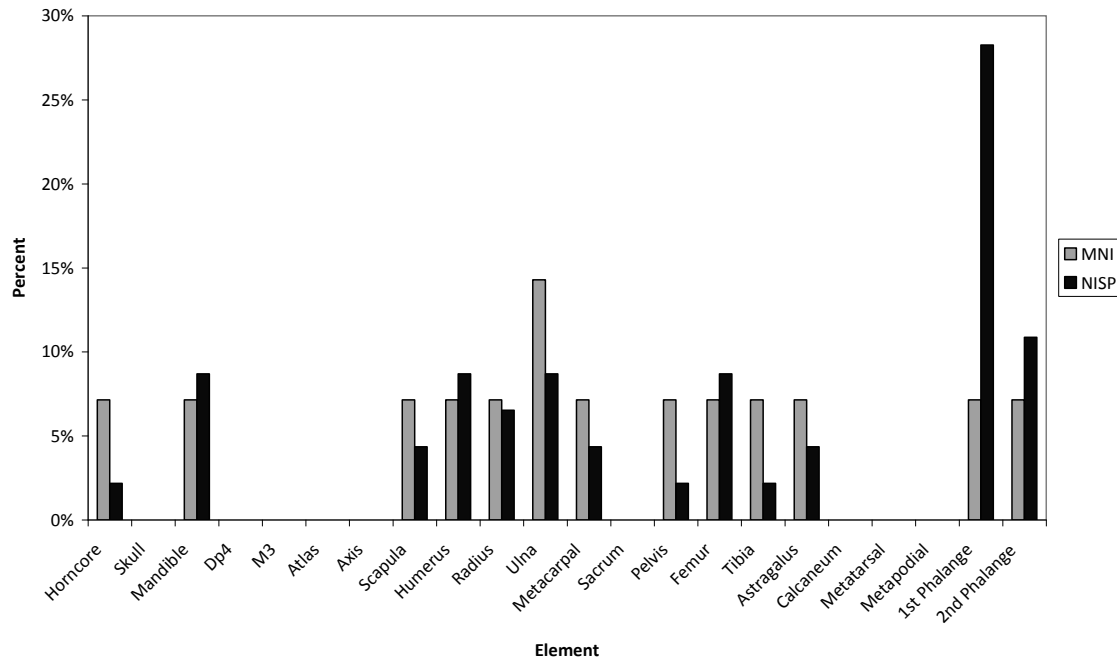


Fig 6.162: Levels A9-A5 bos body part proportions

In levels A4-A3 most parts of the skeleton were present with the most common parts of the skeleton being the mandible and 2nd phalanx (fig 6.163).

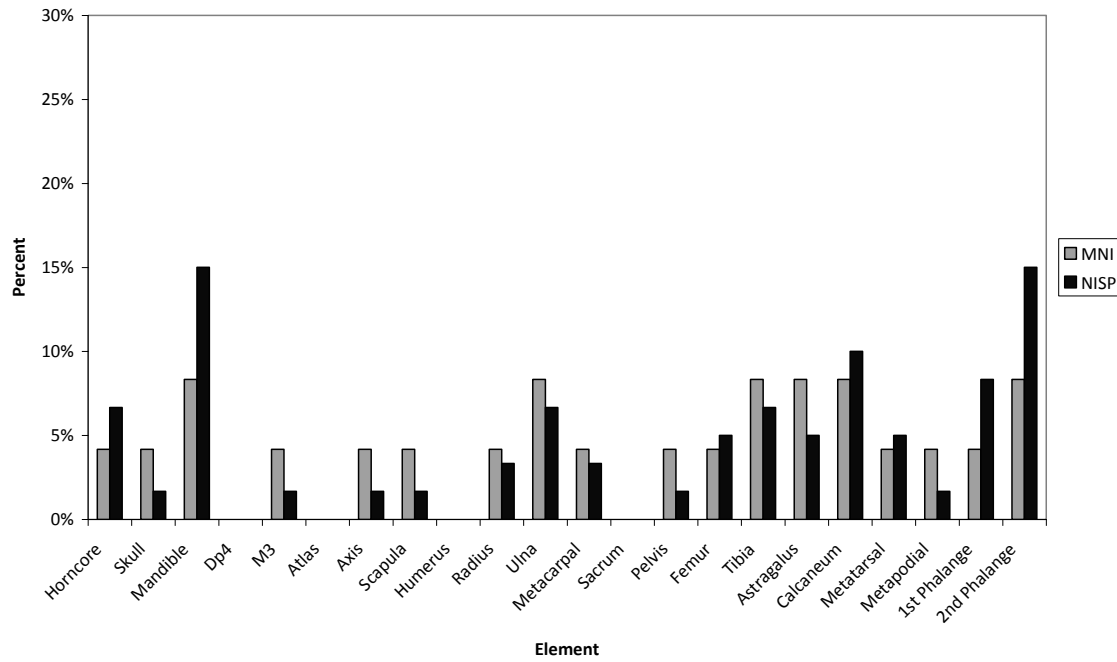


Fig 6.163: Levels A4-A3 *bos* body part proportions

In level A2 the sample size is very small; elements of the forelimb were most common (fig 6.164). In level A1 most parts of the skeleton are present with the astragalus being the most common element (fig 6.165).

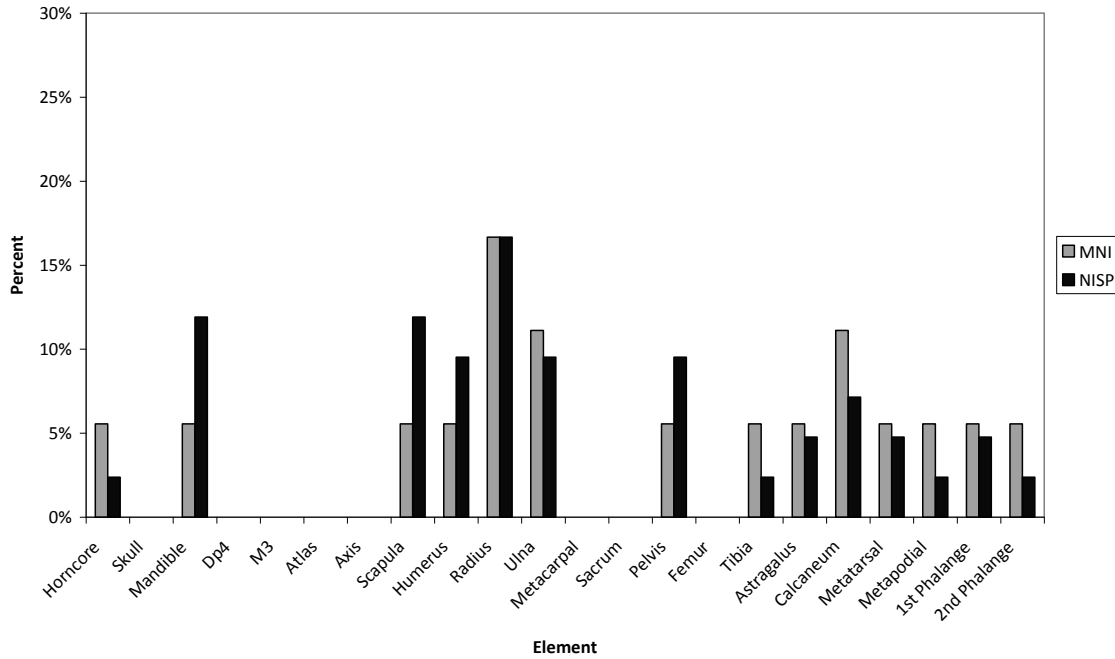


Fig 6.164: Levels A2 bos body part proportions

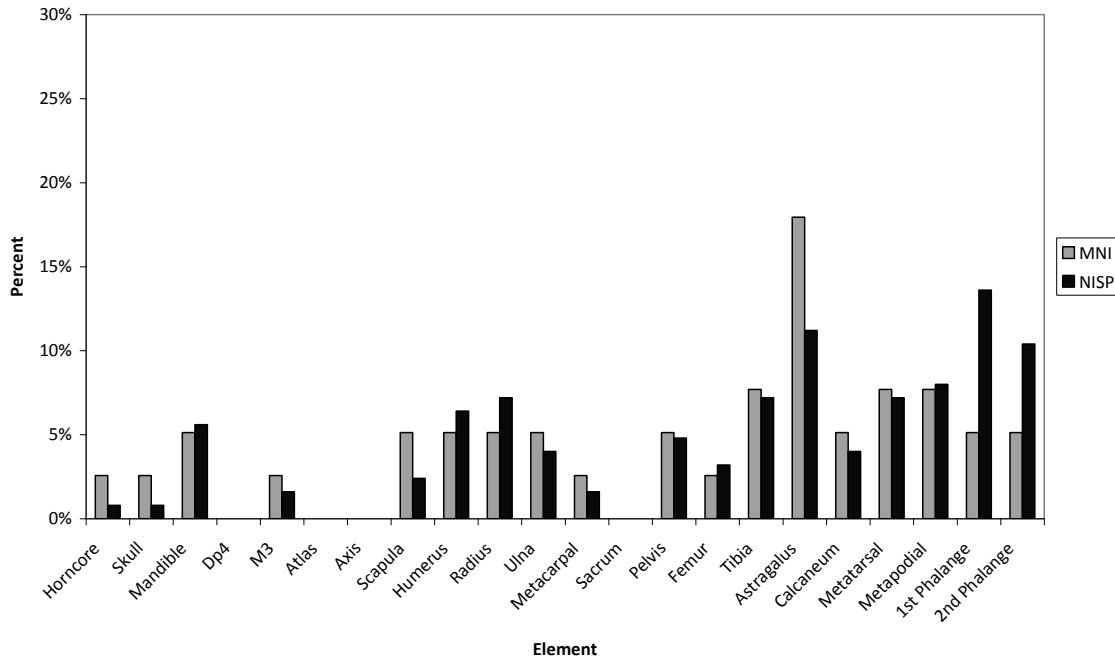


Fig 6.165: Levels A1 bos body part proportions

In levels B8-B4 the most common elements are those of the fore and hind limbs (fig 6.166). In levels B3-B1 the mandible was the most common element. Skulls and horncores were absent as was the ulna and calcaneum (fig 6.167).

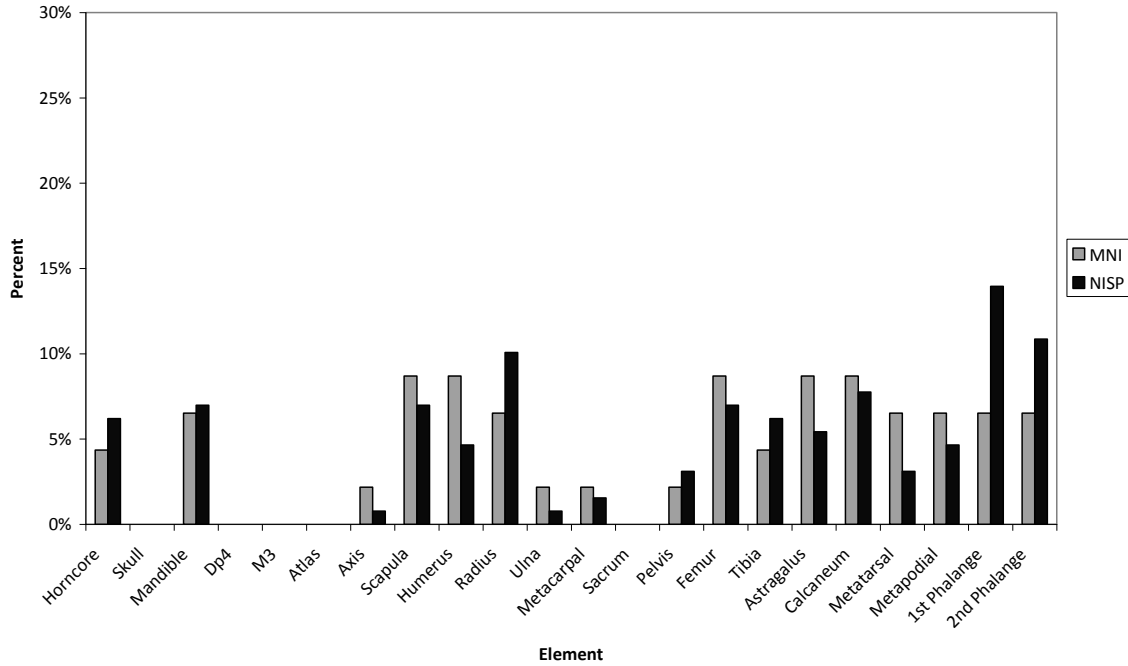


Fig 6.166: Levels B8-B4 bos body part proportions

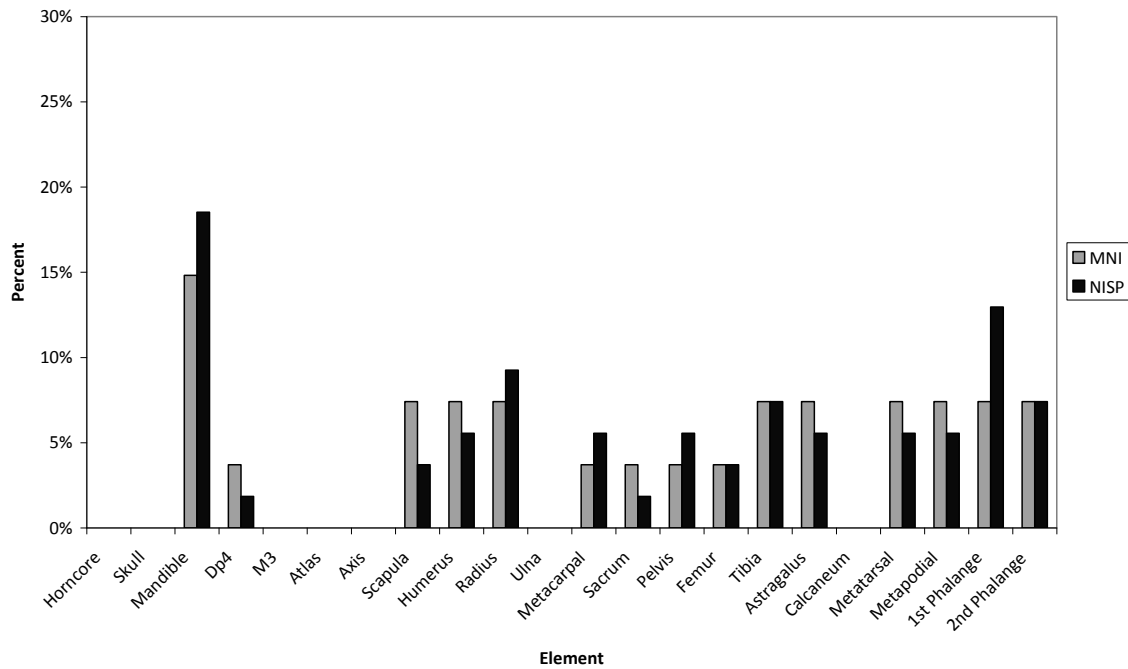


Fig 6.167: Levels B3-B1 bos body part proportions

The most common skeletal elements in level C were phalanges with many parts of the skeleton missing including the skull, horncore, neck, humerus, sacrum, pelvis, tibia and metatarsal (fig 6.168). In the A and B levels most areas of the skeleton were present and it appears as if whole carcasses were processed on site.

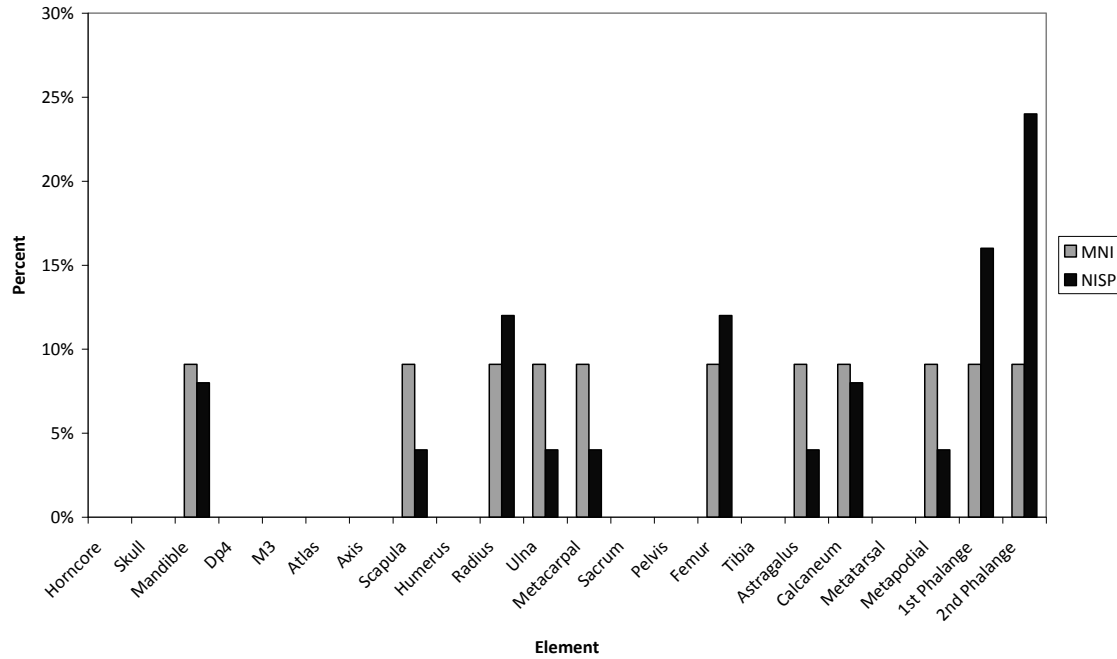


Fig 6.168: Level C bos body part proportions

Body part proportions were also analysed by context: open area (fig 6.169), pit (fig 6.170) and room fill (fig 6.171).

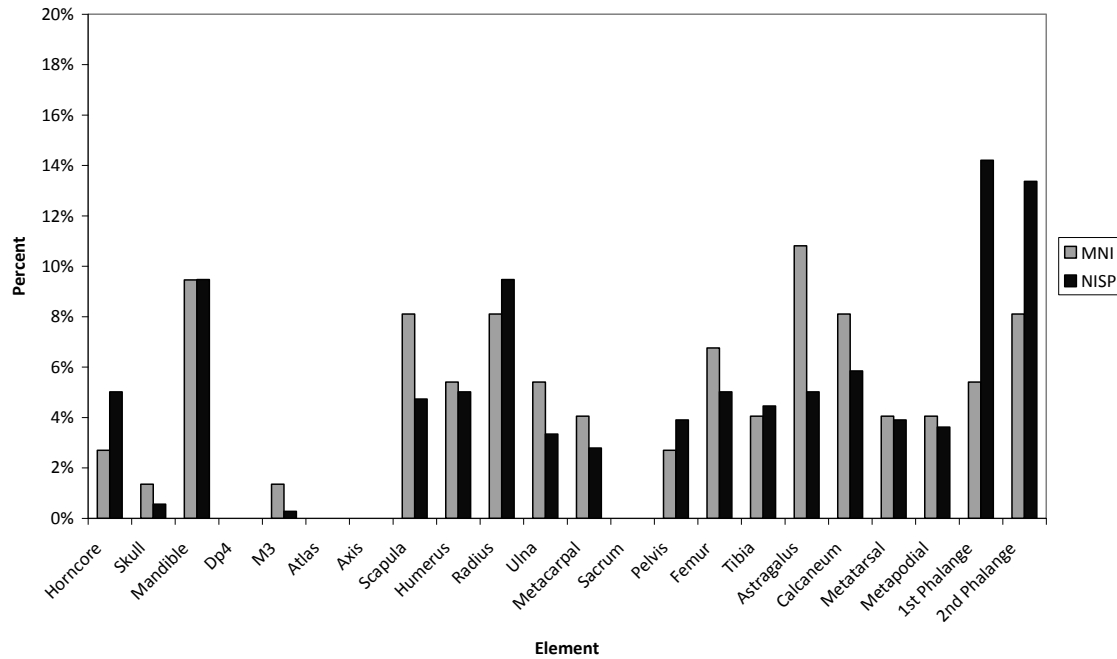


Fig 6.169: Open area bos body part proportions

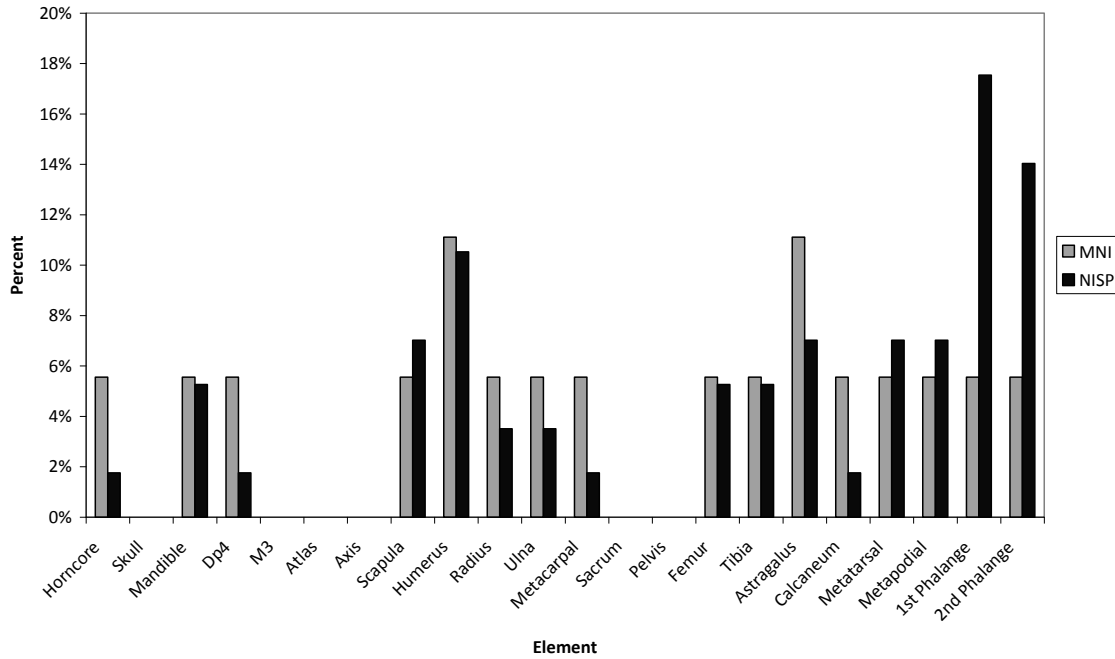


Fig 6.170: Pit bos body part proportions

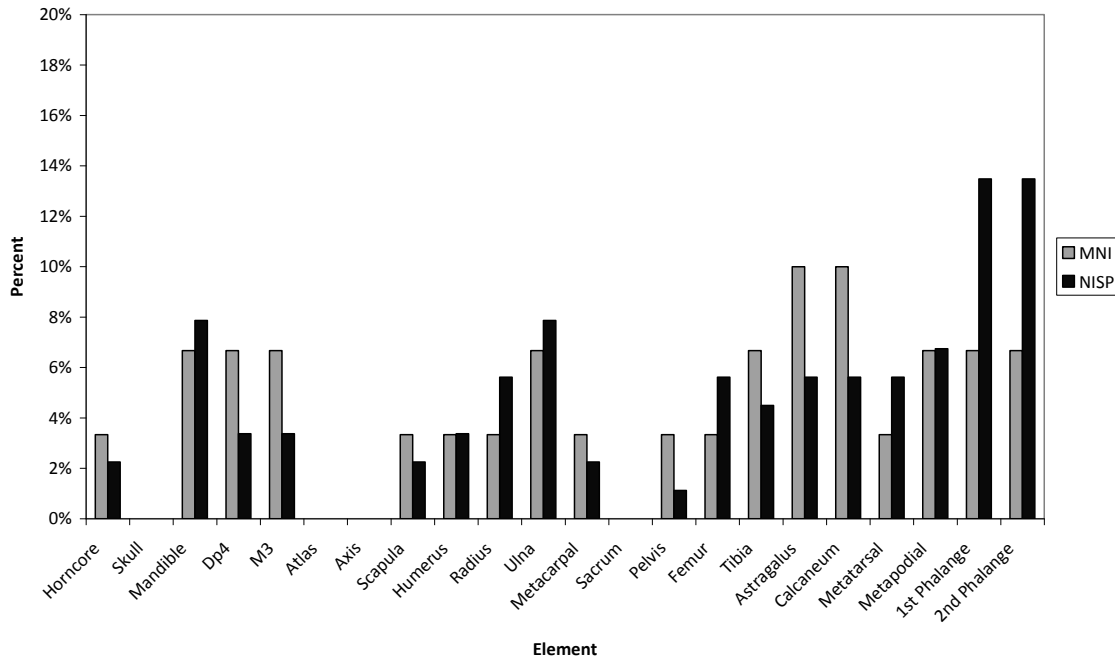


Fig 6.171: Room fill bos body part proportions

The body part proportions were very similar in all contexts. In general, all parts of the skeleton were present and in particular hind limbs were most common.

6.5.3 Butchery

Thirteen bos bone fragments showed signs of butchery. The majority of the cut marks were located at the astragalus/calcaneum joint. The cut marks on the bos remains are typical of marks caused by the skinning and disarticulation of the carcass (fig 6.172).

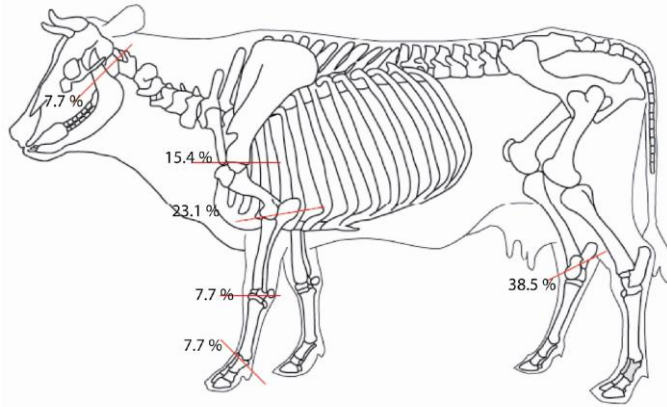


Fig 6.172: Location of butchery mark on the Bos skeleton

6.5.4 Age profiles

Age profiles were calculated from postcranial bone fusion only as there were not enough teeth and tooththrows available to produce mortality profiles based on toothwear.

In levels A12-A10 only c. 50% of bos lived up to 36 months of age and no animals lived beyond three years (fig 6.173).

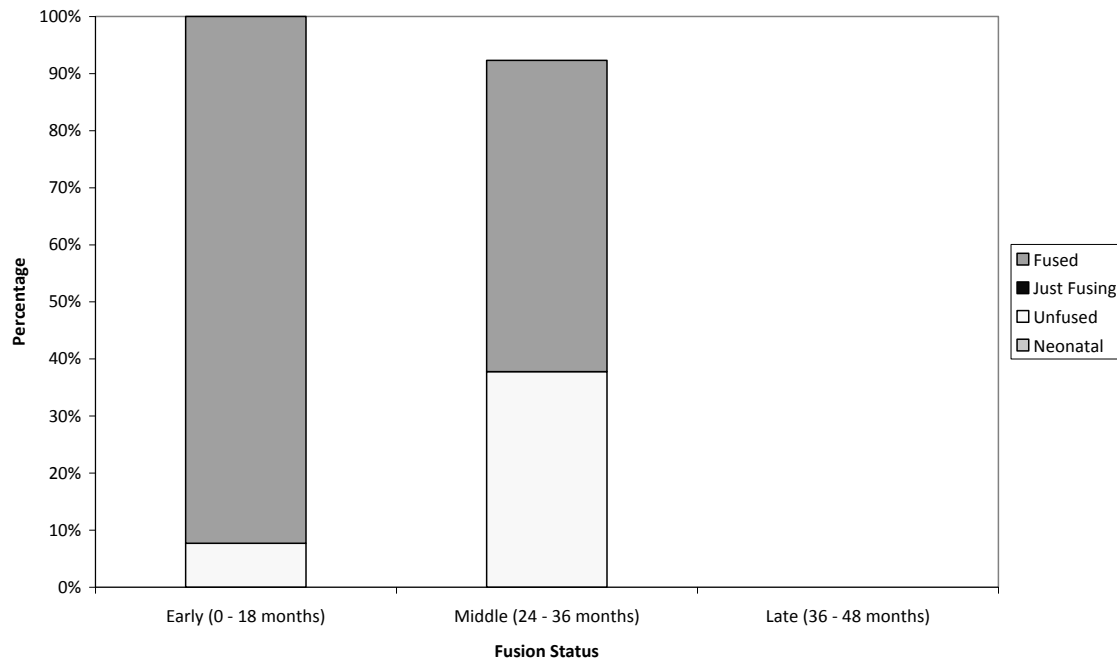


Fig 6.173: Levels A12-A10 bos age profiles from bone fusion

In levels A9-A5 100% of bos survived up to 36 months of age but all were culled before they reached 48 months of age (fig 6.174). No animals survived beyond three years.

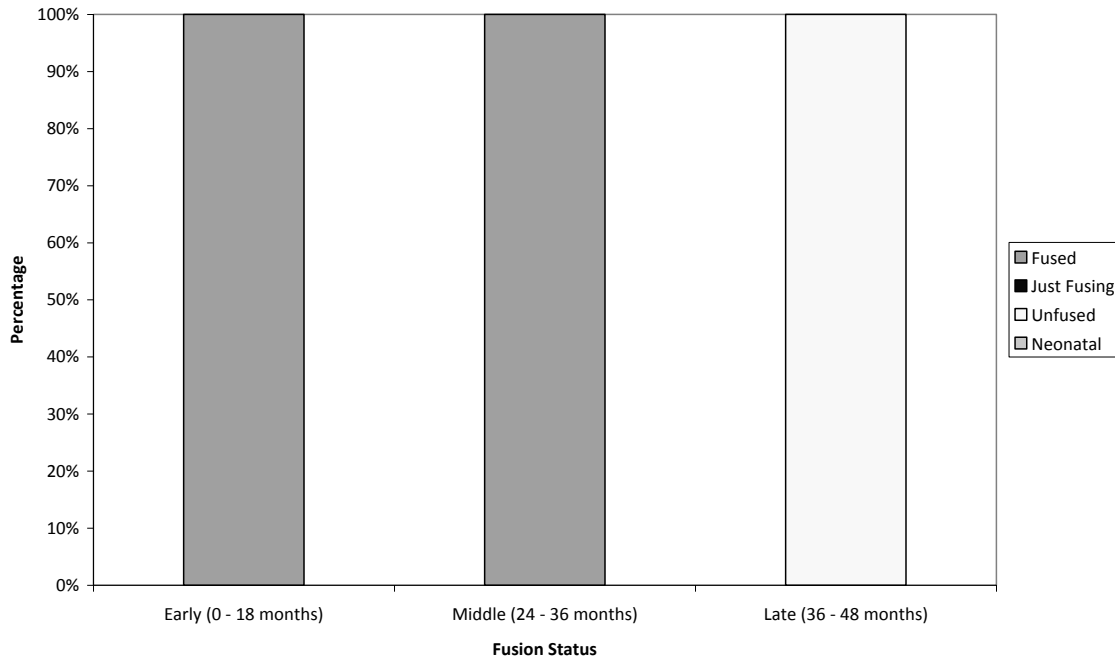


Fig 6.174: Levels A9-A5 bos age profiles from bone fusion

A similar pattern of kill off is seen in levels A4-A3 and A2 with c. 60% of bos surviving to 48 months or over (fig 6.175 and 6.176). The main age for culling was between three and four years of age.

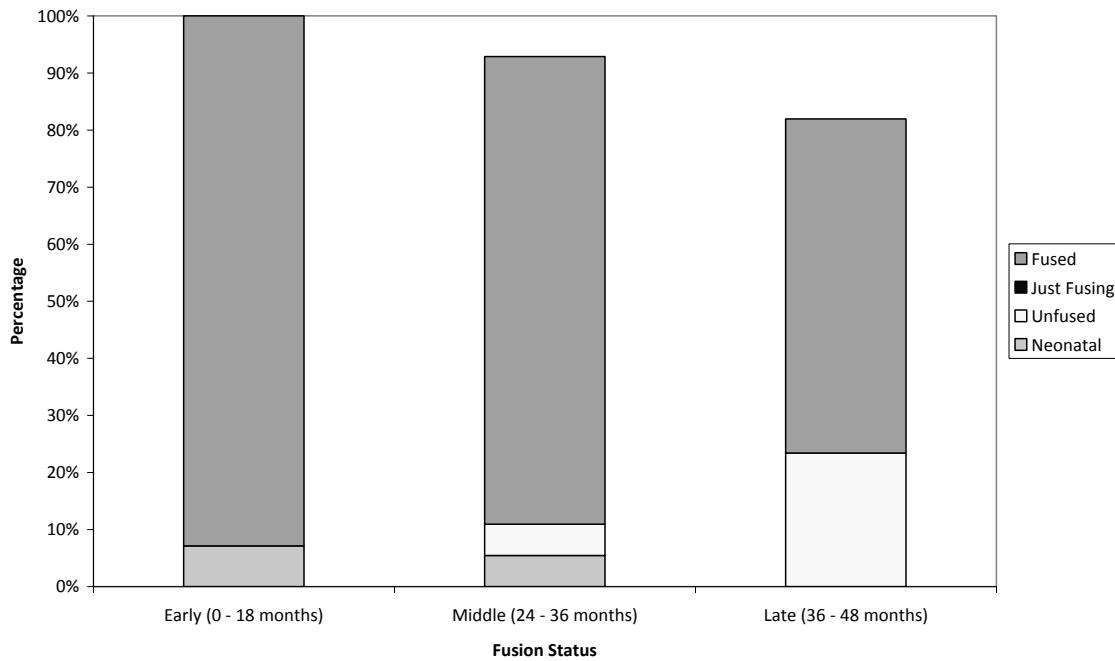


Fig 6.175: Levels A4-A3 bos age profiles from bone fusion

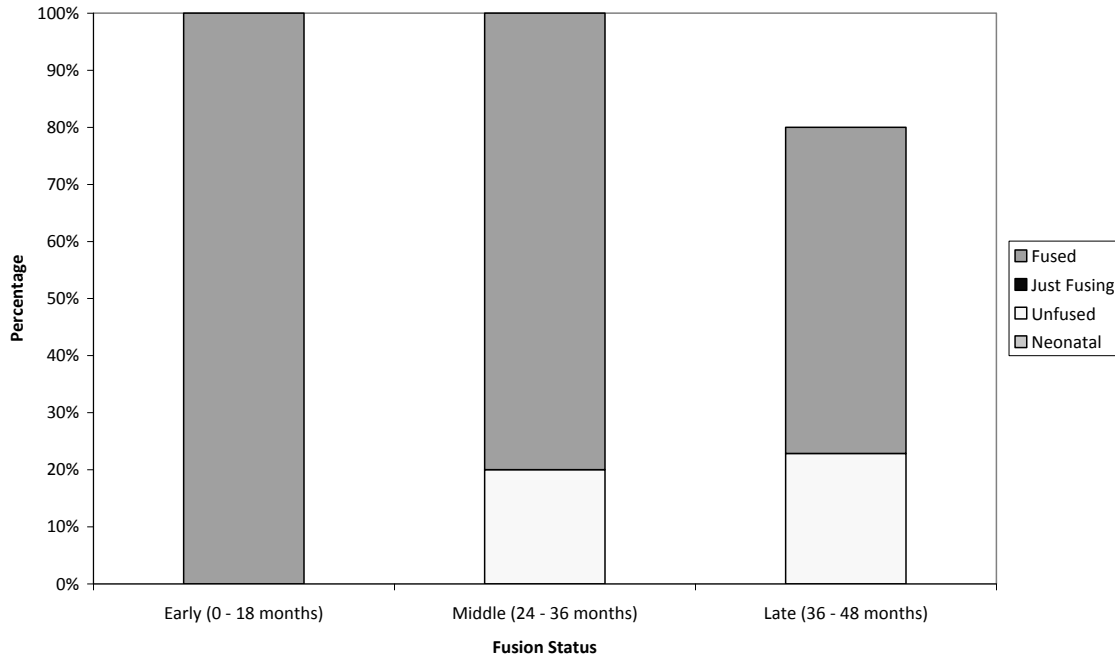


Fig 6.176: Level A2 bos age profiles from bone fusion

In level A1 far more bos survived up to 48 months or over with c. 50% of animals reaching this age (fig 6.177).

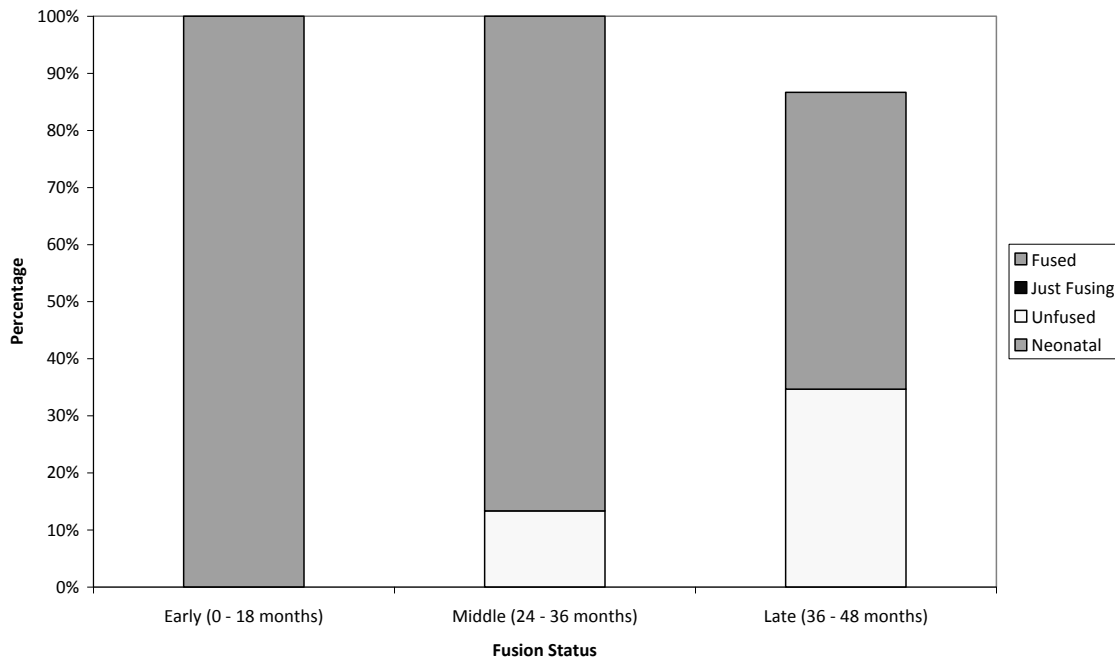


Fig 6.177: Level A1 bos age profiles from bone fusion

In levels B8-B4 the sample size was very small (fig 6.178). In these levels over 90% of bos survived to 36 months with only 20% of these living to 48 months or over. The main kill off was between three and four

years of age. A very similar mortality profile is seen in levels B3-B1 (fig 6.179), where c. 90% of bos survived up to 36 months of age with c. 20% of these animals living up to 48 months and over.

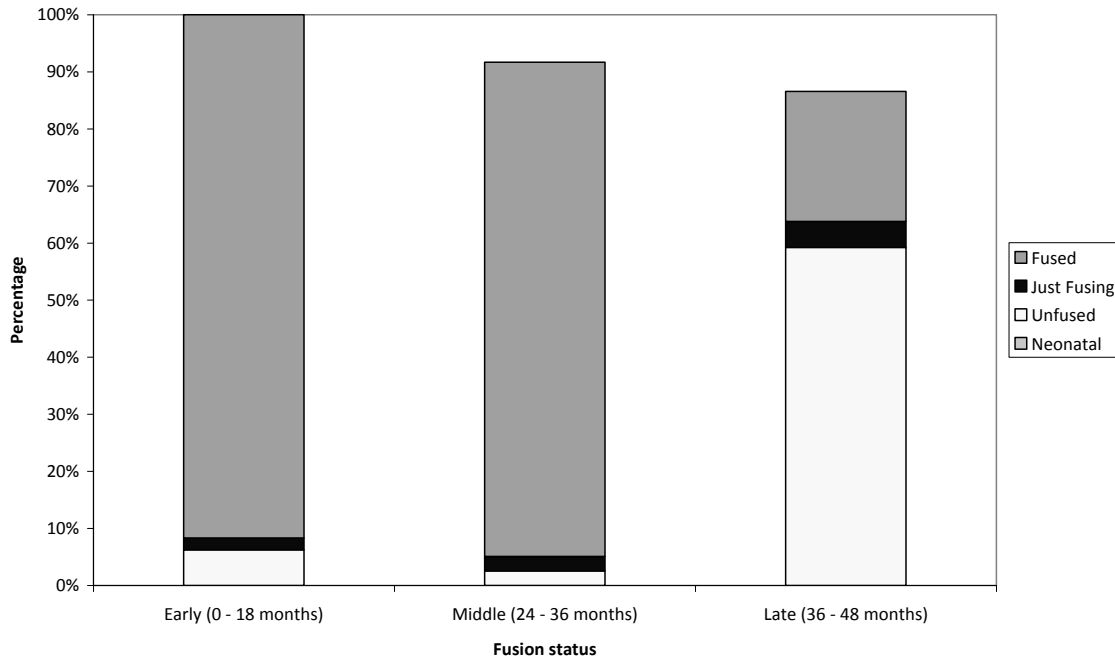


Fig 6.178: Levels B8-B4 bos age profiles from bone fusion

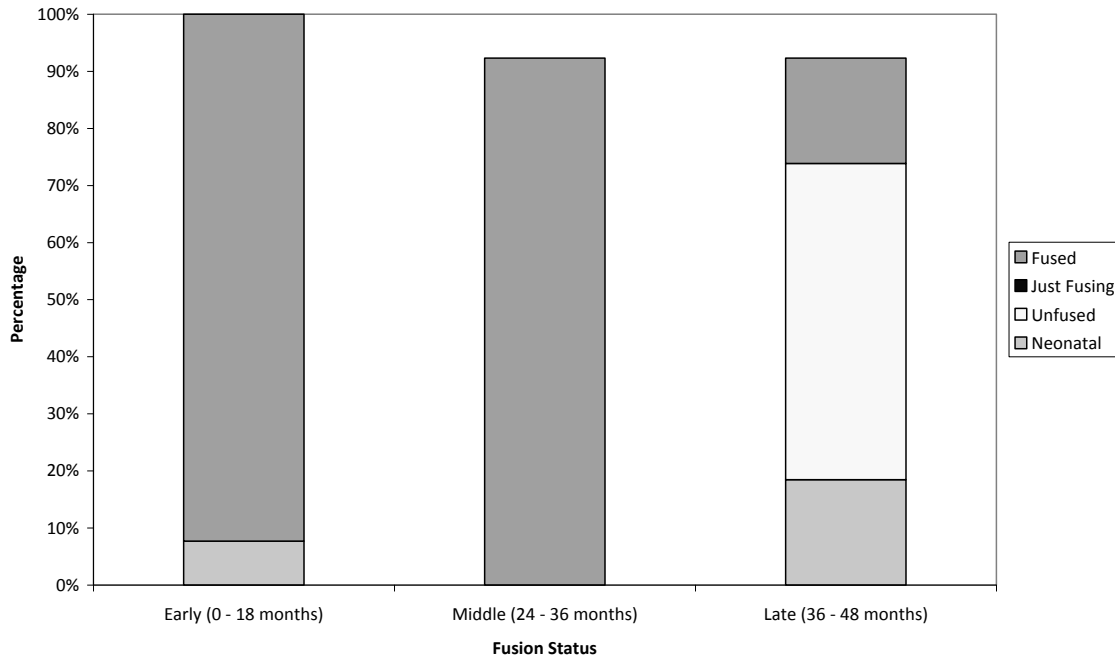


Fig 6.179: Levels B3-B1 bos age profiles from bone fusion

In the C levels 100% of bos survived to 18 months of age with c. 90% of those animals surviving up to 36 months (fig 6.180). Only c. 40% survived to 48 months. This suggests that the main culling age of the bos in level C was between three and four years of age.

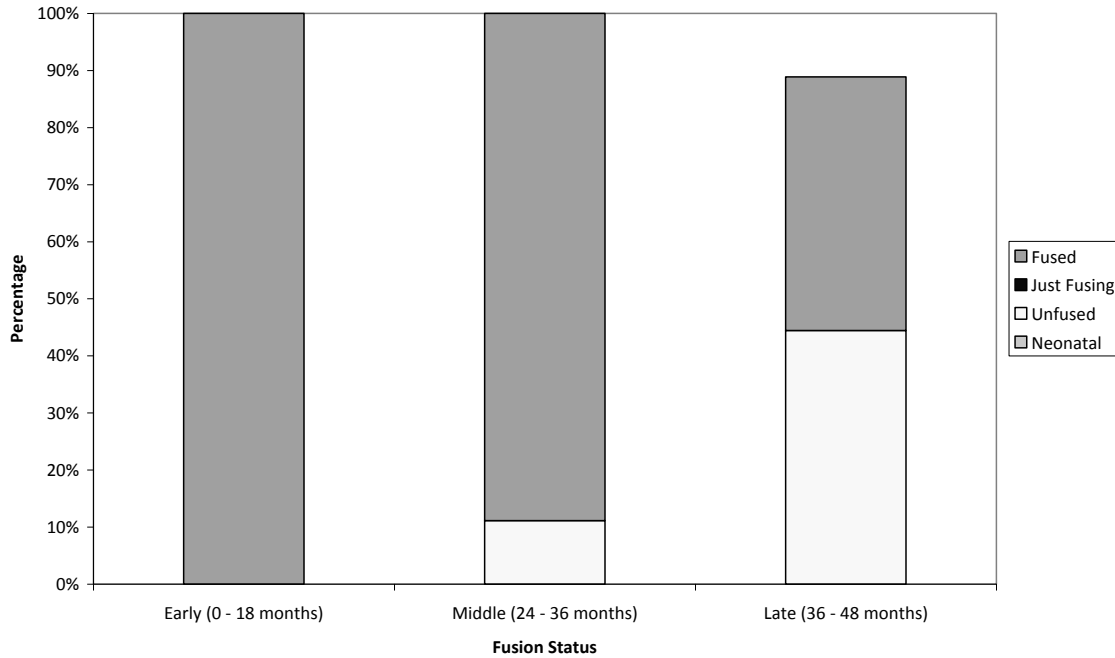


Fig 6.180: Level C bos age profiles from bone fusion

Even in the oldest levels the bos mortality profiles do not reflect that of a wild, hunted population but that of a culturally controlled or proto-domestic population of cattle bred primarily for their meat. Only 50% of animals lived up to reproductive maturity and these animals did not live beyond three years until levels A4-A3 where 60% of animals lived up to at least 48 months of age. In these levels there were a number of neonatal remains recovered. Herd security and meat production seem to be the focus of bos husbandry in levels A4-A3. This form of animal management continues through levels A2 and A1 by which time the bos can be considered fully domestic. From levels B8-B4 there is a switch to a more intensive meat production with less animals surviving to 48 months and a focus on breeding bos for meat, being culled at around three years of age, with a small number of older animals kept as breeding stock. This form of animal husbandry continues through to level C.

6.5.5 Pathology

One bos longbone showed sign of a serious infection with an external cloaca and internal reactive bone growth suggesting osteomyelitis, a bone inflammation caused by bacteria that usually enter the bone via an open wound.

6.5.6 Metrical analysis

During the recording of the Tell Sabi Abyad material measurements were taken where possible. For a full list of the measurements taken see appendix 5.

As the number of individual measurements by species and element by level are so small all length, width and depth measurements were grouped and analysed using the LSI technique (see chapter 5) by animal exploitation phase (fig 6.181– 6.199). A full list of all bos measurements and a list of the measurements used in the LSI analysis are listed in appendix 5 and 6. The measurements from the average of *Bos*

primigenius measured from the site of Mureybet (Gourichon *per comms*) in Syria were used as the standard.

The length LSI was first calculated for the bos from all the levels combined (fig 6.181). This graph appears to be roughly binomial with the majority of values falling below 0. There are however a number of measurements that are larger than the standard and these may be derived from wild and/or male individuals. The distribution of data is skewed to the left (skew = -0.27).

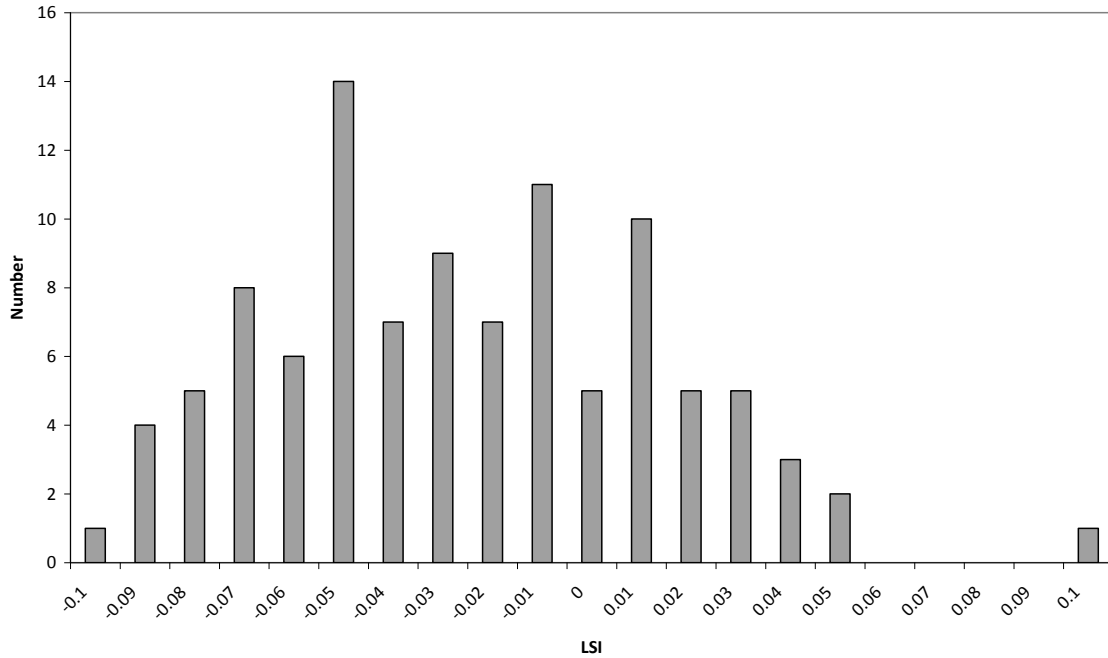


Fig 6.181: Bos length log ratio (site total): standard measurements based on average measurements of *Bos primigenius* from Mureybet.

In levels A12-A10 there are more measurements larger than the standard than there are smaller (fig 6.182).

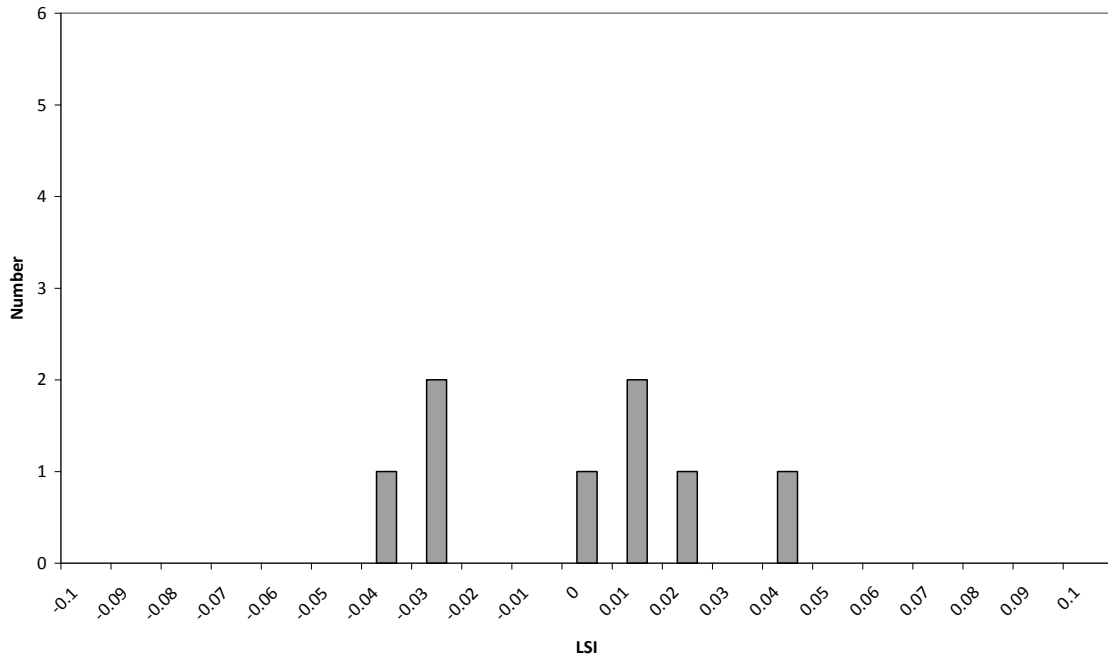


Fig 6.182: Levels A12-A10 bos length log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = 0.00)

In levels A9-A5 and A4-A3 there are an equal number of measurements that are larger and smaller than the standard (fig 6.183 and 6.184).

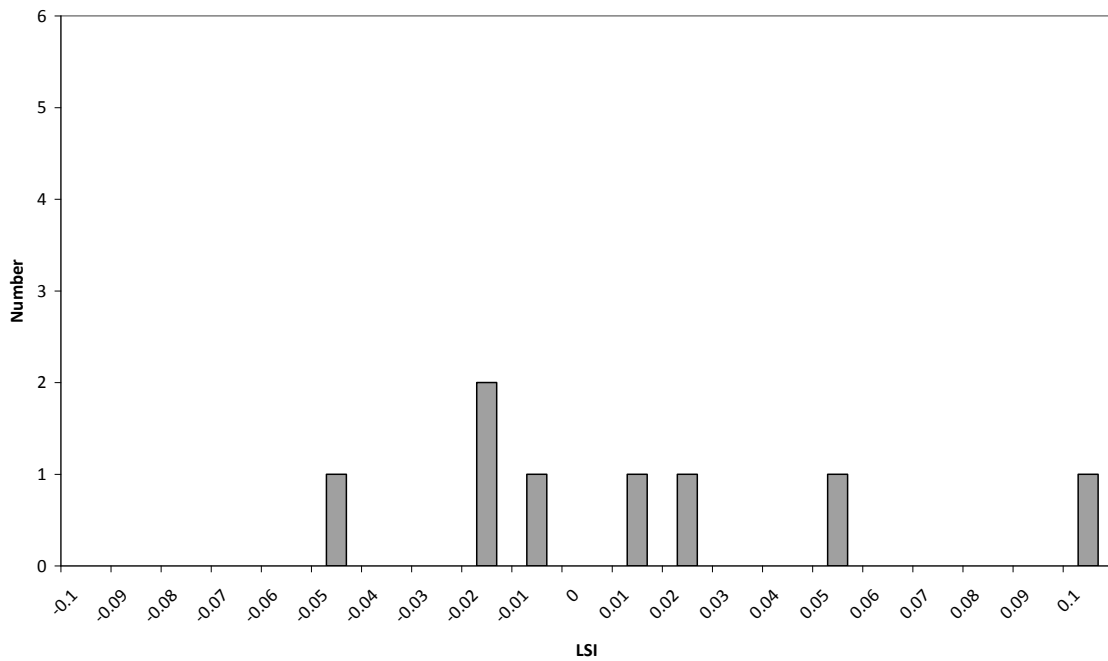


Fig 6.183: Levels A9-A5 bos length log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = 0.01)

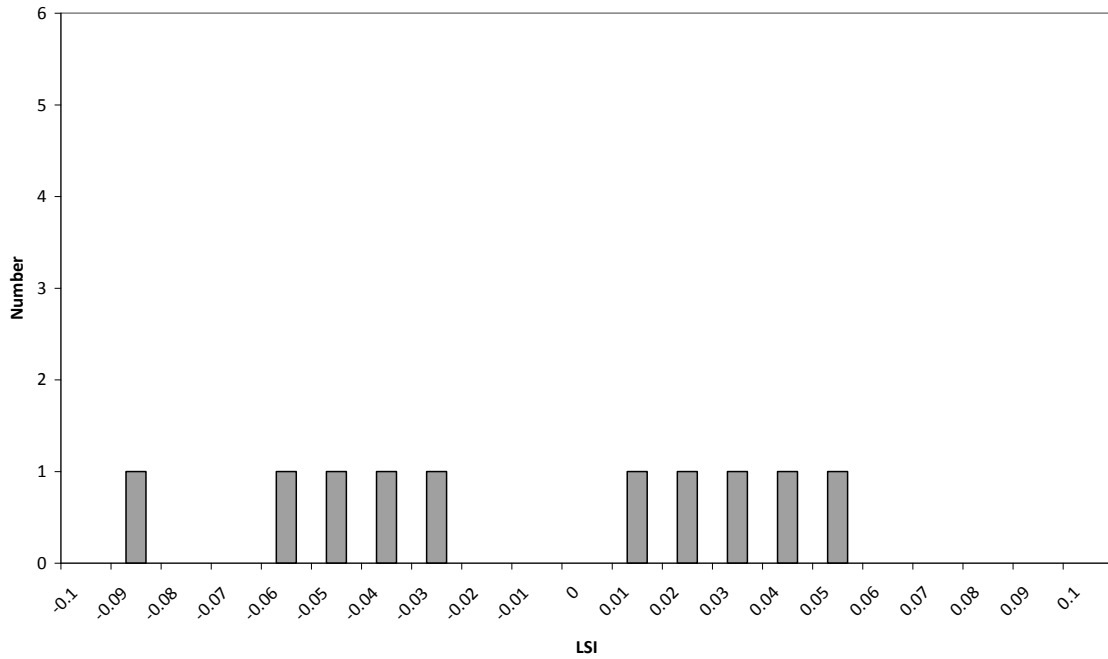


Fig 6.184: Levels A4-A3 bos length log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean -0.01)

The number of length measurements from level A2 was very low. All measurements were smaller than the standard (fig 6.185).

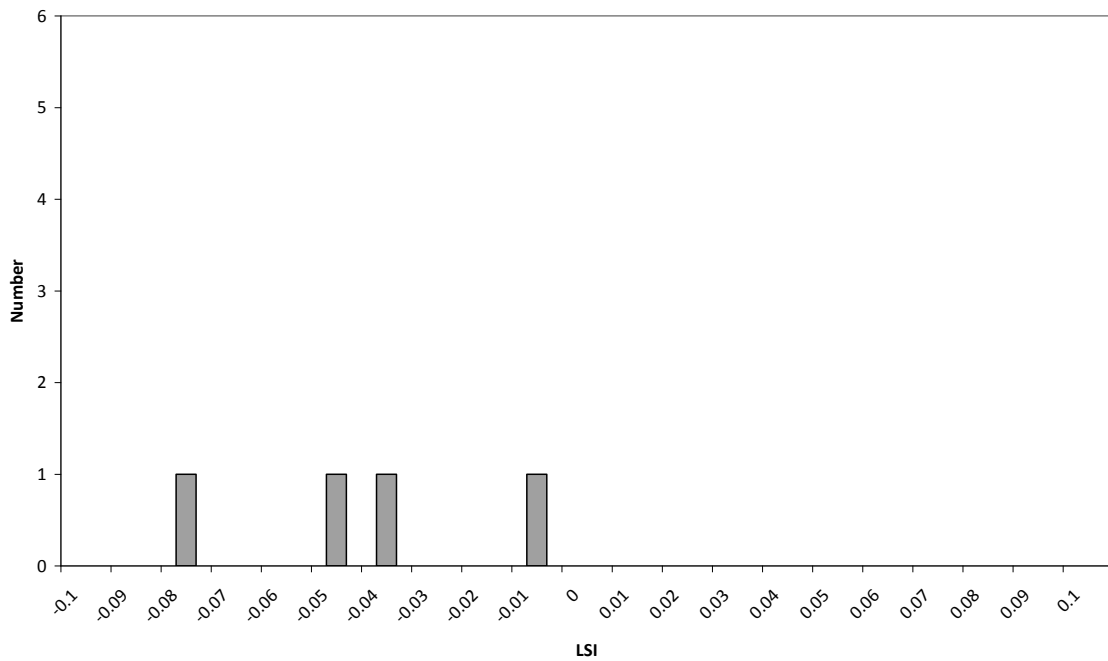


Fig 6.185: Level A2 bos length log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.04)

There were a large number of measurements available from level A1 (fig 6.186). The majority of measurements were smaller than the standard but there were a number of larger measurements. LSI values range from -0.09 to 0.04.

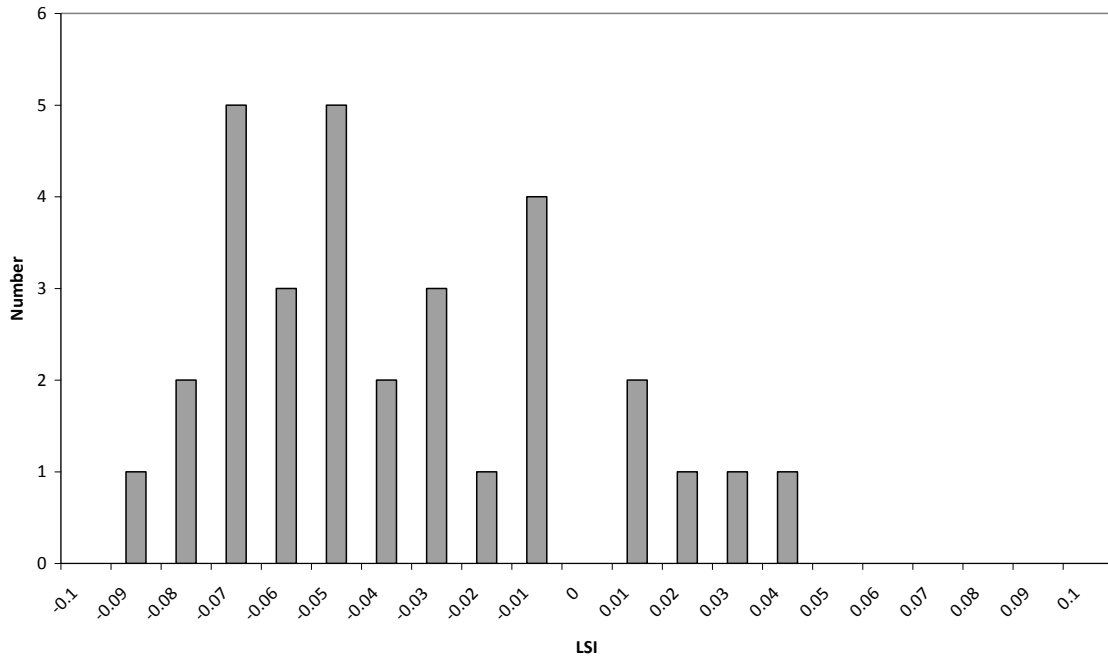


Fig 6.186: Level A1 bos length log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.04)

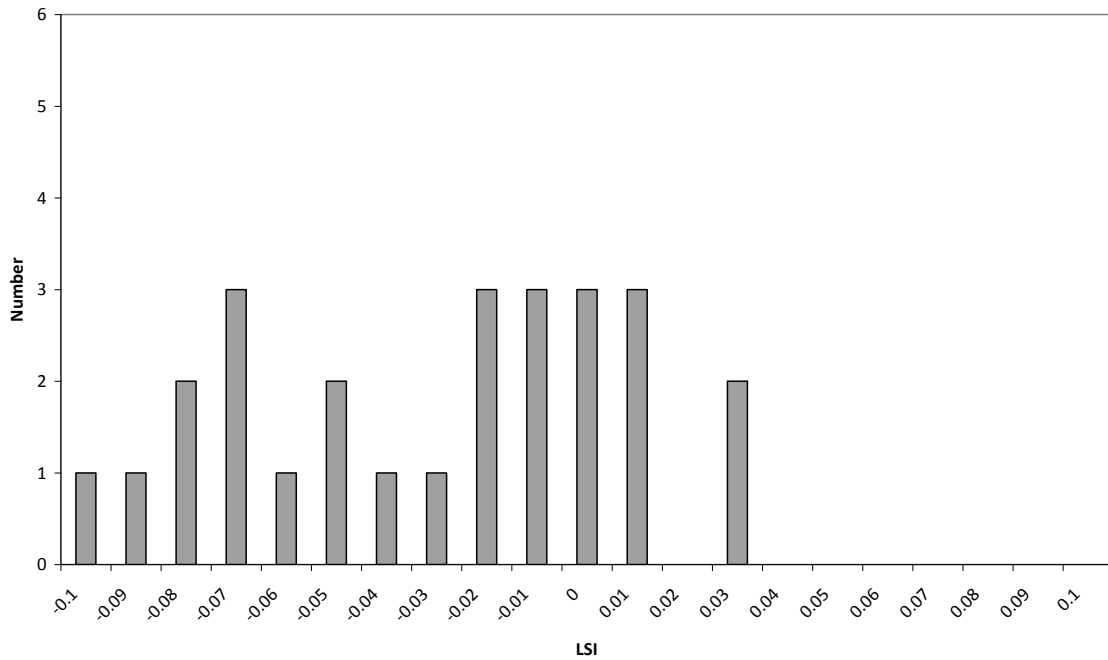


Fig 6.187: Levels B8-B4 bos length log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.02)

Levels B8-B4 show a similar distribution of LSI values as levels B3-B1, with most measurements being far smaller than the standard (fig 6.187 and fig 6.188). In levels B3-B1 all measurements bar one were smaller than the standard (fig 6.188).

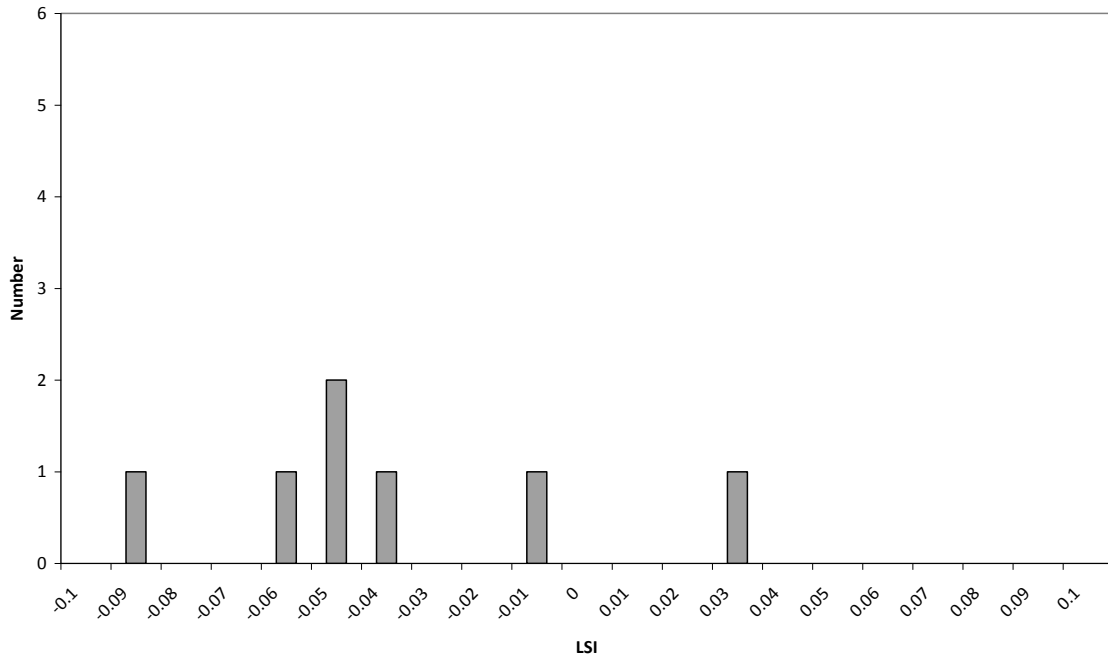


Fig 6.188: Levels B3-B1 bos length log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.04)

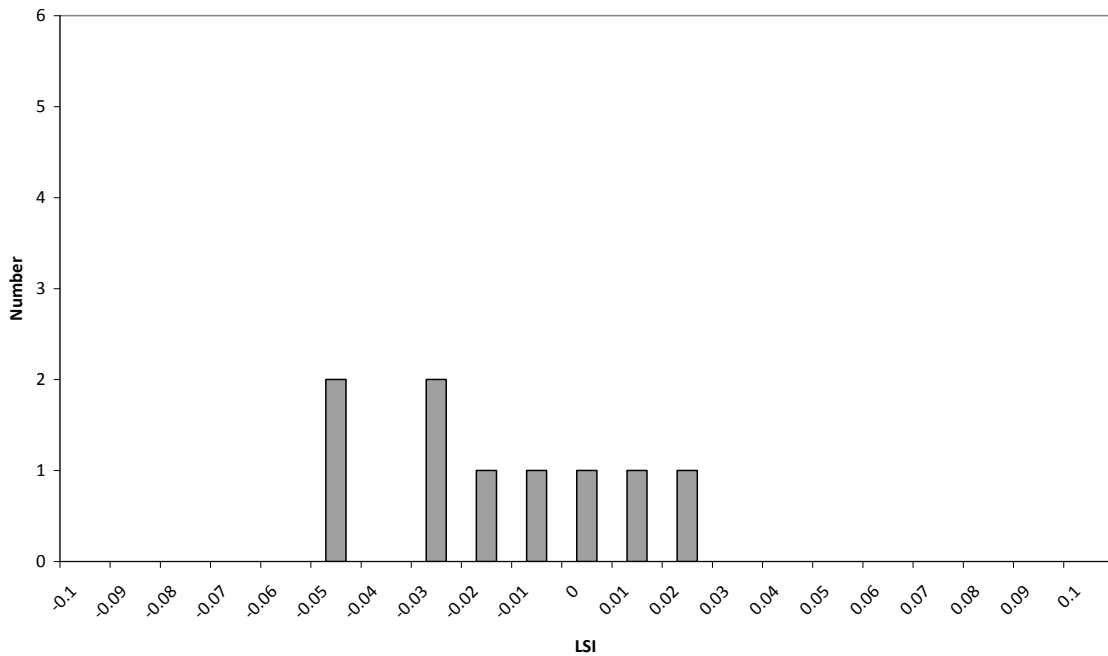


Fig 6.189: Level C bos length log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.02)

In level C there is a narrow range of LSI values ranging from -0.05 to 0.02 with most measurements below 0 (fig 6.189).

Looking at the length LSI analysis by animal exploitation phase it is clear that there is a shift in the general size of the bos from a mixture of animals both smaller and larger than a *Bos primigenius* in the oldest levels to animals generally smaller than a *Bos primigenius* in the youngest levels.

The width LSI was first calculated for the bos from all the levels combined (fig 6.190). There is a large range of LSI values from -0.15 to 0.07 with most measurements being smaller than the standard. The presence of measurements far larger than the standard suggests the presence of very heavy animals which are probably male and/or wild. The range of measurements is skewed to the left (skew = -0.11) indicating that lighter animals were more common.

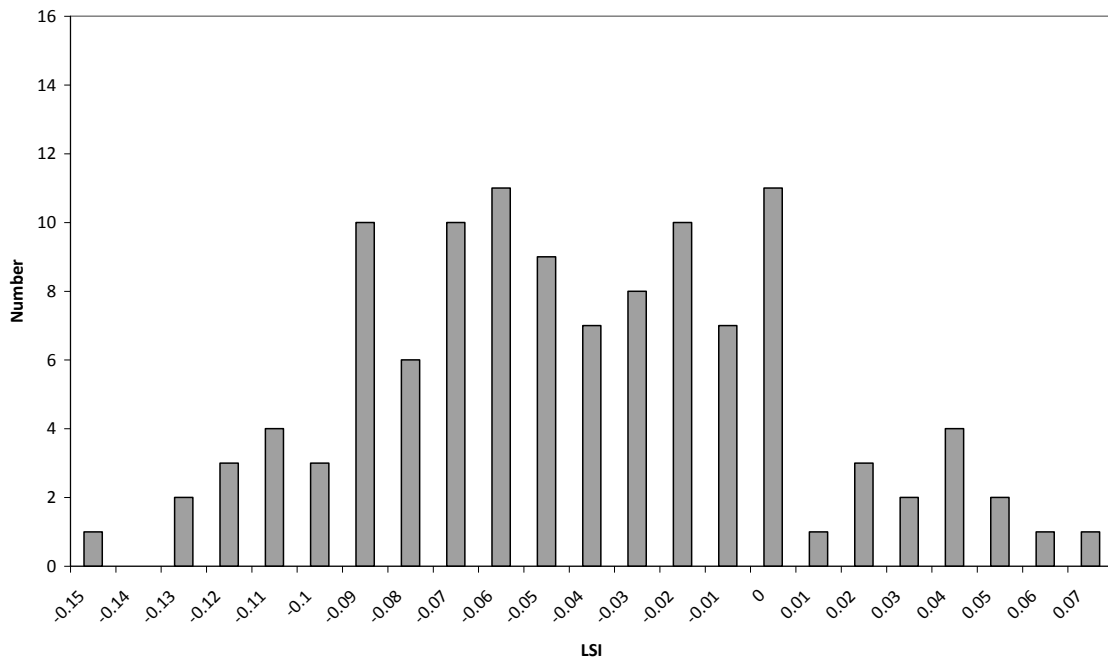


Fig 6.190: Bos width log ratio (site total): standard measurements based on average measurements of *Bos primigenius* from Mureybet.

In levels A12-A10 and A9-A5 there are a number of measurements larger than the standard with less of the smaller measurements seen in levels A4-A3 (fig 6.191 - 6.193).

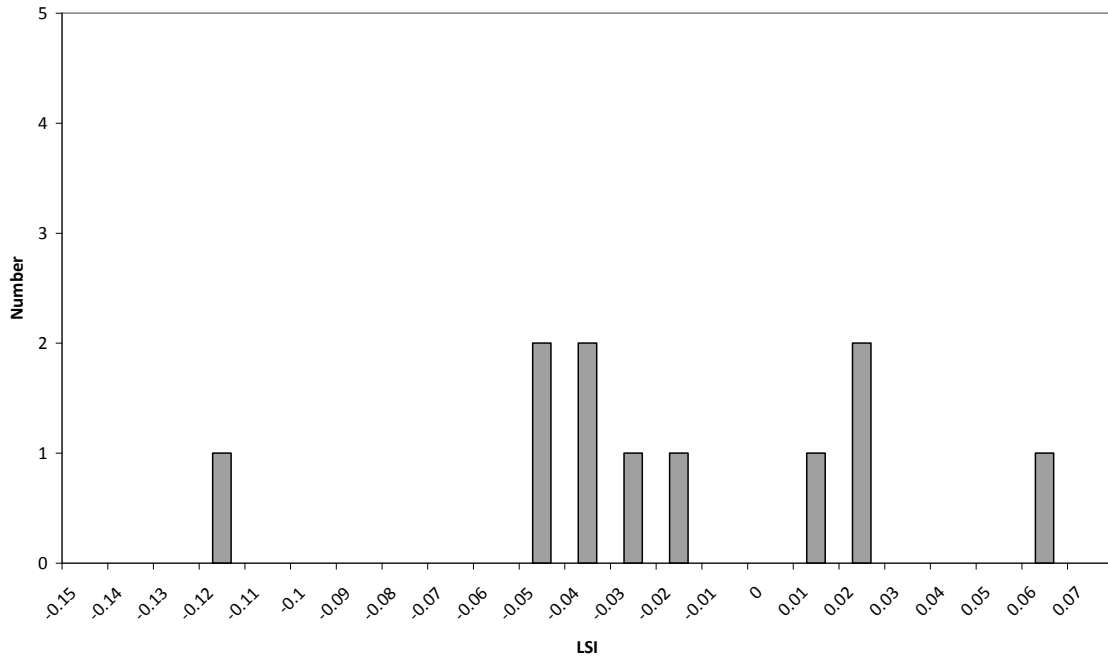


Fig 6.191: Levels A12-A10 bos width log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.02)

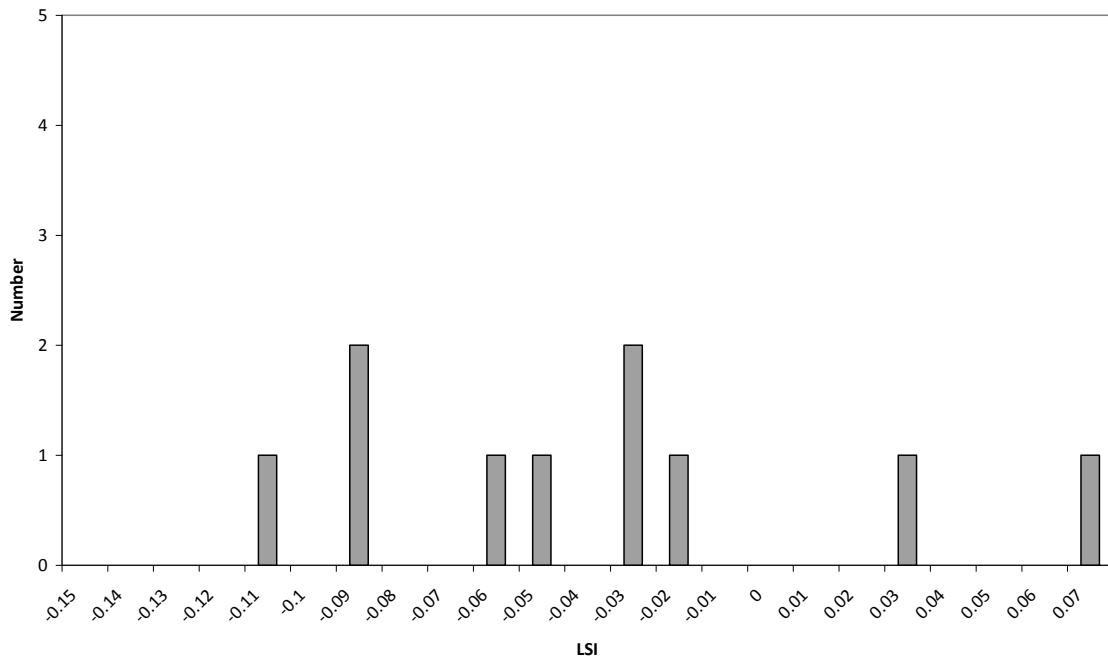


Fig 6.192: Levels A9-A5 bos width log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.04)

In levels A4-A3 there was a large range of LSI values with measurements both far smaller and measurements far larger than the standard (fig 6.193). In level A2 all measurements were smaller than the standard (fig 6.194).

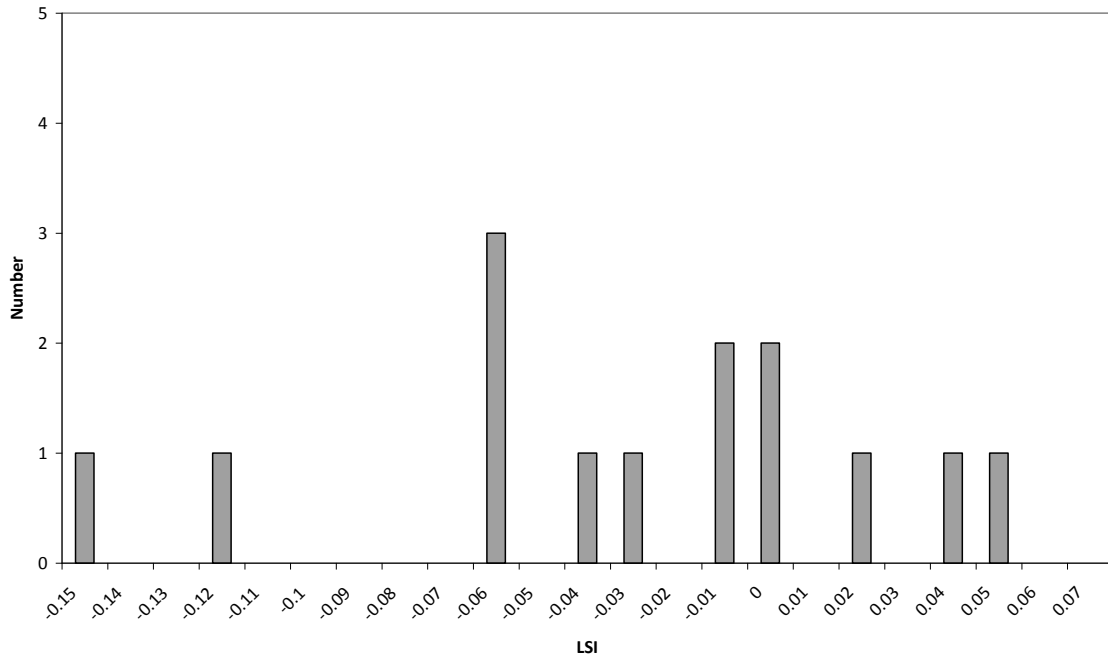


Fig 6.193: Levels A4-A3 bos width log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.03)

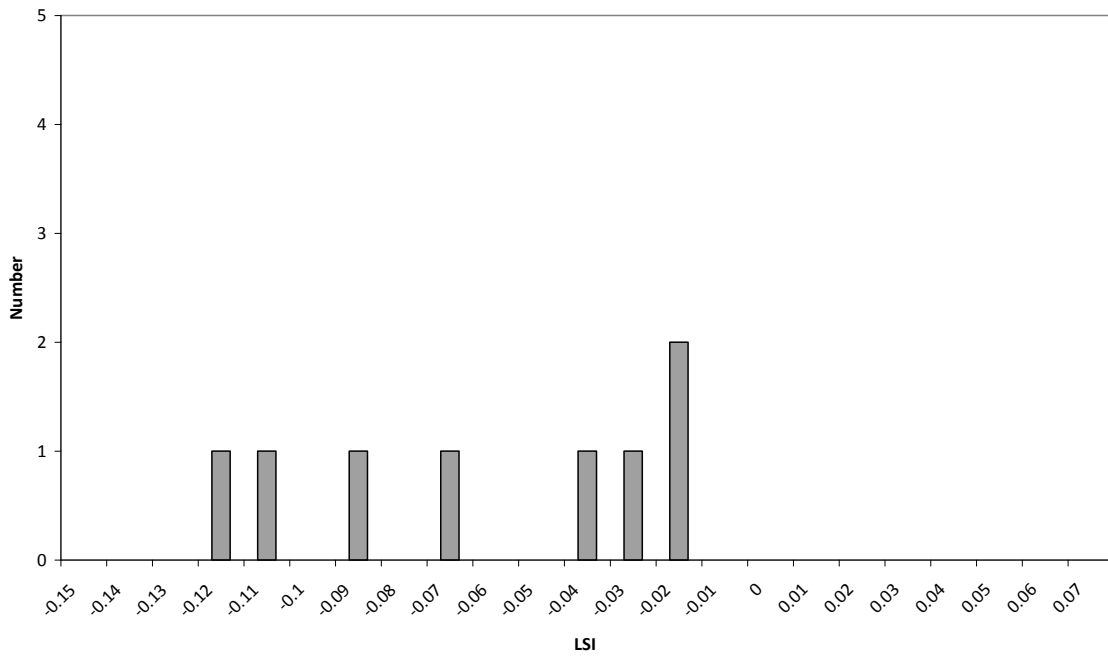


Fig 6.194: Level A2 bos width log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.06)

In level A1 the sample size was large and the vast majority of measurements were far smaller than the standard (fig 6.195). There are perhaps two overlapping groups visible: a larger group of light individuals

(values -0.13 to -0.01), probably females, and a smaller group of heavier individuals (values 0 to 0.05), probably males.

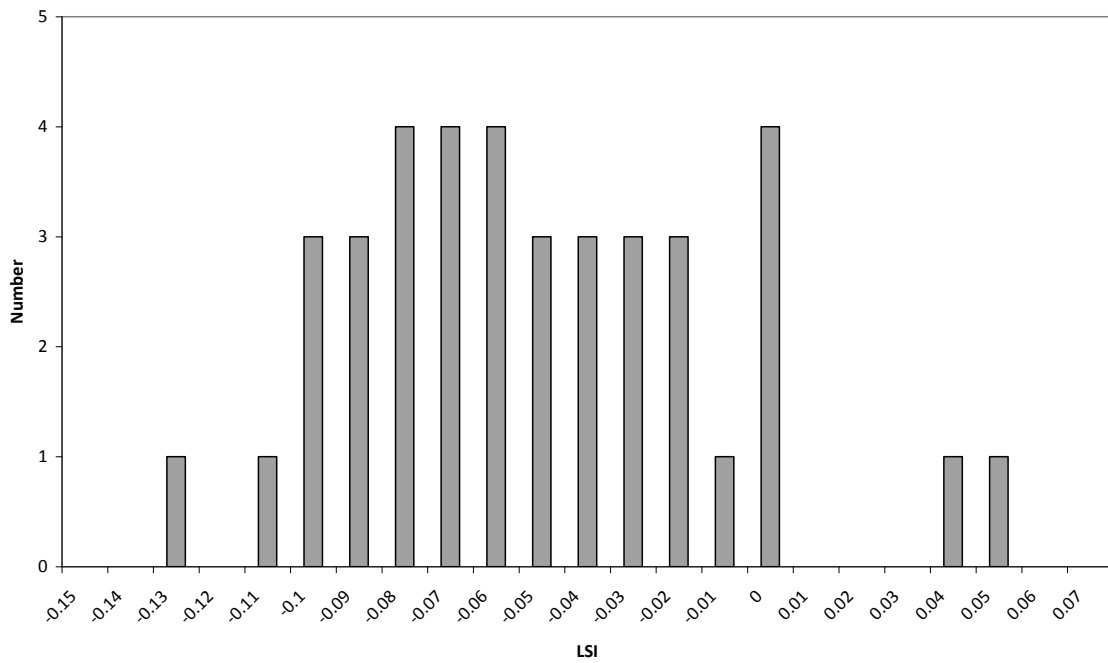


Fig 6.195: Level A1 bos width log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.05)

In levels B8-B4 only one measurement was larger than the standard (fig 6.196) but as in level A1 there appears to be two groups present. Levels B3-B1 have a range of LSI values from -0.13 to 0.03 (fig 6.197), a range of LSI values very similar to those seen in level C (fig 6.198). In the C levels one measurement was larger than the standard (fig 6.198) with most of the measurements being much smaller than the standard implying the presence of quite light bos individuals.

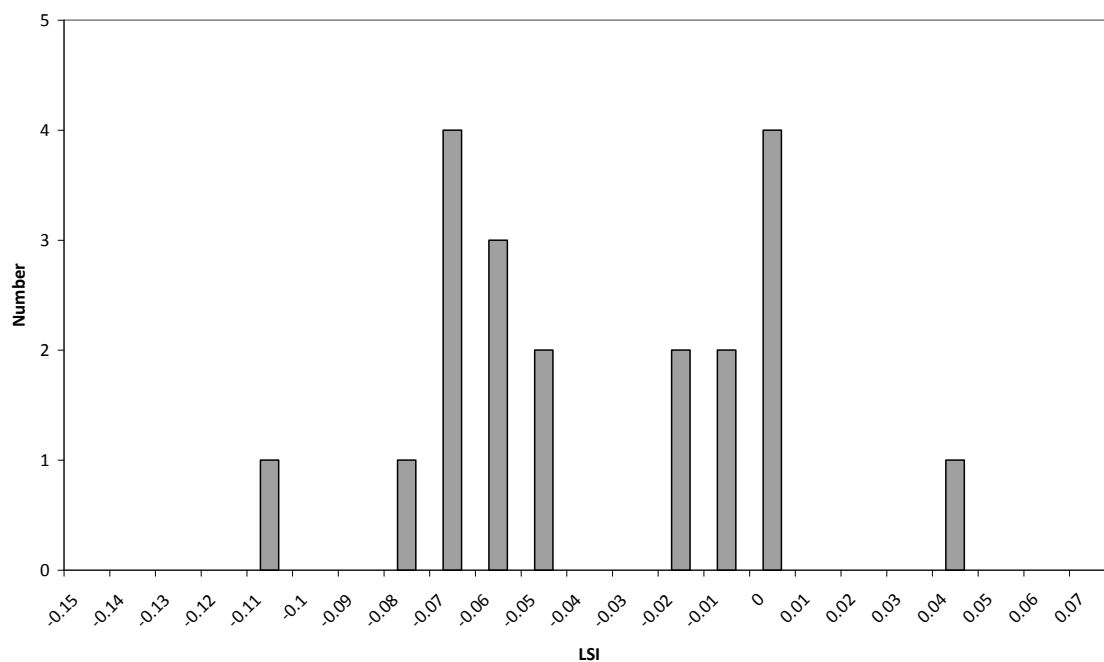


Fig 6.196: Levels B8-B4 bos width log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.04)

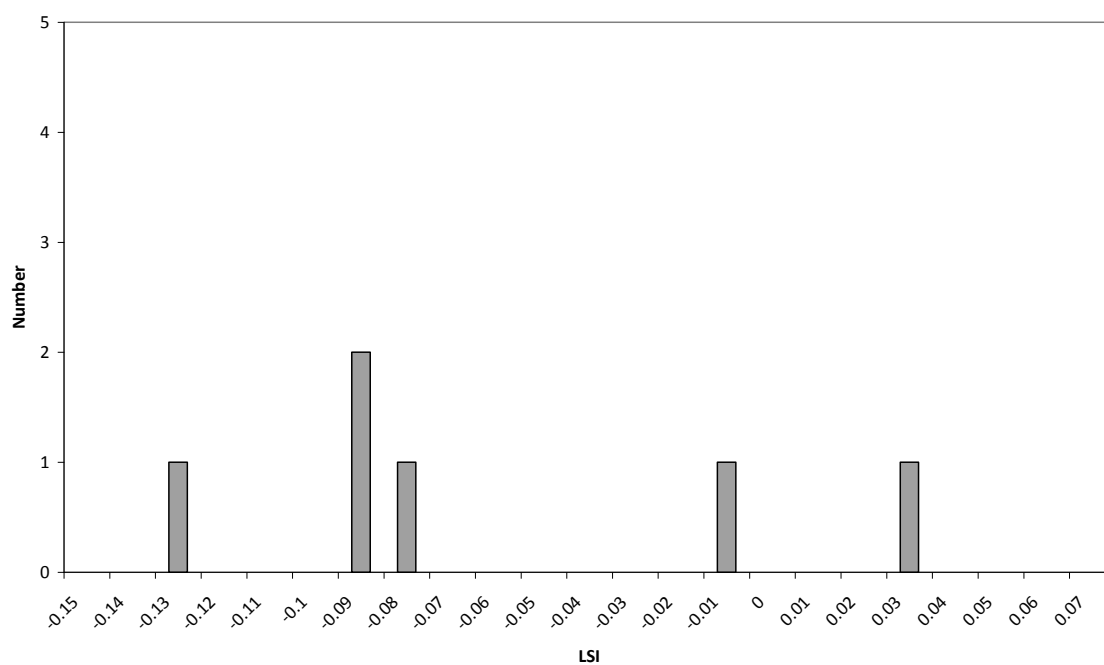


Fig 6.197: Levels B3-B1 bos width log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.03)

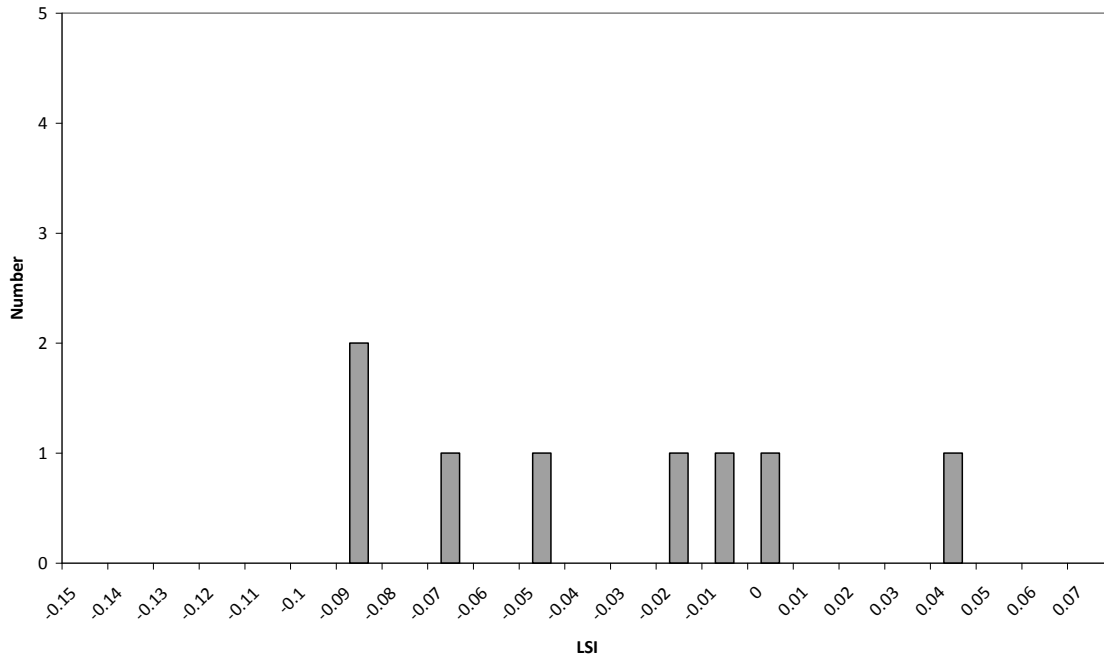


Fig 6.198: Level C bos width log ratio: standard measurements based on average measurements of *Bos primigenius* from Mureybet (mean = -0.04)

As with the length LSI analysis, the width LSI analysis shows that there was a shift to more smaller, lighter bos individuals through time. There appears to be two groups present, one representing the smaller females, the other the larger males.

There were too few depth measurements available for LSI analysis and these measurements will not be analysed by level but as a site total (fig 6.199). The majority of measurements were smaller the standard with only four being larger.

The population of bos at Tell Sabi Abyad were in general smaller than the population of *Bos primigenius* found at Mureybet. There were some measurements that were larger than this standard which implies the presence of some very large bos individuals, especially in the oldest phases. These could represent large male and/or wild individuals. There is a trend for a reduction in the general size of animals in the bos population at Tell Sabi Abyad through time.

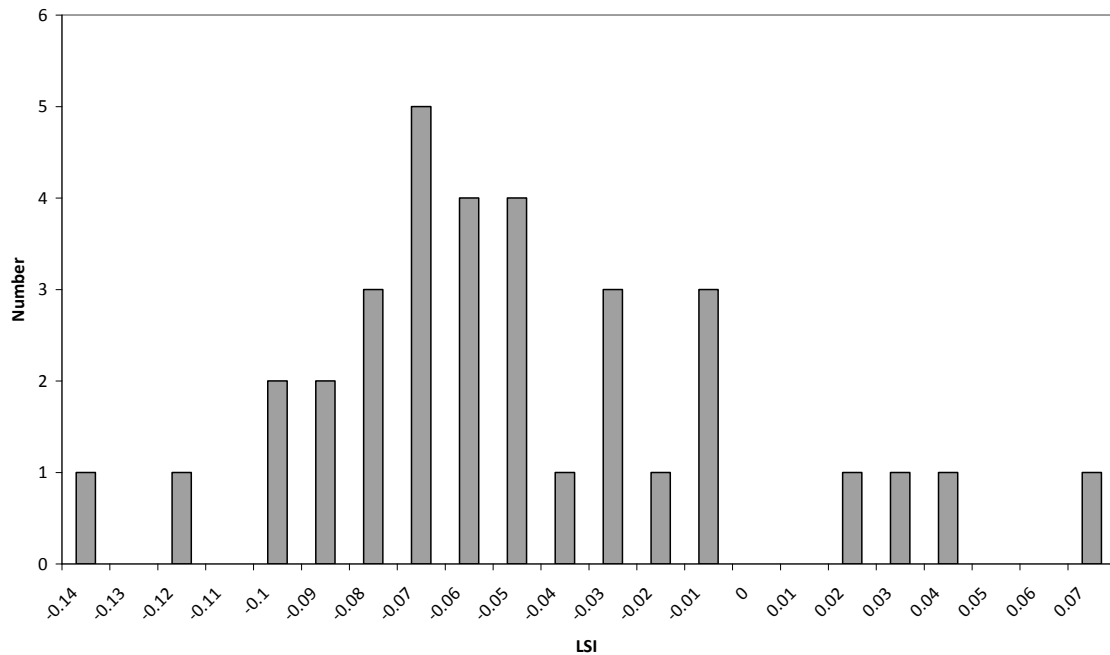


Fig 6.199: Bos depth log ratio (site total): standard measurements based on average measurements of *Bos primigenius* from Mureybet.

6.5.7 Domestication status

The bos at Tell Sabi Abyad appear to be in a state of proto-domestication or ‘cultural control’ in the oldest levels (A12-A10) based on the culling profiles and the metrical data. Through time the domestication process continues resulting in a slight reduction in the size of cattle through time.

6.5.8 Conclusions

In levels A12-A10 and A9-A5 the bos were in a state of proto-domestication. While some of the animals were as large as a *Bos primigenius* others were much smaller, perhaps a result of the domestication process. The animals were reared for their meat, being culled at the prime meat producing age of between three and four years. Through time the process of domestication continued with the animals still being bred for meat but with herd security being more important in levels A4 to A1. From level B8 onwards there was a stronger selection for meat production with only a small number of breeding stock kept. The size of the animals decreased through time with fewer large animals being present. As the vast majority of bos appear to be domestic they will from now simply be referred to as cattle.

6.6 Equids

6.6.1 Equid proportions

Equids make up 1.9% of the total site NISP with the highest proportion being found in the A levels at 2.1% of the NISP and 7.9% of the bone weight. The proportion of equids is highest in levels A9 to A1 after which their numbers rapidly decline. In levels B3-B1 a large number of skull fragments, probably representing just one skull, have artificially inflated the NISP count (fig 6.200).

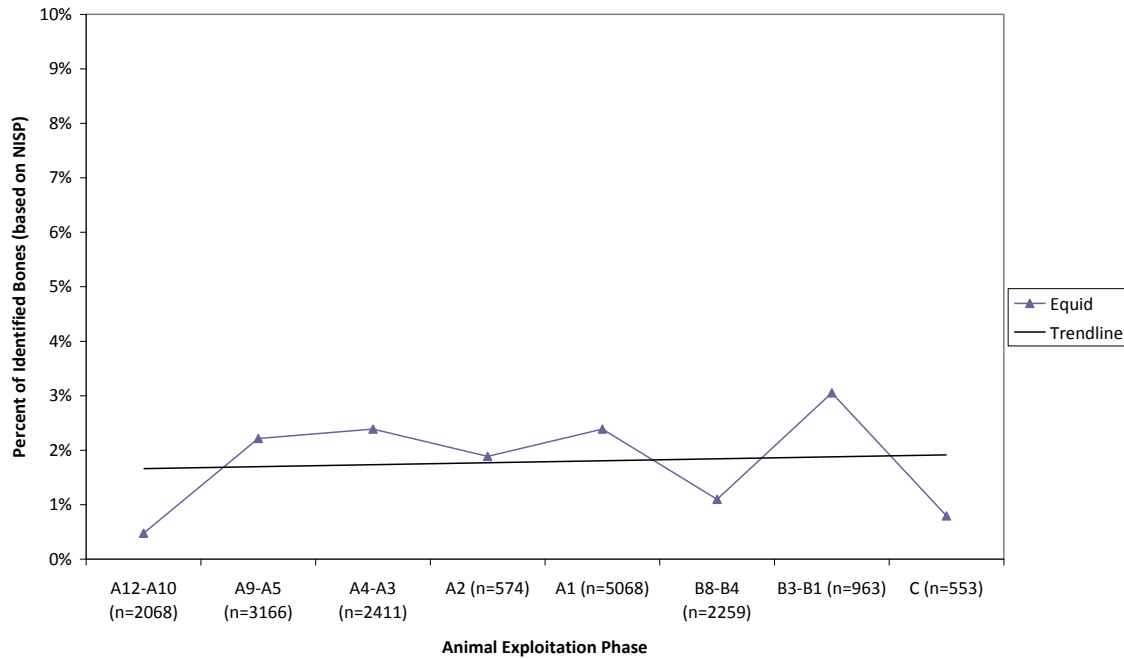


Fig 6.200: Equid species proportions by animal exploitation phase (NISP)

Analysing the proportion of equids by bone weight shows that there is clearly a decline in the weight of bones found, and therefore the contribution of equid meat to the diet, through time with practically no equid remains found in the B levels (fig 6.201).

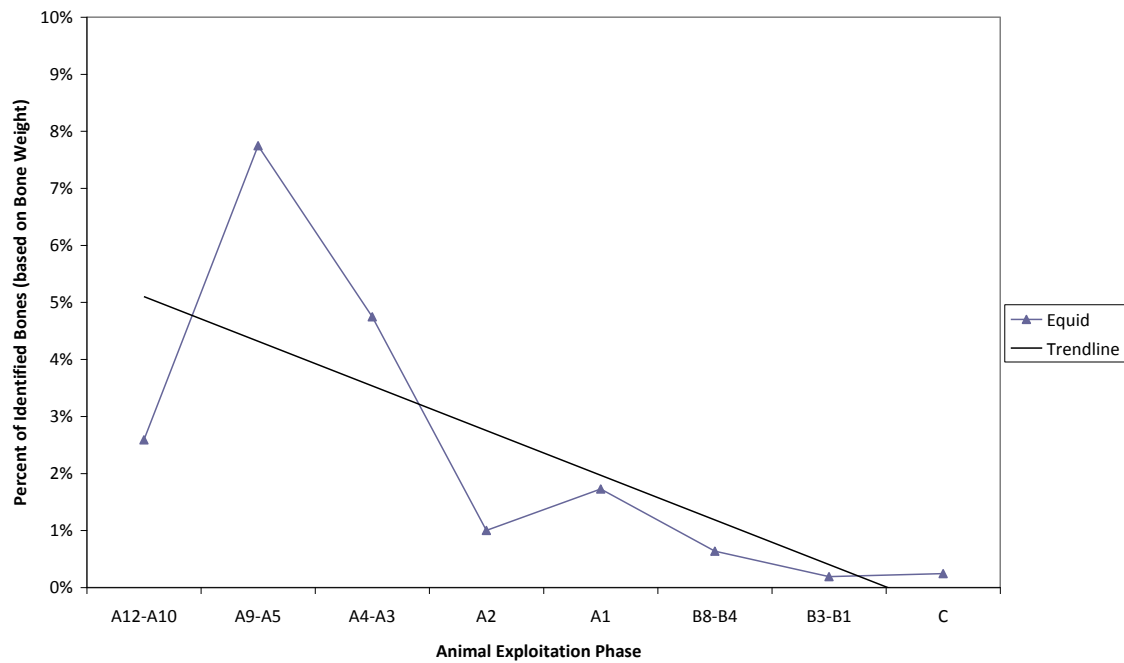


Fig 6.201: Equid species proportions by animal exploitation phase (Bone Weight)

6.6.2 Species distinction

The only wild equid from northern Syria in sub-recent times was a small subspecies of onager, *Equus hemionus hemippus*, but archaeological evidence has suggested the presence of other species (Ducos, 1986). Theoretically the equids recovered from Tell Sabi Abyad could be derived from two species *Equus hemionus* or *Equus africanus*. As there are so few modern skeletons of these species, or of hybrids of these species, it is very difficult to assess the degree of morphological and metrical variation to be expected within these species (Meadow and Uerpmann, 1986). This makes identifying the species of equid in archaeological material very difficult. *Equus hemionus* has in many respects a similarly proportioned postcranial skeleton to *Equus africanus* (Groves, 1986).

The question as to whether these two species of ass could have co-existed in Northern Syria is much debated (Groves, 1986; Ducos, 1972; Uerpmann, 1986). *Equus hemionus* lives in flat desert country such as salt flats and gravel plains whereas *Equus africanus* lives in stony deserts and in broken, undulating country not on broad plains (Groves, 1986). Traditionally *Equus africanus* was thought to be African in distribution (*Ibid*) whereas *Equus hemionus*' natural range was thought to be the whole of South West Asia (Uerpmann, 1986). There is however no reason why these species could not, in theory, coexist and recent finds of *Equus africanus* in Northern Syria at the site of Mureybet (Ducos, 1986) have highlighted the fact that one cannot assume the presence of a certain species on geographic distribution alone.

Unfortunately the equid remains from Tell Sabi Abyad are very fragmentary and there were very few whole bones with which to do a metrical analysis of bone proportions, a method often used to distinguish between the species. Complete skulls were also absent.

The enamel folds of both mandibular and maxilla teeth can be used to distinguish between species but only *Equus caballus* and *Equus hydruntinus* can be distinguished from *Equus hemionus* and *Equus africanus*. It is very difficult to distinguish the latter two species from each other and as such the teeth found at Tell Sabi Abyad do not contribute much to the question of the *hemionus/africanus* distinction. None of the teeth exhibit a pattern likely to be *E. hydruntinus*. One tooth from a mixed topsoil/Bronze Age level exhibited *E. caballus* like features. All the teeth from the Neolithic phases were identified as *Equus hemionus/africanus*. Previous work on material from Tell Sabi Abyad (Cavallo, 2000) identified only one species of equid, *Equus hemionus*. A metrical analysis of the bones may shed some more light of the question of species (see section 6.6.6)

6.6.3 Body part distribution

Body part distribution was calculated using both the NISP and MNI (the Minimum Number of Individuals which was used to compensate for the bias of naturally more common bone elements in the skeleton) by both level (fig 6.202 – fig 6.205) and for open areas (fig 6.206), pits (fig 6.207) and room fills (fig 6.208). Vertebrae (with the exception of the first two vertebrae the axis and atlas) and ribs were excluded because of the difficulties associated in identifying these elements to species.

In levels A12-A10 and A9-A5, which were combined due to the small sample size in levels A12-A10, most areas of the body were present with the radius being the most common element (fig 6.202).

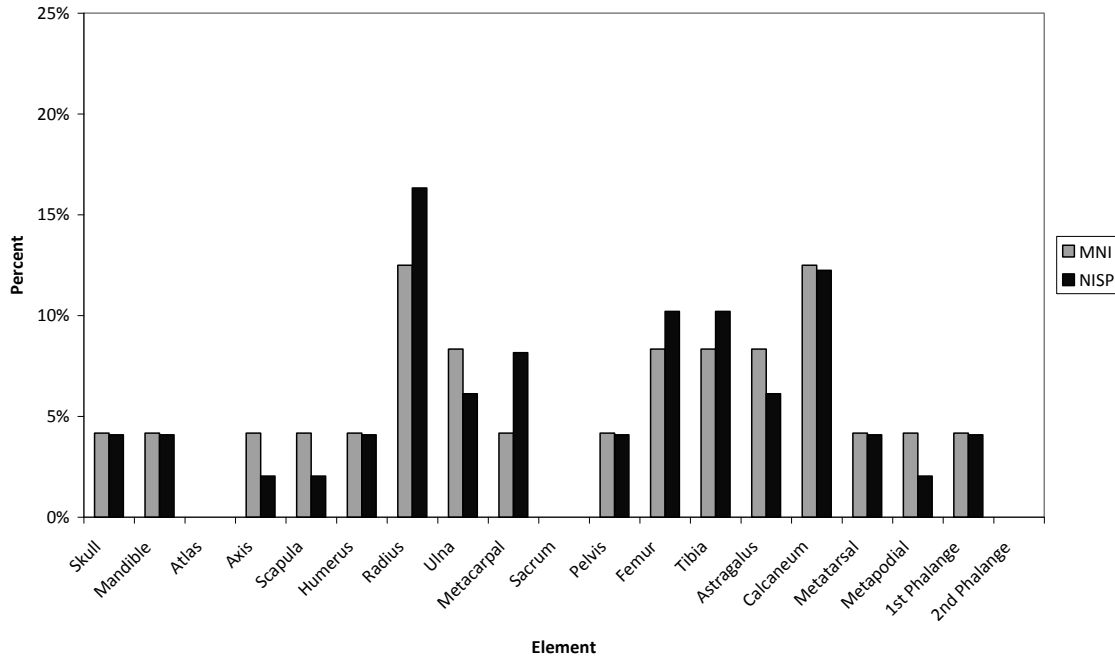


Fig 6.202: Levels A12-A5 equid body part proportions

In levels A4-A3 skulls and phalanges were absent, but most elements of the limbs were present (fig 6.203).

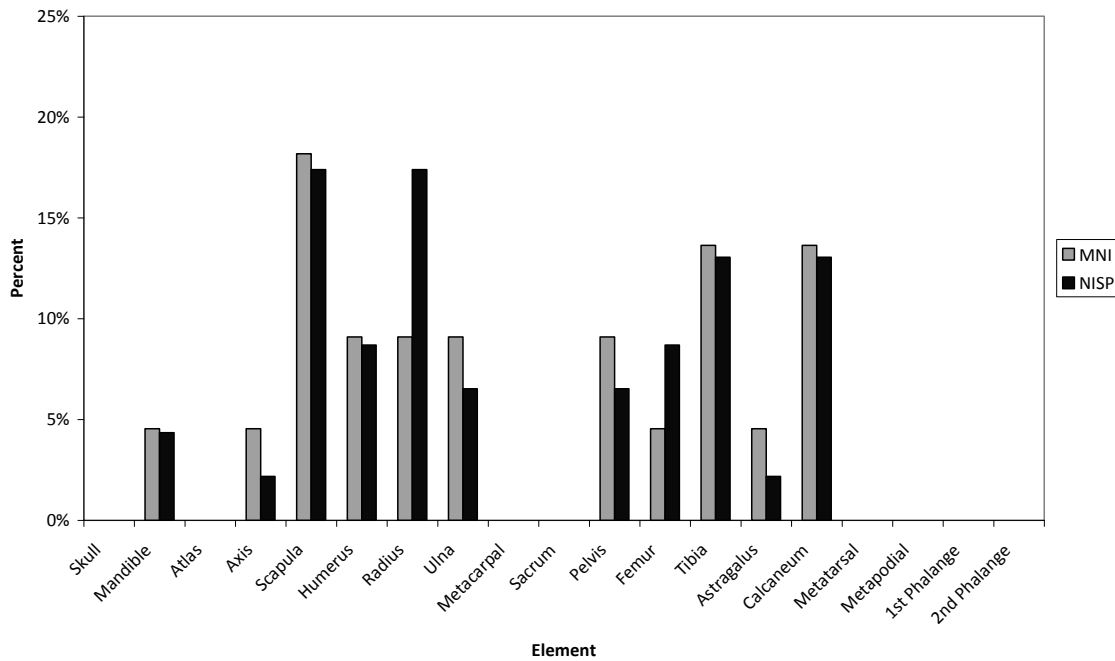


Fig 6.203: Levels A4-A3 equid body part proportions

Levels A2 and A1 were also combined due to small sample sizes (fig 6.204). In these levels elements of the fore limb were most common with skulls and the lower hind limb absent from the assemblage.

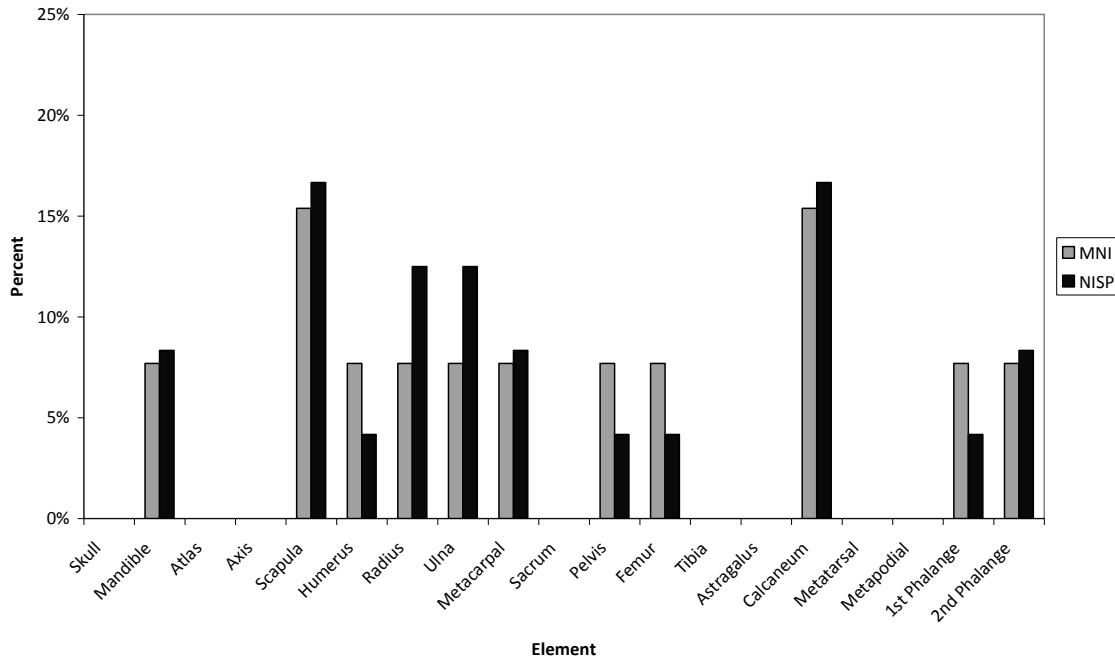


Fig 6.204: Levels A2 and A1 equid body part proportions

The sample sizes were also very low in levels B8 to B1 so these levels were combined for this analysis (fig 6.205). Not all areas of the skeleton were present, elements such as the skull and phalanges were conspicuous in their absence. The most common parts of the body present were the fore and hind limbs.

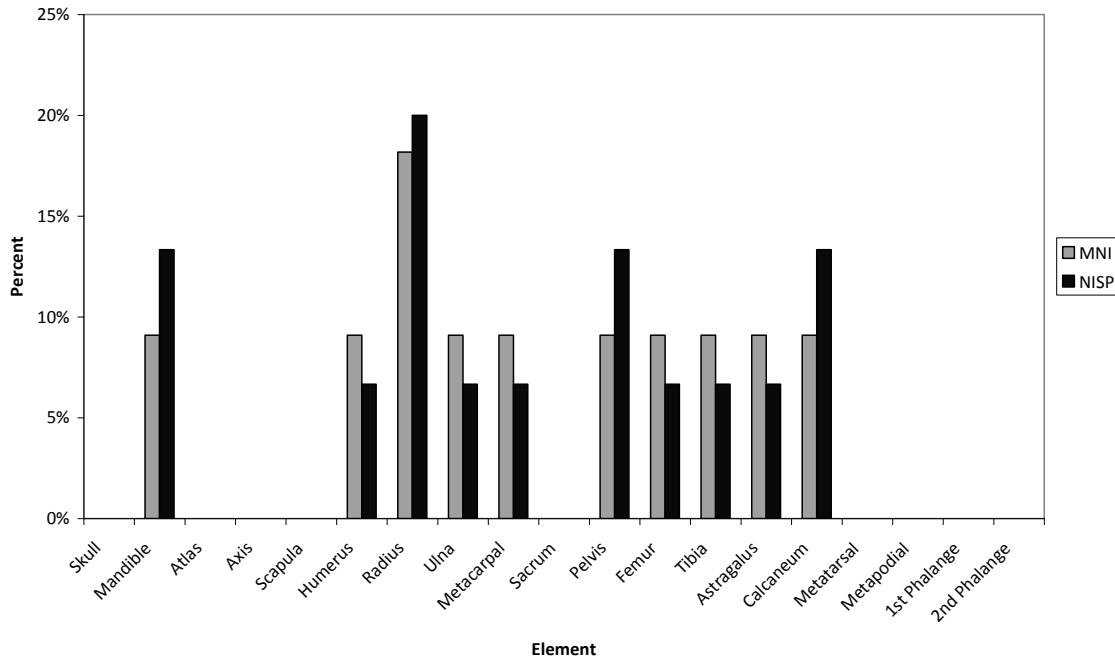


Fig 6.205: Levels B8-B1 equid body part proportions

There were not enough equid remains in the C levels to produce a body part distribution graph.

In general only the major meat bearing limb bones were present in all levels, with the exception of the oldest levels where most parts of the body were present. This suggests that whole equid were only present and processed on site in the oldest levels with apparently just major meat bearing bones being brought to the site in the younger levels.

There were some differences in the body part proportions by context. In open areas most body parts were present with the radius and calcaneum being most common (fig 6.206).

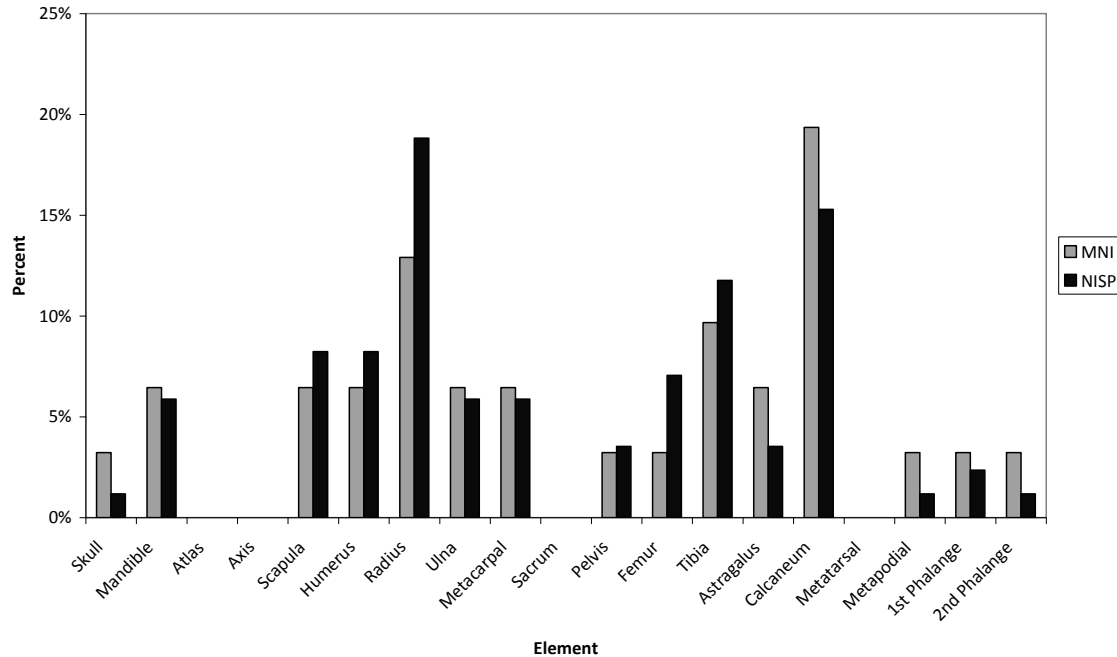


Fig 6.206: Open area (site total) equid body part proportions

In pits mainly elements from the fore and hind limbs were present with no skulls, mandibles or phalanges present (fig 6.207).

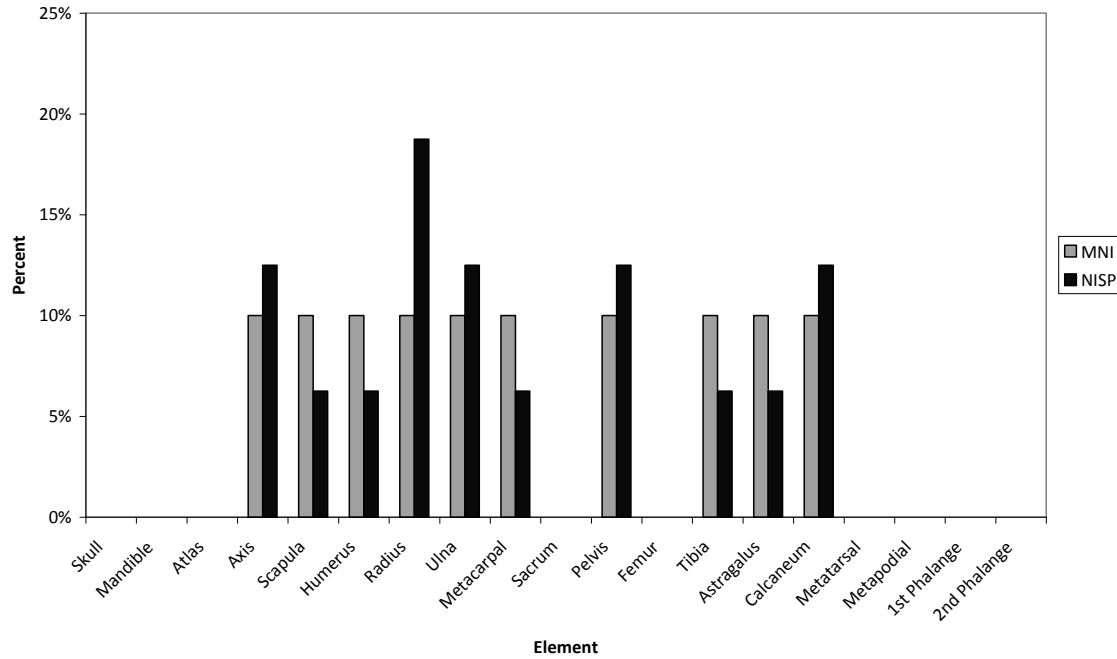


Fig 6.207: Pit (site total) equid body part proportions

In room fills the most common elements were the scapula and the femur, an element that was very scarce in other contexts (fig 6.208). There does therefore seem to be some structured spatial distribution of equid remains but this could perhaps be a false pattern formed due to the small sample sizes in room fills and pits.

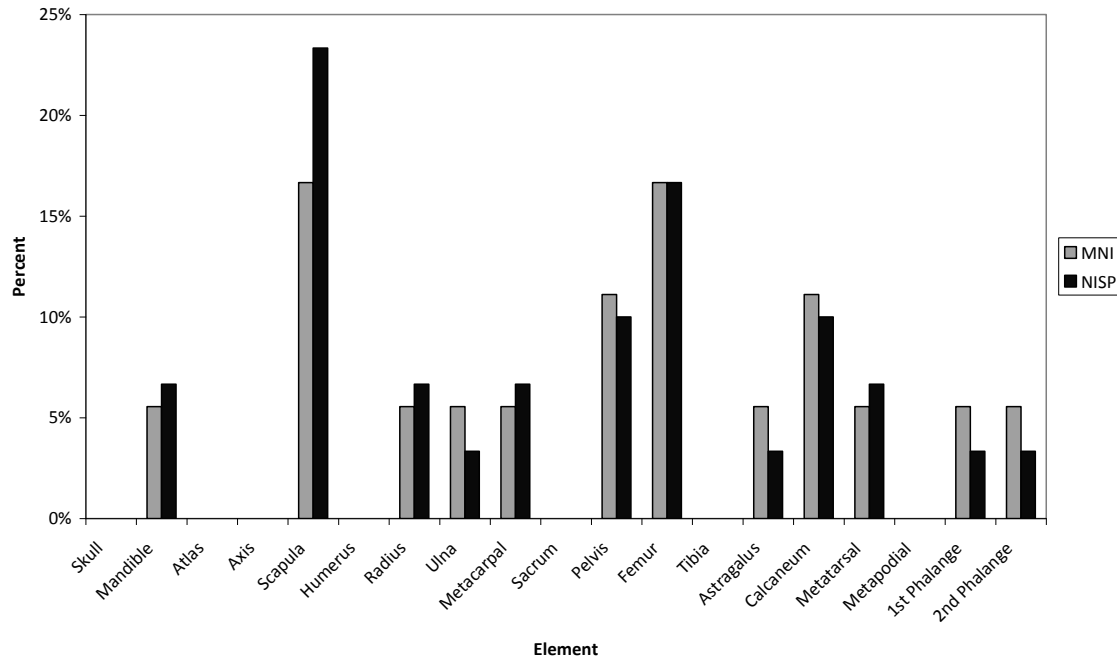


Fig 6.208: Room fill (site total) equid body part proportions

6.6.4 Butchery

Three equid bones had butchery marks present: a scapula with a cut mark around the neck, an astragalus with a cut mark along the medial edge and a calcaneum with a cut mark around the articular surface. These are cut marks typical of disarticulation and skinning of the carcass.

6.6.5 Age profiles

No reliable methods for determining age at death from toothwear in equids have been developed. Age profiles for equids could only be constructed using postcranial bone fusion. The majority of bones came from adult animals with no neonatal remains recovered (fig 6.209). Over 90% of the equids found at Tell Sabi Abyad were over 18 months of age with over 60% being 36 months or older. There is no evidence that the equids were domestic and they were apparently hunted at a time of year when very young animals were not present. Alternatively adults were selectively hunted.

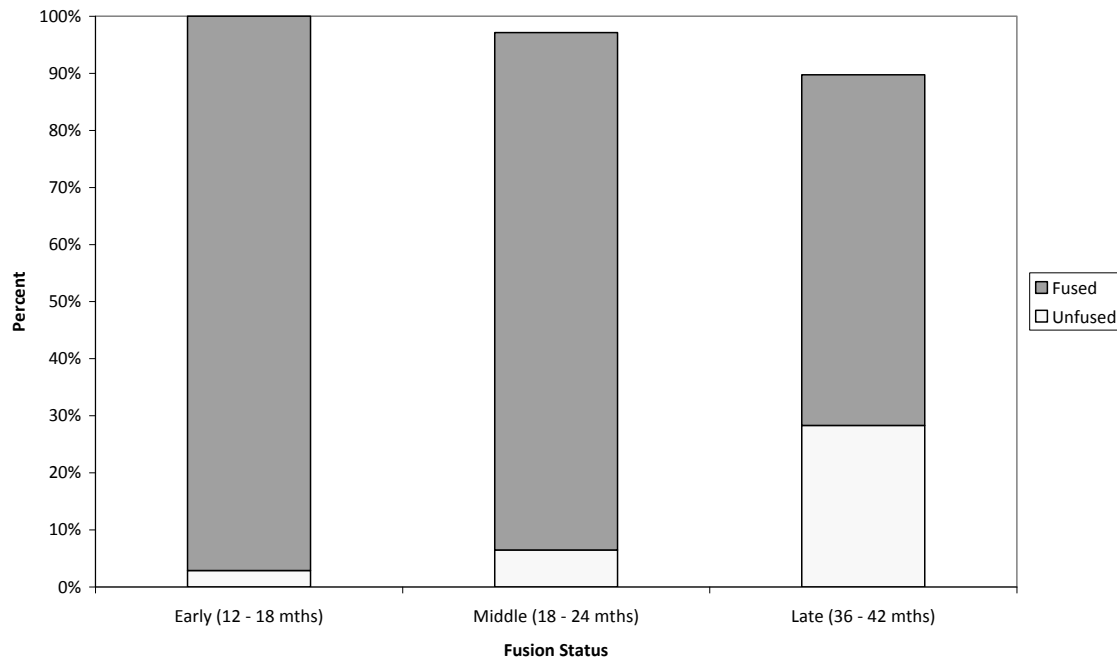


Fig 6.209: Equid Mortality based on postcranial bone fusion (site total).

6.6.6 Pathology

No pathology was seen on any of the equid bone fragments

6.6.7 Metrical analysis

During the recording of the Tell Sabi Abyad material measurements were taken where possible. For a full list of the measurements taken see appendix 7.

Due to the low proportions of equid in the assemblage and the highly fragmentary state of the remains very few measurements were available. The Standard Index (SI) method outlined in Uerpmann (1982) was used to combine different measurements. To calculate the SI the following formula was applied:

$$SI = \frac{(x - m)}{2s} \times 50$$

Where x is the actual measurement, m is the mean or standard measurement, and s is the standard deviation of the measurement series used as the standard. A list of measurements used can be found in appendix 9. One measurement from each element was included where available.

The equid measurements from Tell Sabi Abyad were compared using this method to three standards: the mean and standard deviation of the Tell Sabi Abyad data itself (SAB), the mean and standard deviations of the Mureybet measurements (MUR) and the mean and standard deviations of the Shams ed-Din measurements (SHAM) (fig 6.210). The Mureybet and Shams ed-Din data was taken from Uerpmann (1982).

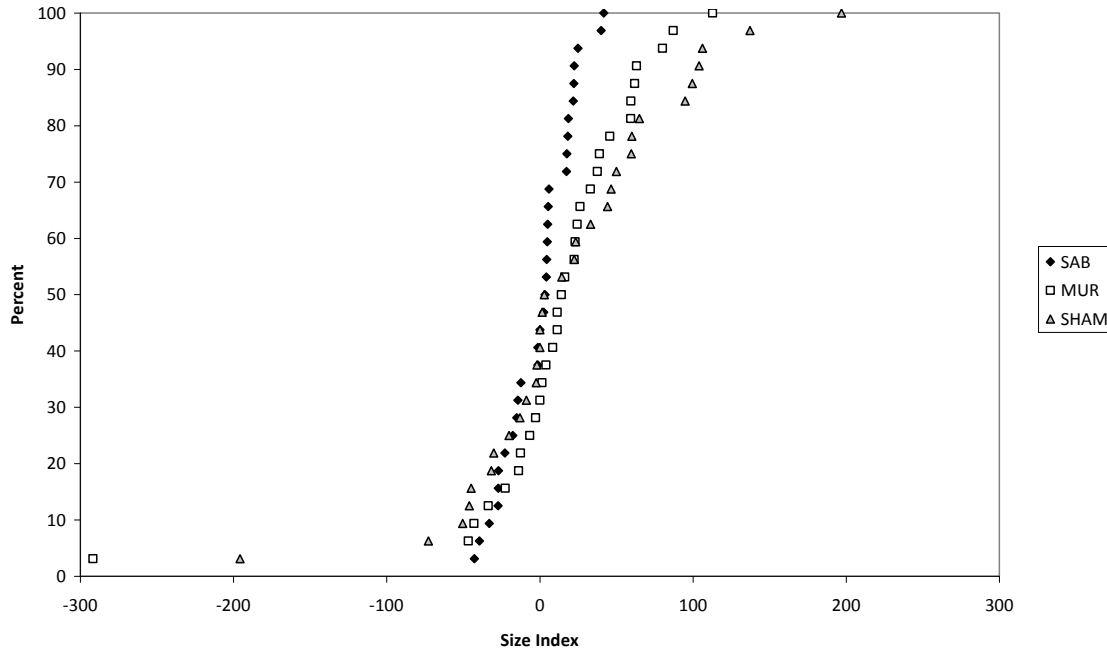


Fig 6.210: Cumulative frequency-distributions of size indices of equid bones from Tell Sabi Abyad in comparison to Mureybet and Shams ed-Din

The mean value was not zero in the comparison with Mureybet (mean = 11.53) or Shams ed-Din (mean = 20.14) as would have been expected if the equids of the three populations were of equal size. The size indices are more or less normally distributed. The Tell Sabi Abyad equids were not smaller than those at Mureybet or Shams ed-Din. The size difference between the equids of Tell Sabi Abyad, Mureybet and Shams ed-Din are not large enough to suggest different species and the relatively narrow and unimodal distribution of size-indices is an indication that only one species was present. This analysis has not however helped in resolving the question of the specific species of the equids at Tell Sabi Abyad. Both *Equus hemionus* and *Equus africanus* were identified at both Mureybet and Shams ed-Din and it is quite possible that both species were also present at Tell Sabi Abyad. According to non-metric morphological features *Equus hemionus* was far more common than *Equus africanus* at Shams ed-Din (Uerpmann, 1982). It is possible that the same was true at Tell Sabi Abyad.

6.6.8 Conclusions

The equids at Tell Sabi Abyad are most likely to be *Equus hemionus* but the presence of a few *Equus africanus* cannot be ruled out. The equids were hunted in all levels but particularly in levels A9 to A3 where apparently whole carcasses (with perhaps the exception of the heavy skull) were brought back to the site. This suggests that they were hunted nearby. The exploitation of these animals dwindled in the B and C levels and only the major meat bearing bones were brought back to the site suggesting that the

animals were perhaps hunted some distance from the site and that primary butchery took place at the kill site.

6.7 Gazelle

6.7.1 *Gazelle proportions*

Gazelle bone fragments make up 3.1% of the total NISP and 2.2% of the total bone weight. The highest proportion of gazelle was found in the A levels at 4.0% of the NISP. This drops dramatically in the B (0.6%) and C (0.3%) levels.

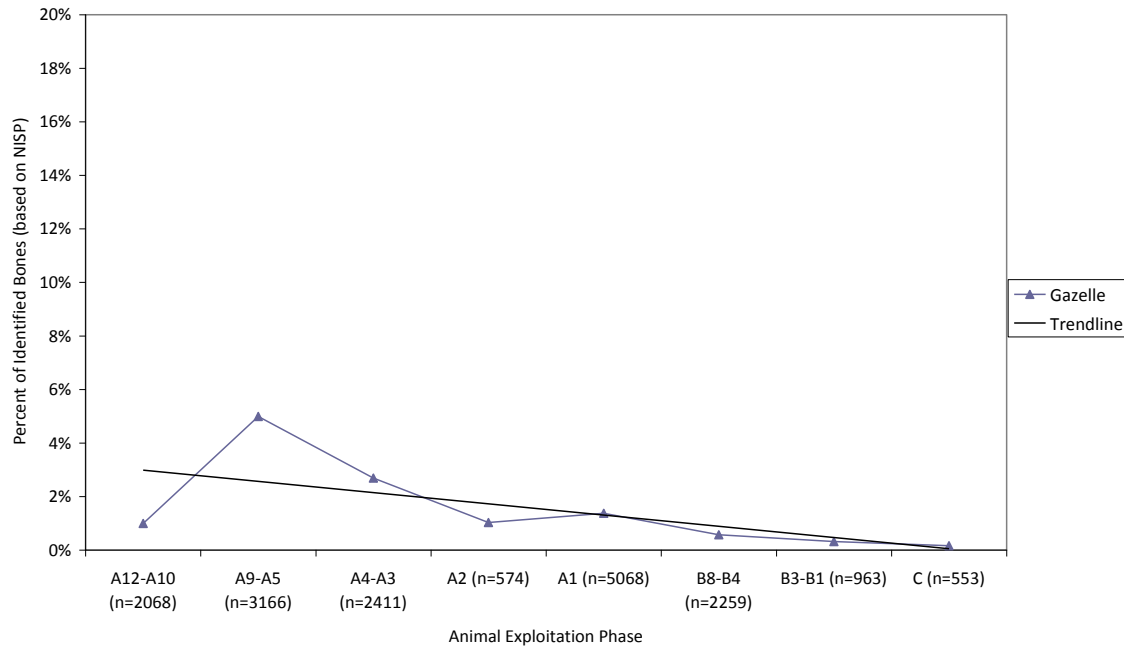


Fig 6.211: *Gazelle species proportions by animal exploitation phase (NISP)*

The highest proportion of gazelle is seen in levels A9-A5, followed by levels A4-A3 (fig 6.211). The presence of gazelle diminishes rapidly from level A2 onwards with practically no gazelle present in levels B3-B1 and the C levels. The addition of a trend line highlights the progressive decrease in gazelle through time.

Analysing gazelle proportions by bone weight shows a much more varied picture with the weight of gazelle bone present fluctuating greatly from level to level (fig 6.212). By bone weight the proportions of gazelle are greatest in phases A4-A3, A2 and B3-B1. This seems to be due to the presence of more complete (and therefore heavier) gazelle bone fragments in these levels. Adding a trend line does show that overall proportions of gazelle decreased through time.

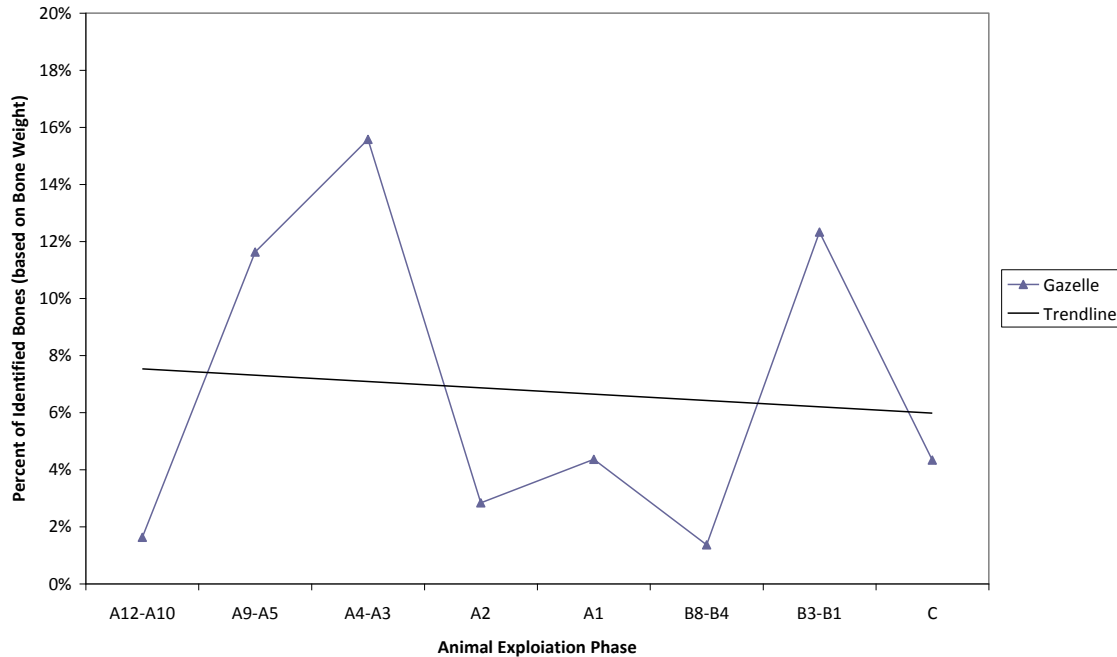


Fig 6.212: Gazelle species proportions by animal exploitation phase (Bone Weight)

6.7.2 Species distinction

Three different species of gazelles can be expected to have occurred around the site: *Gazella gazella*, *Gazella dorcas* and *Gazella subgutturosa* but their distinction using archaeological material is difficult (Uerpmann, 1982). This can only usually be achieved for complete skulls and horncores, neither of which were present at Tell Sabi Abyad. Those larger fragments of horncore recovered resembled most closely those of *G. subgutturosa*.

The size of the remains can be of some help in distinguishing the species with *G. dorcas* being smaller than both *G. subgutturosa* and *G. gazella*, and *G. subgutturosa* being equal in size or larger than *G. gazella* (Uerpmann, 1982; Harrison, 1968). Identification based on size can only be tentative because there is a great deal of geographical size variation (see section 6.7.12).

6.7.3 Body part distribution

Body part distribution was calculated using both the NISP and MNI (the Minimum Number of Individuals which was used to compensate for the bias of naturally more common bone elements in the skeleton) by both level (fig 6.213 – fig 6.217) and for open areas (fig 6.218), pits (fig 6.219) and room fills (fig 6.220). Vertebrae (with the exception of the first two vertebrae the axis and atlas) and ribs were excluded because of the difficulties associated in identifying these elements to species. As some elements are more easily identified as gazelle than others there may be some bias in this analysis.

In levels A12-A10 many elements of the skeleton were missing with the most common element by far being the humerus (fig 6.213).

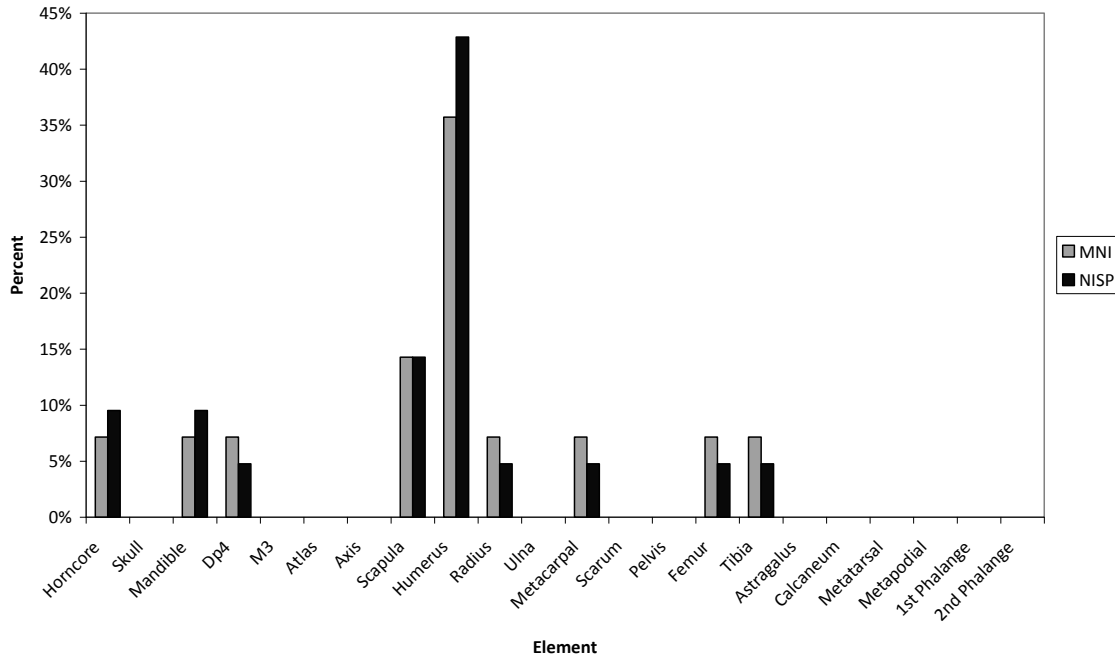


Fig 6.213: Levels A12-A10 gazelle body part proportions

Similar body part proportions were seen in levels A9-A5 (fig 6.214) and A4-A3 (fig 6.215).

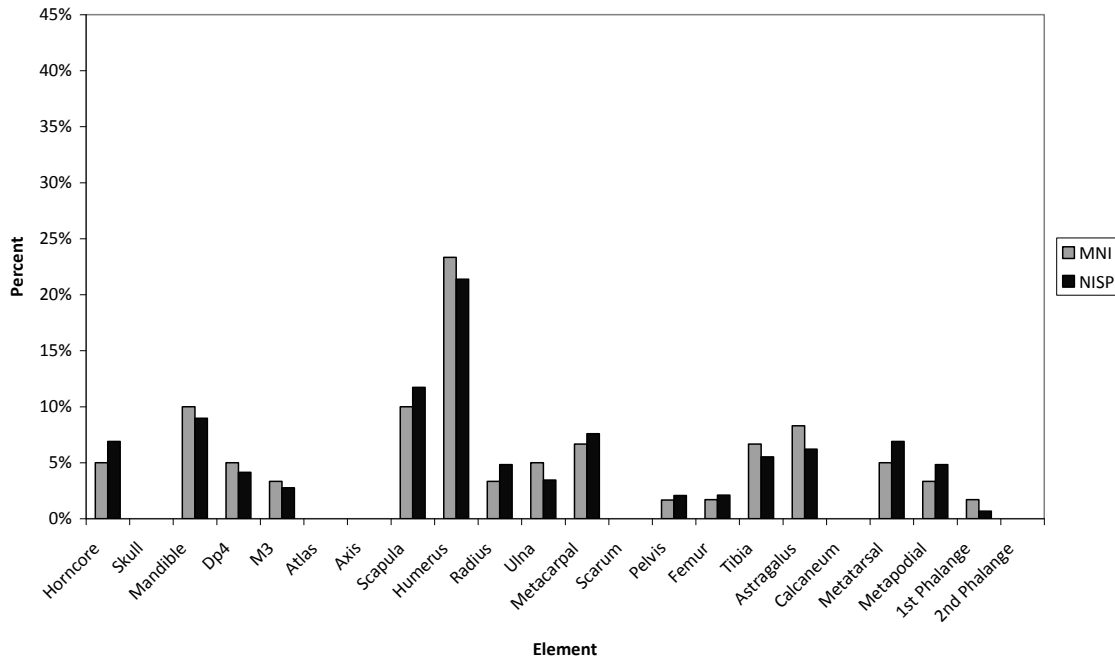


Fig 6.214: Levels A9-A5 gazelle body part proportions

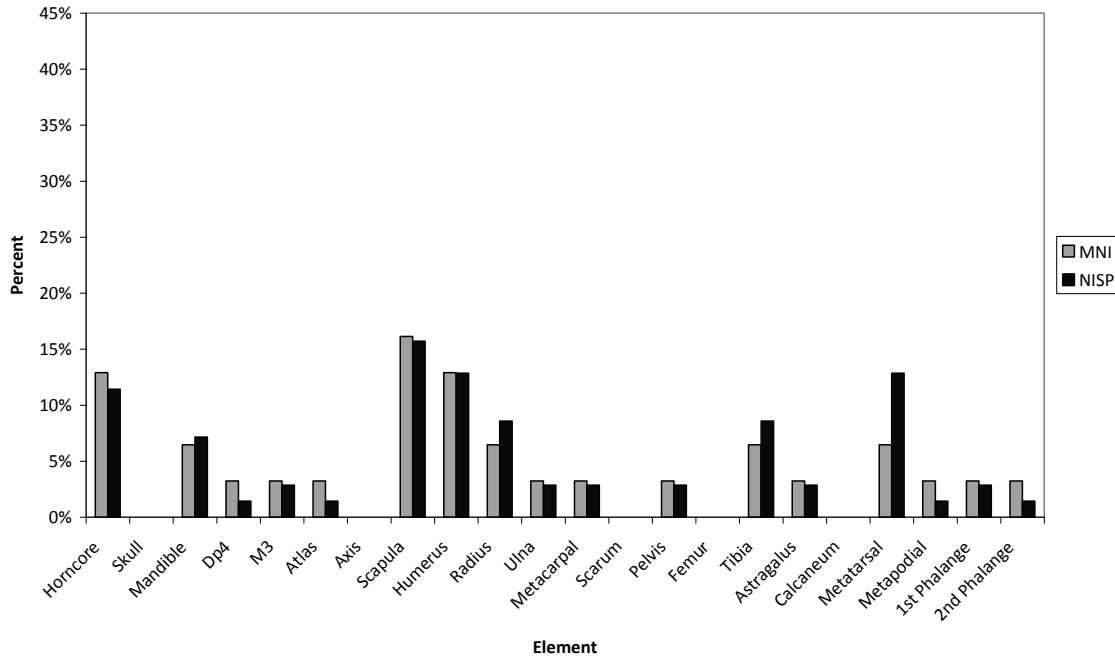


Fig 6.215: Levels A4-A3 gazelle body part proportions

In levels A2 and A1 the sample sizes were very small so the data from these levels was combined. The humerus was the most common element with elements of the forelimb being more common than other areas of the body (fig 6.216).

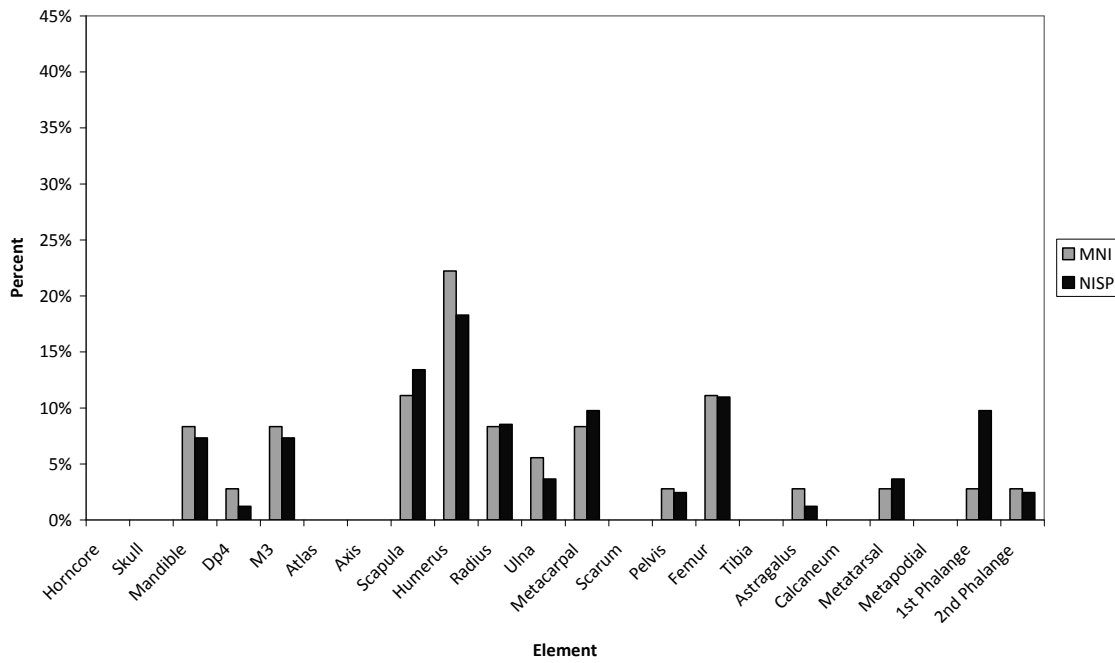


Fig 6.216: Levels A2-A1 gazelle body part proportions

Levels B8 to B1 were combined in order to increase the small sample sizes of these levels (fig 6.217). Many areas of the skeleton were missing in these levels with the most common element being the humerus. In the C levels there were not enough gazelle remains to analyse body part proportions present.

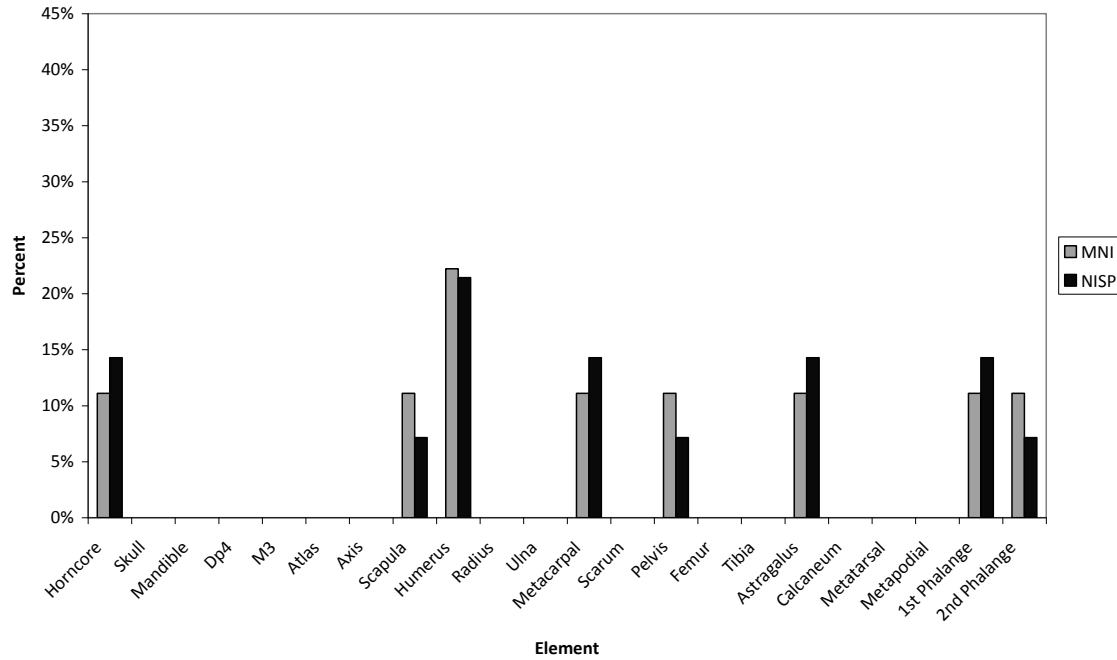


Fig 6.217: Levels B8-B1 gazelle body part proportions

In all levels the humerus was the most common element present. This is one of the most easily distinguishable gazelle elements from those of ovicaprids which may go some way to explain its elevated presence.

The body part proportions of gazelles were also analysed by context. In open areas most parts of the gazelle skeleton were present (fig 6.218). The humerus and scapula were the most common elements.

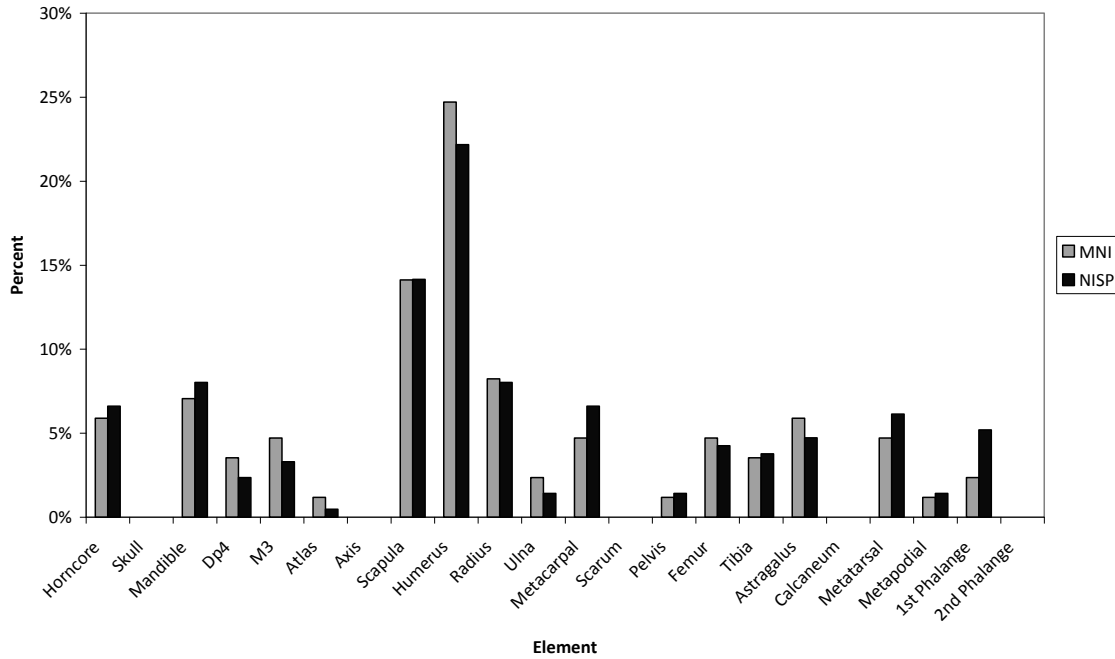


Fig 6.218: Open area gazelle body part proportions

In pits metacarpals and metatarsals were the most common elements with very few humeri present (fig 6.219).

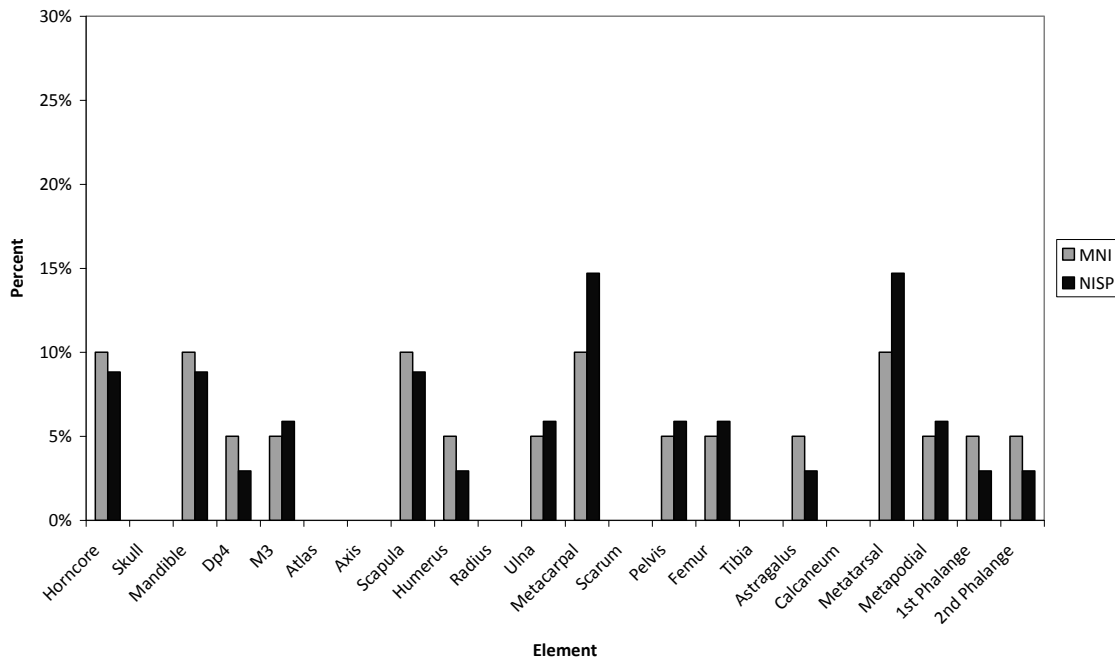


Fig 6.219: Pit gazelle body part proportions

In room fills the humerus is once again the most common element, followed by the scapula (fig 6.220).

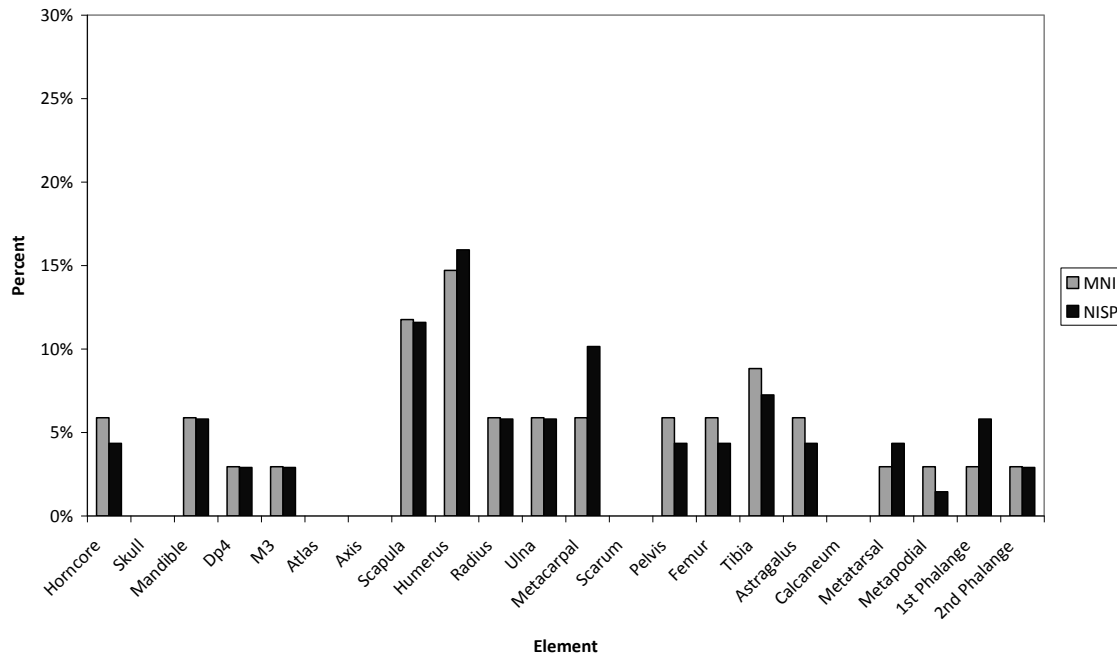


Fig 6.220: Room fill gazelle body part proportions

The gazelle bones appear to have been distributed differently in different contexts with room fills and open areas more similar to each other than pits.

Most elements of the skeleton were present in levels A9-A1 whereas levels B8-B1 had only a few elements of the skeleton present, as was the case in the oldest levels A12-A10. It appears as if more whole gazelle carcasses were present and processed on site in levels A9-A1.

6.7.4 Butchery

Three gazelle bone fragments displayed cut marks: a metacarpal with two cut marks around the distal epiphysis and two ulnas with cut marks around the proximal articular surface. The location of the marks suggests they were produced as a result of skinning and disarticulating the carcass.

6.7.5 Age profiles

Gazelle postcranial fusion and toothwear were used to construct mortality curves. The method of Munro *et al.* (2009) was used to combine these ageing methods and construct a combined mortality curve (fig 6.221). The majority of animals were killed when they were adults and between the ages of 18 and 36 months. Very few neonatal or juvenile animals were recovered (possibly due to the poor preservation of these bones or difficulties associated with distinguishing these remains from those of young ovicaprid bones). The season of the gazelle kills was calculated from the toothwear based on the assumption that the birthing season started in March. This analysis shows that most of the gazelles were killed in September (fig 6.222).

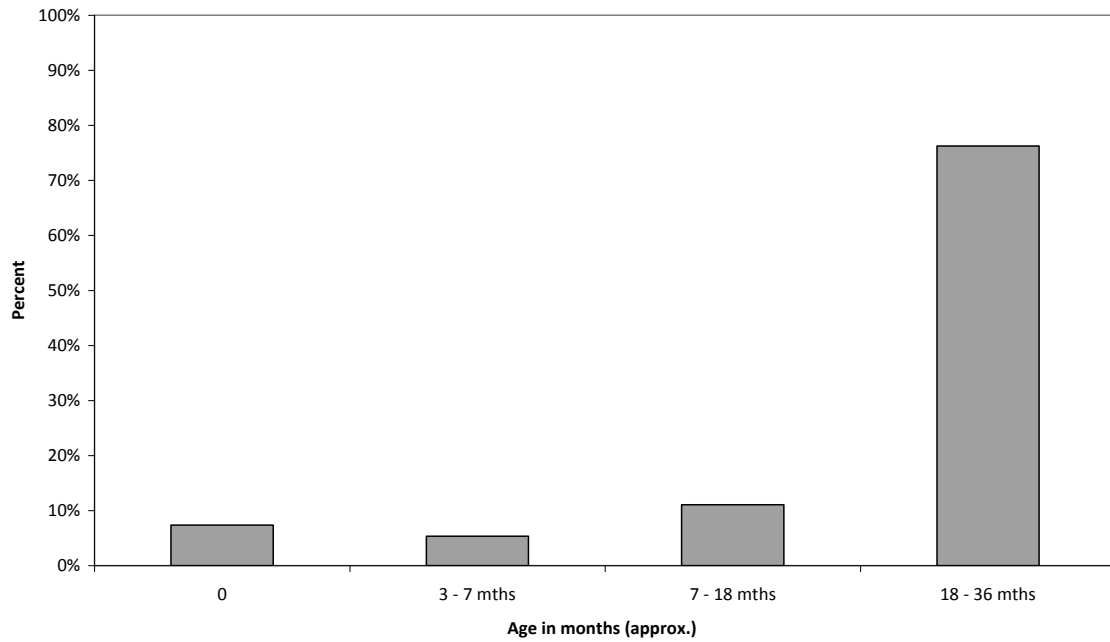


Fig 6.221: Gazelle mortality based on toothwear and bone fusion combined

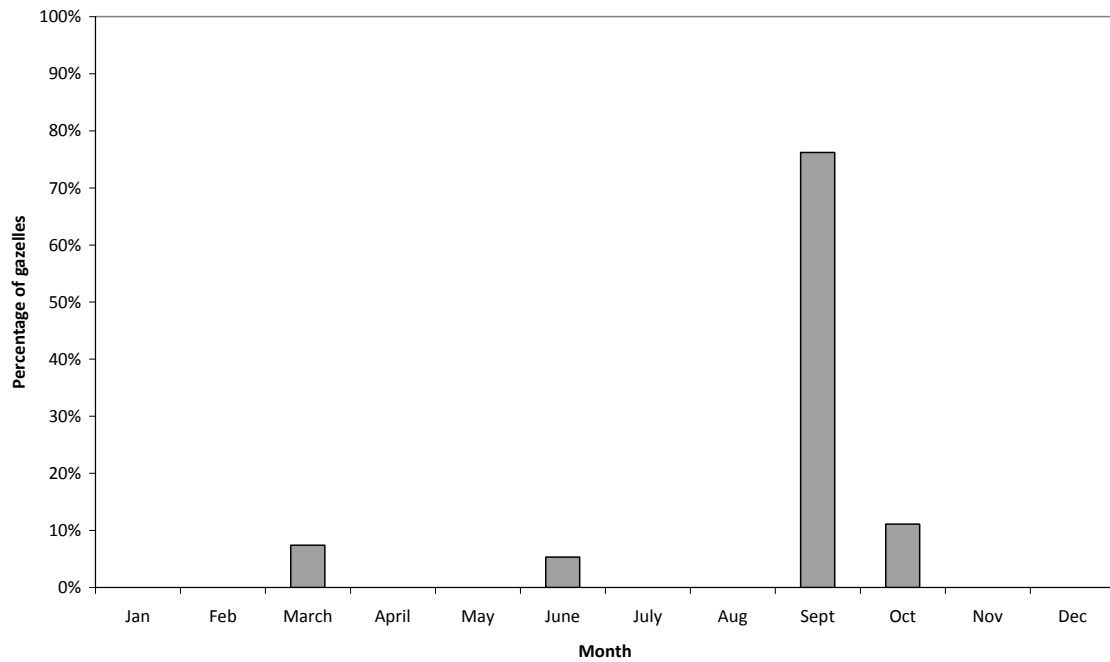


Fig 6.222: Gazelle month of death from toothwear

6.7.6 Pathology

Only one possible pathology was recorded in the gazelle remains: a radius had a strange ridge of bone on the medial side of the proximal epiphysis. It was unclear as to whether this was merely a natural but unusually strong muscle attachment site or some sort of pathology caused by a trauma.

6.7.7 Metrical analysis

During the recording of the Tell Sabi Abyad material measurements were taken where possible. For a full list of the measurements taken see appendix 8.

The Standard Index method outlined in Uerpmann (1982) was used to compare the Tell Sabi Abyad gazelles to those from the nearby sites of Mureybet and Shams ed-Din (fig 6.223). A list of measurements used can be found in the appendix 9. One measurement from each element was included where available. No species was proposed for the gazelles of Mureybet but it was stated that probably only one species was present (Ducos, 1978). The gazelles at Shams ed-Din were identified as *G. subgutturosa*.

The gazelle measurements from Tell Sabi Abyad were compared using this method to three standards: the mean and standard deviation of the Tell Sabi Abyad data itself (SAB), the mean and standard deviations of the Mureybet measurements (MUR) and the mean and standard deviations of the Shams ed-Din measurements (SHAM) (fig 6.223). The Mureybet and Shams ed-Din data was taken from Uerpmann (1982).

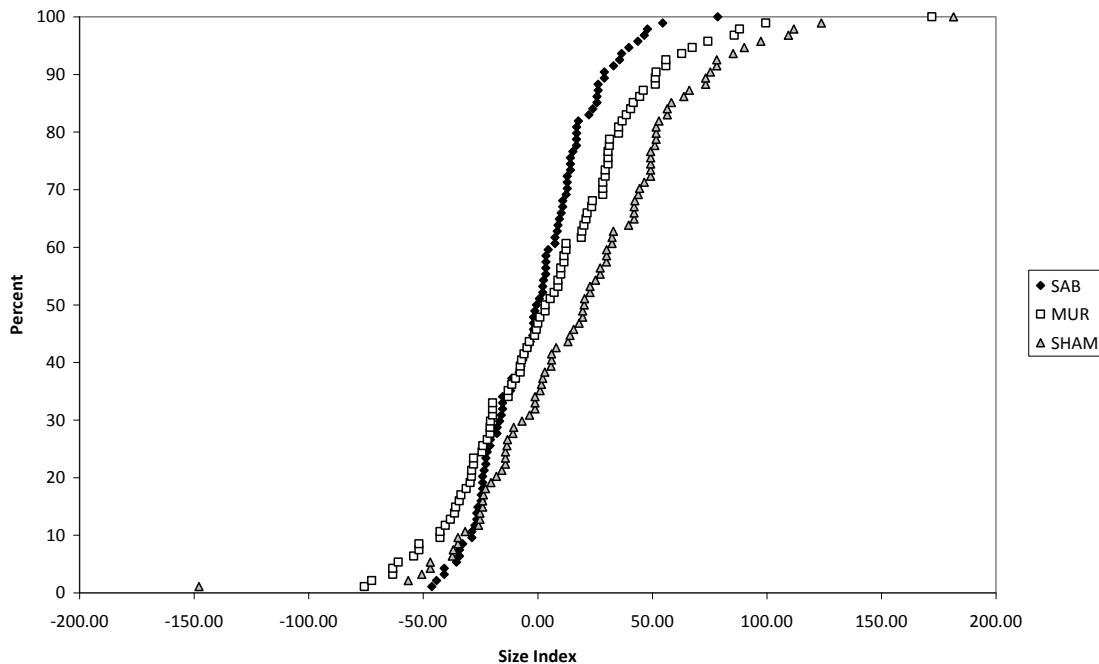


Fig 6.223: Cumulative frequency-distributions of size indices of gazelle bones from Tell Sabi Abyad in comparison to Mureybet and Shams ed-Din

The sizes indices are more or less normally distributed. The mean value was not zero in the comparison with Mureybet (mean = 5.75) or Shams ed-Din (mean = 20.87) as would have been expected if the gazelle in the three populations were of equal size. The Tell Sabi Abyad gazelle were not smaller than those at Mureybet or Shams ed-Din. The size differences between the gazelles of Tell Sabi Abyad, Mureybet and Shams ed-Din are not large enough to suggest different species and the relatively narrow and unimodal distribution of size-indices is an indication that only one species was present, most likely all are populations of *G. subgutturosa*.

6.7.8 Conclusions

Gazelle were hunted and exploited predominately in levels A9-A5 and A4-A3 with the proportions of gazelle in the assemblage rapidly declining from around levels A1/A2. The gazelle at Tell Sabi Abyad appear to belong to one population of the species *G. subgutturosa*. Mostly adults were hunted,

apparently predominately in the autumn months. They were perhaps hunted when the gazelle passed the settlement in their annual migration cycle.

6.8 Other Species

6.8.2 Canids

Species Proportions

The majority of canids were identified as red fox (*Vulpes vulpes*). Domestic dog (*Canis familiaris*) was also identified as were two bones which could belong to either a large dog or a wolf (*Canis lupus*). Domestic dog remains were relatively rare in the assemblage.

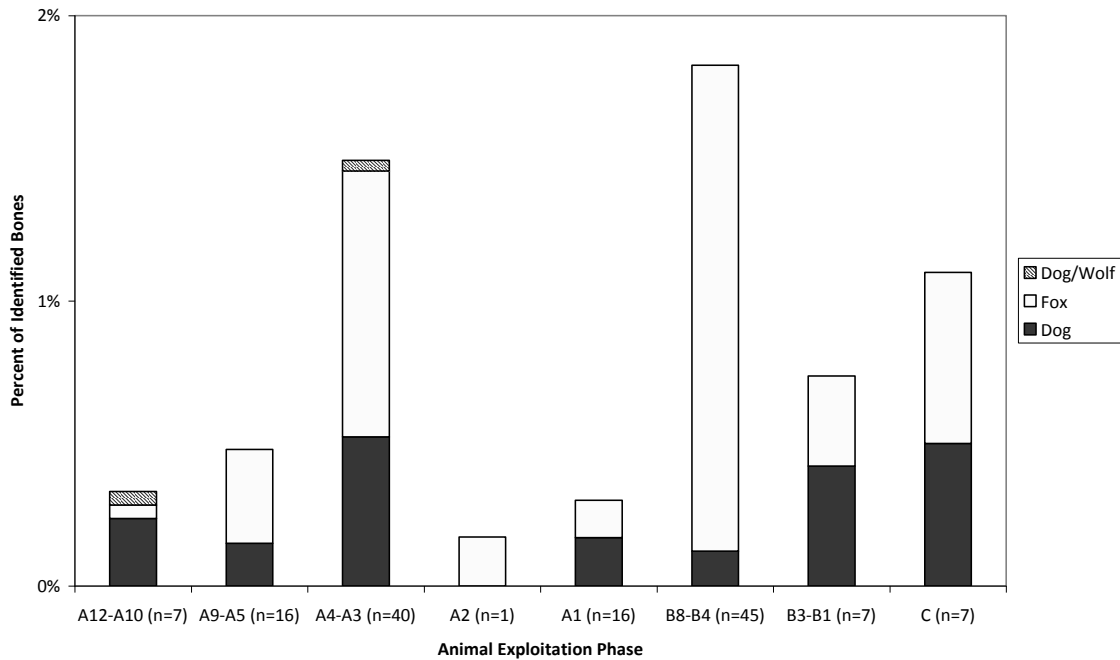


Fig 6.224: Canid species proportions by animal exploitation phase (based on NISP)

The domestic dog was found in almost all levels at very low proportions (less than 0.01% of the total NISP) (fig 6.224). Other signs that dogs were present on the site such as evidence of gnawing were also only present at a very low level. Dogs were apparently not kept in large numbers and may have only been scavengers around the site rather than pets or working animals.

Foxes appear to be particularly prevalent in levels B8-B4 but the high proportion of fox bones is due to the presence of many skull fragments probably belonging to just one skull found in level B8. Fox remains were present in all levels in low numbers and they were probably scavenging on the refuse at the site as well as perhaps being hunted for their fur.

Body part proportions

Body part distributions of both domestic dogs and foxes were calculated using both the NISP and MNI (the Minimum Number of Individuals which was used to compensate for the bias of naturally more common bone elements in the skeleton) for the site total (fig 6.225– fig 6.226). Vertebrae (with the exception of the first two vertebrae the axis and atlas) and ribs were excluded because of the difficulties associated in identifying these elements to species.

Most parts of domestic dog skeleton were present in the assemblage with the exception of the scapula, pelvis, femur, astragalus and phalanges (fig 6.225).

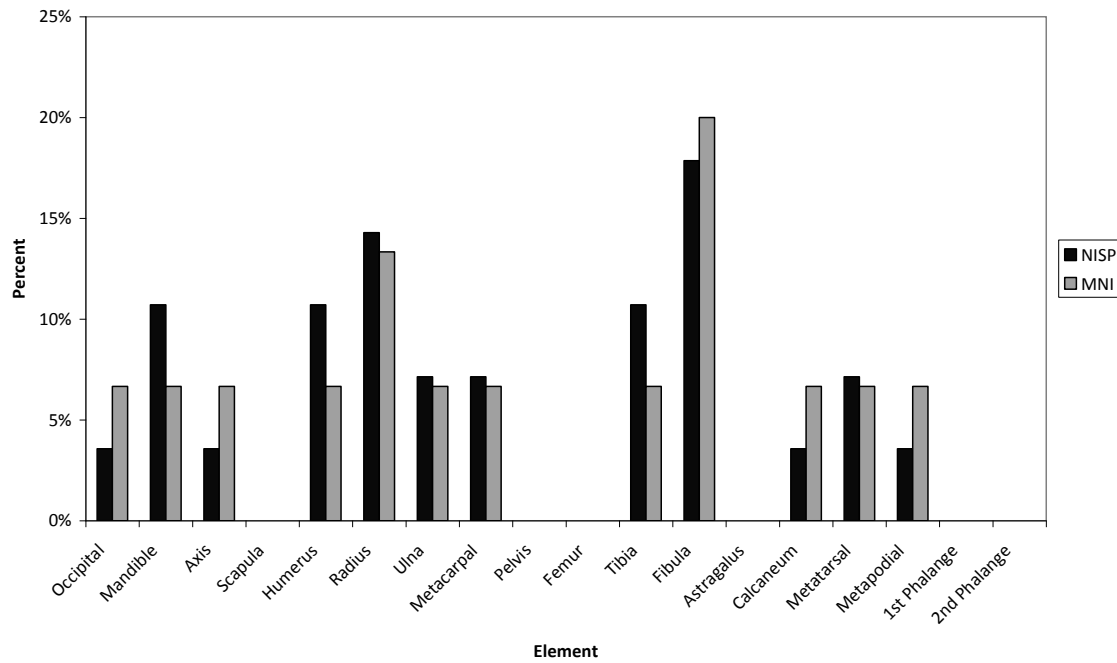


Fig 6.225: Dog body part proportions

Many parts of the fox skeleton were missing from the assemblage. The ulna and phalanges were the most common element (fig 6.226).

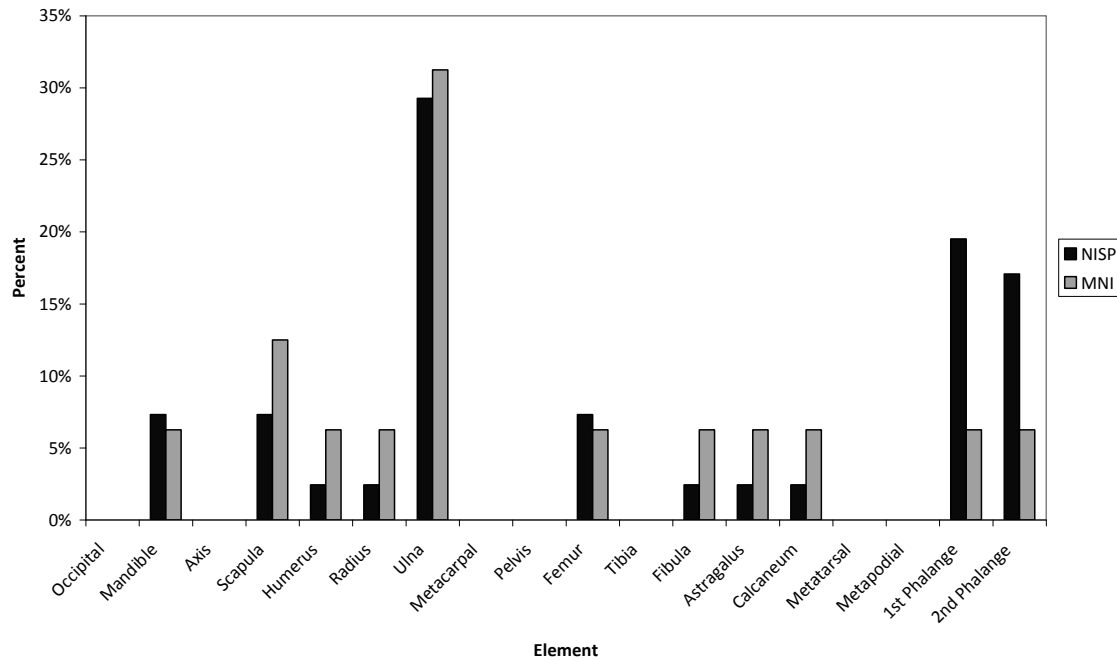


Fig 6.226: Fox body part proportions

Butchery

Two dog bones had cut marks present: an ulna with a heavy, deep cut mark from level A5 and a humerus with a fine cut mark from level B2. Both of these cut marks are characteristic of marks caused by the disarticulation of the elbow joint. No butchery marks were identified on the fox bone fragments.

Age Profiles

A high proportion of the dog remains were from neonatal or young puppies (figure 6.227). The puppies could have been culled in order to control the dog population.

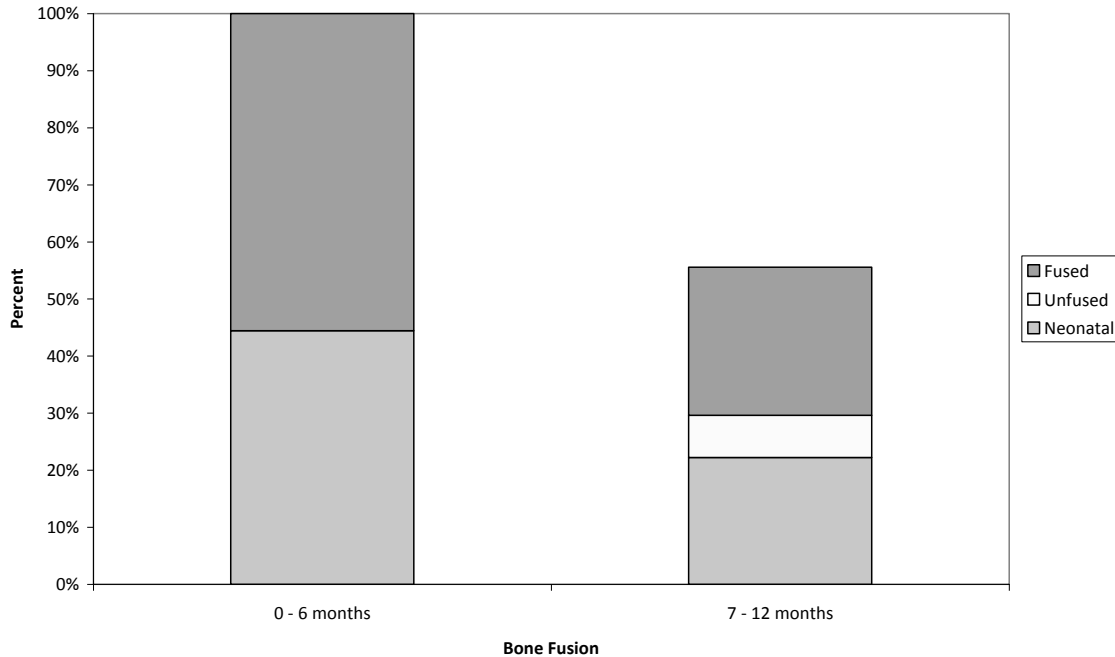


Fig 6.227: Postcranial bone fusion of the domestic dog

All fox remains were from adult individuals over 10 months of age

Pathology

No pathologies were recorded on any of the canid bones.

Metrical Analysis

Very few measurements could be taken (see appendix 10) and none could be used in calculations of shoulder height. Very subjectively, one can say that the dog bones were from small to medium sized dogs.

Conclusions

Domestic dogs were present in only very low numbers in all levels. The populations of these animals were apparently controlled with many neonatal and young puppies being culled. These animals were not apparently treated any differently to other animals at the site. There is certainly no evidence that they were treated as 'pets' and they were instead probably only tolerated as they scavenged on the site refuse. Dogs were apparently not part of the diet, their bones being few in number and relatively complete. Their skins may however have been used.

Foxes were also present in low numbers. They were likely attracted to the site by the refuse and the opportunity to scavenge.

6.8.3 Felids

Three *felid* bone fragments were recovered: one 2nd metatarsal (level A3), one mandible (level A4) and one maxilla (level A12). The mandible and maxilla fit the size range of the domestic cat (*Felis catus*).

6.8.4 Cervids

Two deer species were identified in the A and B levels: roe deer (*Capreolus capreolus*) and fallow deer (*Dama mesopotamica*). Roe deer was the most common cervid species with seven fragments recorded comprising one humerus, one radius, one metacarpal, two pelves, two metatarsals and one antler fragment. Only three fallow deer fragments were recorded including one metacarpal, one tibia and one metatarsal. Ten bone fragments could not be identified to species and were recorded as cervid species or gazelle/cervid.

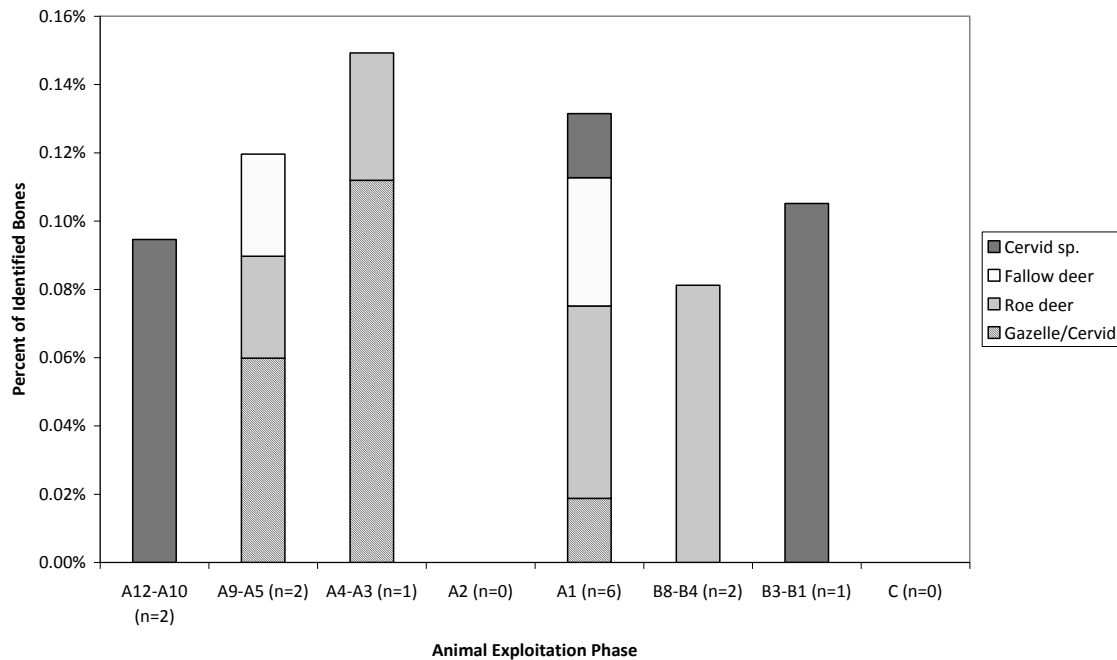


Fig 6.228: Cervid proportions by animal exploitation phase based on NISP

The very low proportions of cervids in the assemblage suggest that these species were not available locally and/or not hunted in large numbers in the area (fig 6.228).

Butchery

Two roe deer bones fragments have butchery marks: a metatarsal with a deep cut mark at the proximal epiphysis and a chop and cut mark at the base of an antler.

Metrical Analysis

A list of measurements can be found in appendix 10.

6.8.5 Bear

Five fragments of brown bear (*Ursus arctos*) bone fragments were recorded, all phalanges. Two 1st and two 2nd phalanges were recovered from the A levels and one 1st phalanx was recovered from the B levels. These elements could have been brought to the site attached to skins. It is highly unlikely that bears would have been found in the arid desert steppe and they were instead probably hunted and/or traded from the mountains to the north.

6.8.6 *Mustelids*

Three mustelid mandibles were recorded, all from the A levels. No postcranial fragments were identified.

6.8.7 *Hare*

Hare (*Lepus capensis*) bone fragments were only recovered from the A levels peaking in levels A4-A3 (fig 6.229).

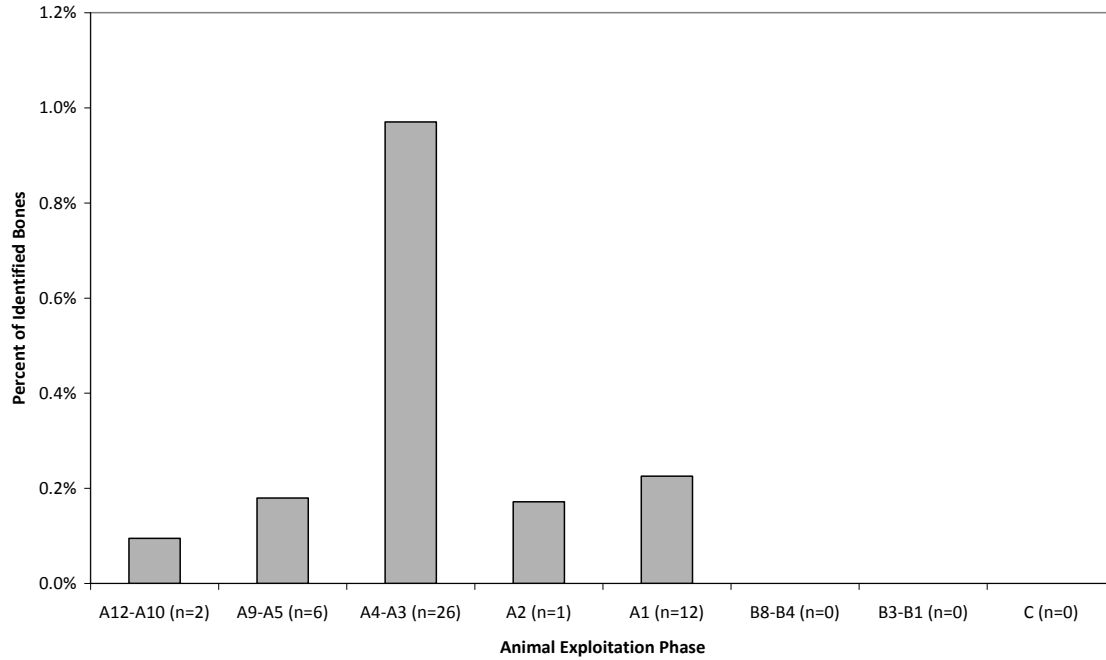


Fig 6.229: Hare species proportions by animal exploitation phase (based on NISP)

In total 47 bone fragments were recovered with the elements from the hind limb being most common (fig 6.230)

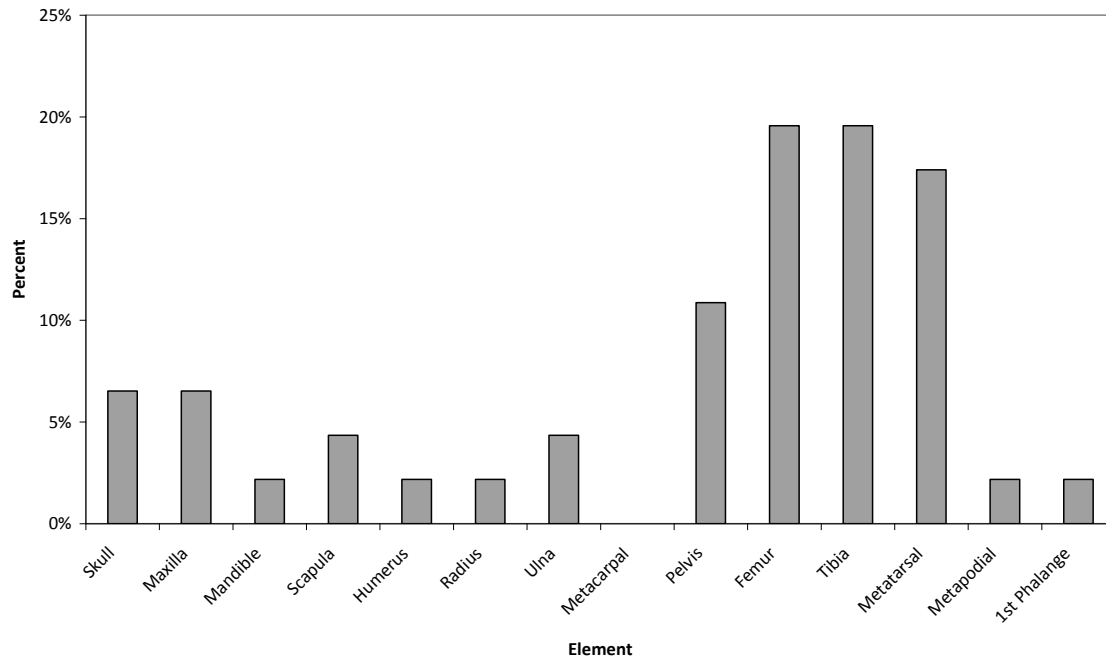


Fig 6.230: Hare body part proportions based on NISP

Summary

Hares were probably hunted with a slingshot, snared or trapped for their meat and fur. The exploitation of hare peaks in levels A4-A3 and drops rapidly from level A2 onwards. No hare remains were recovered from the B levels.

6.8.8 Rodents

Three hundred rodent bones were recovered in A, B and C levels. Four species/genus could be identified: gerbil (*Meriones* species), bandicoot rat (*Nesokia* species), hedgehog (*Erinacaeus* species) and bat (*Chiroptera* species). The majority of the post cranial elements could not be identified to species and were recorded as rodent sp. Only one bat bone was recovered, a mandible from the fill of a large pit. One hedgehog mandible was recovered from an open area and one bandicoot rat skull was recovered from a large pit. Seven gerbil bones were recovered: three skulls and a mandible from open areas, one skull in the fill of an oven, and one mandible and one maxilla from room fills. With the exception of the bat, these small mammals are burrowing animals and as such may be intrusive.

6.8.9 Birds

The osteological analysis was carried out with the help of a BA student, Daniella Vos using the reference collection of the Zooarchaeology Department of the Faculty of Archaeology, University of Leiden, the reference collection of the Zooarchaeological Institute, The State University of Groningen and the museum collections of avifauna at the Naturalis Museum, Leiden. The limited amount of comparative skeletons affected the possibility of identifying each specimen to species. In total 219 bird bones or fragments were analysed of which 166 (75.8%) could be identified as a specific skeletal element and 79 (37.1%) could be identified to species or genus (table 6.10 and 6.11). 63.9% of the fragments could only be identified as *Aves* and no further. Twenty species/genus of birds were identified, the most common of which was *Columba livia* (Rock Dove) at 19.2% of the avifauna. The high presence of this species is due to the presence of two bone concentrations most likely representing two articulated carcasses. The second most common species was *Otis tarda* (Great Bustard) of which there were nine bone fragments representing 4.1% of the assemblage. Many species were only represented by one bone fragment. No

avifauna were recovered from the C levels and only in the A levels were avifauna present to any degree and even then they made up only a very small percentage of the total faunal remains.

Table 6.10: Bird NISP by broad period

Latin Name	Common Name	C Levels	B Levels	A Levels	Site Total	Percentage
<i>Alectoris chukar</i>	Chukar Partridge			2	2	0.9%
<i>Anas crecca</i>	Teal			3	3	1.4%
<i>Anas sp.</i>	Duck sp.			1	1	0.5%
<i>Anser albifrons</i>	White-fronted Goose			3	3	1.4%
<i>Anser sp.</i>	Goose sp.			3	3	1.4%
<i>Anthropoides virgo</i>	Demoiselle Crane		1		1	0.5%
<i>Columba livia</i>	Rock dove/Feral pigeon			42	42	19.2%
<i>Columba palumbus</i>	Wood pigeon			1	1	0.5%
<i>Columba sp.</i>	Pigeon sp.			1	1	0.5%
<i>Falconid sp.</i>	Bird of prey sp.			3	3	1.4%
<i>Haematopus</i>	Oyster catcher			1	1	0.5%
<i>Larus sp.</i>	Gull			1	1	0.5%
<i>Otis tarda</i>	Great Bustard			9	9	4.1%
<i>Perdix perdix</i>	Grey partridge			1	1	0.5%
<i>Philomachus pugnax</i>	Ruff			1	1	0.5%
<i>Rallidae sp.</i>	Rail sp.			1	1	0.5%
<i>Scolopax rusticola</i>	Woodcock			1	1	0.5%
<i>Turdidae sp.</i>	Thrush sp.			2	2	0.9%
<i>Turdus iliacus</i>	Redwing			1	1	0.5%
<i>Turdus philomelos</i>	Song Thrush			1	1	0.5%
Unidentified Aves	Unidentified birds		3	137	140	63.9%
Grand Total		0	4	215	219	100.0%

Element representation

All elements of the avian skeleton were recognised in the Tell Sabi Abyad material. The most common elements were the sternum, ulna, radius and humerus (table 6.11). When grouped into general body parts it is clear that wing elements are by far the most common followed by breast elements (figure 6.231). Breast elements may have been selected for their meat as has been recorded at other sites in the Near East (Tchernov, 1993). Wing elements have less meat and as such may have been selected for other reasons (see below).

Table 6.11: Bird skeletal element NISP by species

Element	Unidentified bird	<i>Anas crecca</i>	<i>Anas sp.</i>	<i>Anser albifrons</i>	<i>Anser sp.</i>	<i>Alectoris chukar</i>	<i>Anthropoides virgo</i>	<i>Columba livia</i>	<i>Columba palumbus</i>	<i>Columbid sp.</i>	<i>Falconid sp.</i>	<i>Hamatopus sp.</i>	<i>Larus sp.</i>	<i>Otis tarda</i>	<i>Perdix perdix</i>	<i>Philomachus pugnax</i>	<i>Rallidae sp.</i>	<i>Turdus iliacus</i>	<i>Turdus philomelos</i>	<i>Turdidae sp.</i>	<i>Scolopax rusticola</i>	Grand Total
1st Phalange	3																					3
3rd Phalange	1																					1
Carpometacarpus	1	1						6								1				1		10
Coracoid	2	1					1	4												1	1	10
Femur	5							2		1	1			1								10
Furculum		1																				1
Humerus	5				1			8			1			1					1			17
Longbone	19																					19
Radius	8		1					9									1					19
Rib	8																					8
Scapula	3							2				1	1									7
Skull	1							1														2
Sternum	26							1	1													28
Tarsometatarsus	2							2						1								5
Tibiotarsus	3				1			2	1		1			3								11
Ulna	11			1	1	2		5						1	1			1				23
Unidentified	33													1								34
Vertebrae	11																					11
Grand Total	140	3	1	3	3	2	1	42	1	1	3	1	1	9	1	1	1	1	1	2	1	219

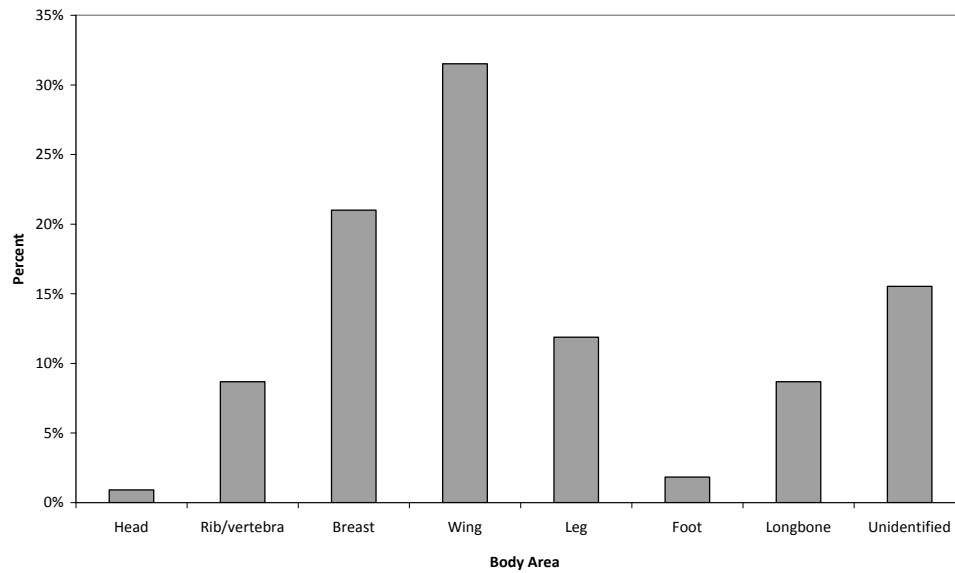


Fig 6.231: Differential presence of skeletal parts

Modifications on bird bone

Cut marks were seen on only two bone fragments, both from the Great Bustard. These consisted of fine cut marks on a tarsometatarsus and a tibiotarsus. Gnawing was present on just one unidentified bird humerus, the culprit being a rodent. Signs of burning were noticeable on five bone fragments including one *Anser* species ulna, an unidentified bird coracoid, two unidentified bird bone fragments and one unidentified bird longbone that was burnt at such a high temperature that it was calcined.

Context

The majority of avian bones were found in room fills, open areas and pits (fig 6.232).

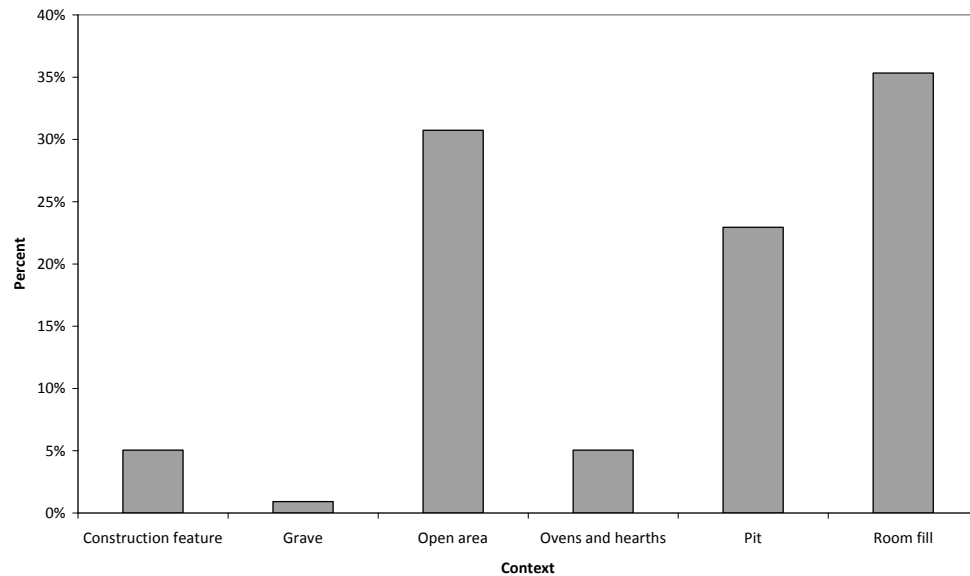


Fig 6.232: Percent of avifauna by context

Environment

An analysis of the known habitats of modern versions of the species identified three broad habitat types: open steppe, woodland, and water (fig 6.233 and fig 6.234). The predominant environment around the site in the Late Neolithic was apparently one of large open areas of steppe with some water (the Balikh river) and woodland (riverine forest) within a reasonable distance from the site. This conclusion is mirrored in analyses of the palaeobotanical material at the site (Van Zeist and Waterbolk van Rooijen, 1989; Van Zeist and Waterbolk van Rooijen, 1996).

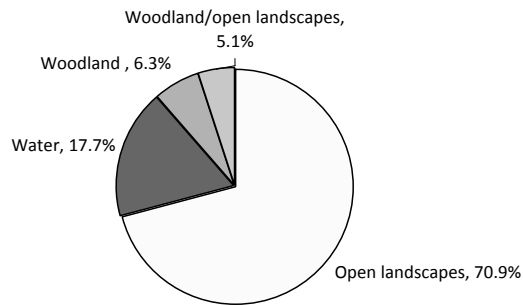


Fig 6.233: Known habitat preference of the birds of Tell Sabi Abyad by NISP

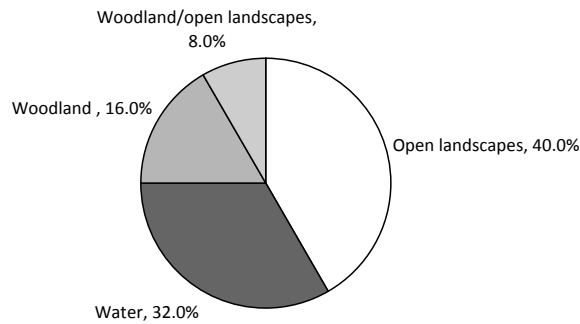


Fig 6.234: Known habitat preference of the birds of Tell Sabi Abyad by MNI

Seasonality

The majority of the remains were derived from birds resident in the Balikh all year round with only 13.3% of the bird bone fragments coming from migrant species (figure 6.235 and fig 6.236). This suggests that the local birds were exploited all year round with the migrant birds also being exploited when they were in the area. There is no evidence that the site was abandoned at any time of the year.

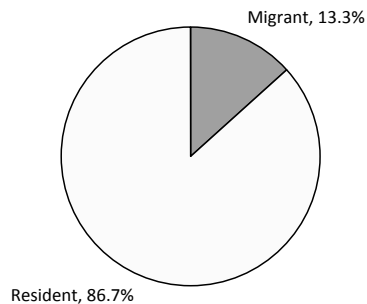


Figure 6.235: Residential status of the Tell Sabi Abyad Birds by NISP

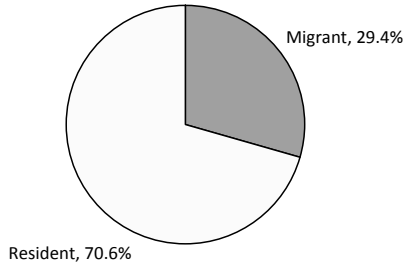


Figure 6.236: Residential status of the Tell Sabi Abyad Birds by MNI

6.8.10 Reptiles and amphibians

Three reptile and six amphibian bone fragments were present in the assemblage. The only reptile present was the tortoise (*Testudo* species), with one carapace fragment and one tibia from open areas in the C levels and one carapace fragment from an open area in the A levels.

The amphibian bones belong to frogs or toads and were present only in the A levels with three tibiofibulas and two pelves recovered from room fills, pit fills and open areas.

6.8.11 Molluscs

The identification of the molluscs was done with the help of the Naturalis, Leiden. Three species could be identified: *Unio tigridis*, *Melanopsis (praemorsa)* and *costata* subspecies) and a *Xeropicta* species.

Unio tigridis is a freshwater bivalve also known as the 'river clam' (Lubell, 2004). It is a very common species in the Near East where it is common in the Euphrates and Tigris rivers and its tributaries. It has a solid elongate shell which it buries obliquely in the mud (Plaziat and Younis, 2005).

Melanopsis is a common gastropod in Europe, North Africa and the Near East with the subspecies *praemorsa* and *costata* occurring throughout the Mediterranean area where they are found in freshwater streams and rivers (Elkarmi and Ismail, 2006). These snails live today in agricultural canals, ponds and streams (Farahnak *et al.*, 2006). *Melanopsis praemorsa* in particular is indicative of clear perennial running fresh water and is today limited to perennially flowing streams (Hunt *et al.*, 2004). Although they are freshwater species they can tolerate salinities more than 2‰ during both winter and summer reductions in the delivery of fresh water (Plaziat and Younis, 2005).

Xeropicta is a genus of land snail found throughout Europe and the Near East.

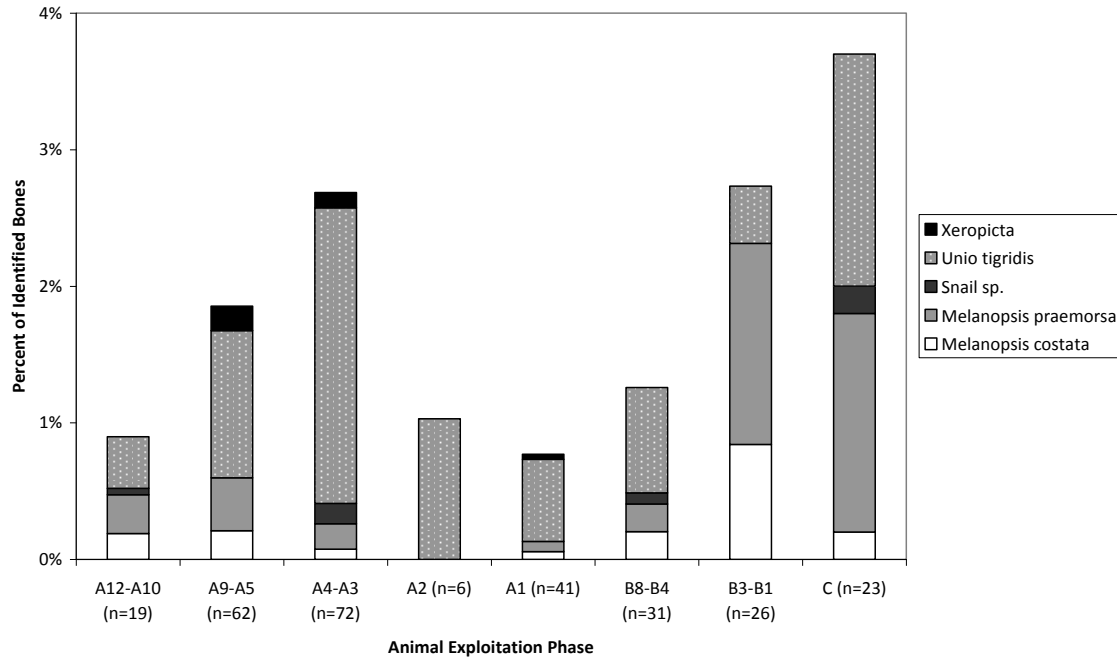


Fig 6.237: Proportions of molluscs by animal exploitation phase (based on NISP)

Molluscs were present in all levels. In total over 700 grams of mollusc remains were recovered and recorded. The most common species was that of *Unio tigridis*. In levels A12 to B4 *Unio tigridis* is present in the highest proportions but in levels B3-B1 the *Melanopsis* species dominated. *Xeropicta* species were only present in levels A9 to A3 (fig 6.237).

Freshwater molluscs are usually found at archaeological sites as a result of human deposition (Bar-Yosef Meyer, 2005). *Unio tigridis* are edible and were perhaps collected from the Balikh to be eaten. These molluscs were not however sufficiently abundant to be considered an important food source. It is not thought that *Melanopsis* were eaten but were instead probably brought to the site in the mud used for mudbricks as is the case at several other Neolithic sites in the Near East (Serrand *et al.*, 2005). *Melanopsis* species are a known carrier of diseases such as human schistosomiasis, fascioliasis, paragonimiasis and clonorchiasis (Farahnak *et al.*, 2006).

The switch from *Unio tigridis* to *Melanopsis* species being dominant occurs around level B3. Molluscs react strongly to environmental changes making them perfect palaeoenvironmental indicators. *Unio* species cannot tolerate contaminated water so the reduction in the proportion of this species may be related to the polluting or salination of the Balikh. As noted above *Melanopsis* species can cope with some salinity.

Chapter 7 Isotope Analysis of Ovicaprid Diet

7.1 Stable isotope analysis and diet

The purpose of this small test study was to assess the possibility of using carbon and nitrogen isotope composition in archaeological bone samples to infer information about animal husbandry and herding practices in the Late Neolithic in the Balikh Valley, Northern Syria. First and foremost, was the bone material well preserved enough to yield good quality collagen to be studied? If so, can isotopic analysis of such material provide enough information about the diet of the animals so as to inform about herding practices?

Questions about when pastoralism began in the Near East and what forms of pastoralism were being undertaken would be greatly aided by such studies. As outlined in chapter 4, several broad forms of pastoralism have been hypothesised and defined, with village-based herding at one end of the spectrum and nomadic pastoralism at the other. One of the main differences between these two strategies is the question of mobility: the former involving moving only very short distances from a permanent settlement with the herd's diet perhaps being supplemented by foddering, the latter involving long distance movements and the absence of agriculture (Abdi, 2003). It is argued that pastoralism has played an important role in the Near East since the domestication of sheep and goats, but the form, or forms, of pastoralism being undertaken in the Late Neolithic remain elusive. It has been hypothesised that there was an increasingly transhumant component to the society at Tell Sabi Abyad from c. 6200 BC, which only made use of the site for specific purposes at specific times of the year (Verhoeven, 1999: 203; Akkermans and Duistermaat, 1997: 27; Cavallo, 2000). Presumably such a shift in herding practices would show up in the isotopic composition of the sheep and goat bones? Bocherens *et al.* (2000) highlighted that few studies have attempted to use isotopic analysis of large archaeological populations to provide an evaluation of general livestock herding strategies on a local scale. A study by Pearson *et al.* (2007) showed that there is merit in such a studies, with dramatic changes in the diet of sheep and goats at the Neolithic sites of Çatalhöyük and Aşıklı Höyük in south-central Anatolia, being associated with a transition in herding strategies. It is hoped that the faunal material from Tell Sabi Abyad will also be conducive to such research.

Carbon and nitrogen isotopes

Over three decades ago the potential of using carbon isotopes in studies of diet was discovered in the 1970's, with DeNiro and Epstein (1976) stating: "*You are what you eat (plus a few ‰)*". The discovery that nitrogen isotopes could also be used in dietary studies soon followed (DeNiro and Epstein, 1980). Today, the use of isotopic measurements to reconstruct diet, as well as mobility and palaeoclimatological conditions is an upcoming field of research. The use of carbon and nitrogen isotopic abundances in bone collagen for palaeodietary reconstruction has greatly developed over the past twenty years or so and it is now a well established technique used in the analysis of both diet and ecology in archaeological material (Bocherens *et al.*, 1994; Bocherens *et al.*, 2005; Thompson *et al.*, 2005). The ability to determine the food intake of specific individuals or populations using stable isotope ratios has had a huge impact on studies of palaeodiet.

The basic principle behind stable isotope research is that consumers record the isotopic composition of their food, with the foods exhibiting characteristic isotopic signatures (DeNiro and Epstein, 1976; DeNiro and Epstein, 1978; DeNiro and Epstein, 1980; Gannes *et al.*, 1997). So what is a stable isotope? Most elements exist in more than one form or isotope. These isotopes can be stable or unstable (radioactive) but it is the stable isotopes that are used in archaeological studies of diet. The stable isotopes of interest in this study are carbon (^{13}C) and nitrogen (^{15}N). The abundance of these isotopes can be measured using mass spectrometry. The quantity of interest is the rare to abundant isotope ratio ($^{13}\text{C}/^{12}\text{C}$ and $^{15}\text{N}/^{14}\text{N}$), reported as delta (δ) values (see section 7.2.1). The stable isotopic composition of the carbon and nitrogen in a consumer's tissues reflects the $^{13}\text{C}/^{12}\text{C}$ and $^{15}\text{N}/^{14}\text{N}$ of its diet and from this observation

certain aspects of the diet can be reconstructed (DeNiro and Epstein, 1978; 1980). The isotopic signal of a consumer's tissues can therefore be used to determine the relative contribution of different foods to the diet, especially when an ecosystem yields dietary resources with distinct isotopic signatures (Bocherens *et al.*, 2005; Gannes *et al.*, 1997).

In this study it is the bone collagen that has been analysed. This tissue was chosen because of its potential for long-term survival, because it is a good source of carbon and nitrogen and because the isotopic integrity can be assessed relatively easily (Bocherens *et al.*, 2005; Müldner *et al.*, 2005; Richards *et al.*, 2003; Hedges *et al.*, 2004). The bone collagen contains a long-term record of the diet of the individual, usually ± 10 years, and so for the animals used in this study the isotope composition in the collagen represents a measure of the average lifetime diet.

A measure of the carbon isotopes in an animal informs us about the types of plants consumed i.e. whether they are C_3 or C_4 plants¹⁰. Variability in the $^{13}C/^{12}C$ ratios observed in plants informs us about the different modes of photosynthesis due to the different metabolic pathways used in the fixation of inorganic carbon from the air. Trees and herbaceous plants are all C_3 plants, while C_4 plants are mainly grasses such as maize and millet. C_4 plants tend to be found in more warm and arid areas where the growing season is warm. Both types of plant are relatively depleted in ^{13}C relative to their source of inorganic carbon, with C_4 plants ($\delta^{13}C$ ranging from -20‰ to -9‰ with 90% of C_4 plants averaging -13‰) being far less depleted than C_3 plants ($\delta^{13}C$ ranging from -34‰ to -22‰ with 90% of C_3 plants averaging -27‰) (Bocherens *et al.*, 2005; Gannes *et al.*, 1997; Lee-Thorp *et al.*, 1989; Vogel, 1980). Since the $\delta^{13}C$ values of C_3 and C_4 plants do not overlap the $\delta^{13}C$ value in bone collagen directly reflects the plant composition of the animal's diet (Richards *et al.*, 2003). Other factors such as the 'canopy' effect, decreasing light levels or nutrient supply, and altitude (temperature) can all lead to the local depletion of $\delta^{13}C$ and therefore must also be considered (Bocherens *et al.*, 2000). Marine diets also affect both carbon and nitrogen isotopes (Nelson *et al.*, 1986) but this is not relevant for this study.

Carbon enters the food chain through the photosynthetic pathway of plants and is assimilated at successive stages in the food chain, meaning that the types of plant forming the foundation of a food web will be reflected at each trophic level in the $\delta^{13}C$ of the consumer bone collagen (DeNiro and Epstein, 1978). At each step up the food chain there is an enrichment of 3-5‰ (Ambrose and Norr, 1993; Lanting and Van Der Plicht, 1996). The isotopic procedure consists of two steps: estimating the $\delta^{13}C$ value of the diet from the $\delta^{13}C$ value of the bone collagen and then determining the relative contribution of potential diet sources of known $\delta^{13}C$ values which would produce the $\delta^{13}C$ value for this diet (DeNiro and Epstein, 1978).

The majority of plants around Tell Sabi Abyad were probably C_3 plants but C_4 plants such as some wild grasses were also present (Cappers *per comm.*). The $\delta^{13}C$ of archaeological plant remains from Tell Sabi Abyad have unfortunately not been measured. Araus *et al.* (1999) measured the $\delta^{13}C$ of plants from the nearby and contemporary site of Tell Halula, giving an average $\delta^{13}C$ for domestic C_3 crop species to be -23 ‰. As the plants growing at Tell Sabi Abyad would have been grown under the same environmental conditions we can consider -23 ‰ to be the base $\delta^{13}C$ for the C_3 plants eaten by the animals at this site. Pearson *et al.* (2007) record the same average $\delta^{13}C$ value of -23 ‰ for the plants recovered from Çatalhöyük and state that an exclusive C_3 consumer would be expected to have a $\delta^{13}C$ of under -18‰. No measure of C_4 plants was undertaken by Araus *et al.* (1999) as only domestic C_3 crop species were available for analysis. Pearson *et al.* (2007) did record the $\delta^{13}C$ of C_4 plants, giving an average value of -12‰. They also state that an exclusive C_4 consumer would be expected to have a $\delta^{13}C$ of approximately -7‰. This will be assumed to be also the case for consumers at Tell Sabi Abyad who ate exclusively C_4 plants.

¹⁰ There are also CAM plants but these are not relevant to this study

Nitrogen also enters the food chain via plants, this time through nitrogenous compounds absorbed through the soil or fixed from atmospheric nitrogen (Cheng *et al.*, 1964). The nitrogen is then passed along the food chain with an enrichment factor of 3-5‰ (DeNiro and Epstein, 1980; Sealy *et al.*, 1987; Ambrose and Norr, 1993). This marked trophic level fractionation means that the $\delta^{15}\text{N}$ values in bone collagen can indicate the trophic level of an organism in a food chain, with organisms from higher trophic levels being enriched with the heavier isotope compared with their food. Carnivores therefore have a higher $^{15}\text{N}/^{14}\text{N}$ ratio than herbivores. Ruminants can have enriched ^{15}N in the magnitude of a trophic level effect due to their intestinal flora (Steinhour *et al.*, 1982). Nitrogen isotopes can also tell us something about aridity as a link between annual rainfall and $^{15}\text{N}/^{14}\text{N}$ ratios has been discovered showing $\delta^{15}\text{N}$ values increasing with aridity (Bocherens *et al.*, 2005; Gannes *et al.*, 1997; Heaton *et al.*, 1986; Müldner *et al.*, 2005; Sealy *et al.*, 1987; Thompson *et al.*, 2005). This may be in part due to the fact that the feed available to herbivores in arid areas is generally inferior to that from better watered areas leading to dietary and water stress and a recycling of nitrogen in the body leading to enrichment (Bocherens *et al.*, 2000; Sealy, 1987). As well as being linked to rainfall, $\delta^{15}\text{N}$ values are specific to regions and ecosystems and are significantly higher in very warm climates than in more temperate ones (Richards *et al.*, 2003). To complicate things further, body condition can also be elucidated from stable nitrogen isotopes; the tissues of starving animals show a progressive increase in $\delta^{15}\text{N}$ values as lean body mass decreases and the starving animal lives by reabsorbing its own tissues (Gannes *et al.*, 1997).

The $\delta^{15}\text{N}$ of archaeological plants remains from Tell Sabi Abyad have unfortunately not been measured. Once again the data from Tell Halula (Araus *et al.*, 1999) will be used. The $\delta^{15}\text{N}$ of plants from this site gave an average $\delta^{15}\text{N}$ for domestic C_3 crop species of 7‰. A more recent study by Araus *et al.*, 2007 showed that the $\delta^{15}\text{N}$ for C_3 crop species at Tell Halula, which sits on the 250 mm isohyet, were twice as enriched in ^{15}N when compared to C_3 species from Akarçay, a site on the left bank of the Euphrates in Turkey which is situated on the 370 mm isohyet. This demonstrates the connection between $\delta^{15}\text{N}$ and rainfall. A herbivore at Tell Sabi Abyad would have a $\delta^{15}\text{N}$ of approximately 11‰. This $\delta^{15}\text{N}$ value is much higher than studies on similar fauna in Europe where herbivores have values between 4 and 6‰ (for example see Müldner and Richards, 2005). The $\delta^{15}\text{N}$ values from Tell Halula clearly show the Balikh Valley to be an arid area with signs of nitrogen enrichment.

Interpreting stable isotopes can therefore be very complicated and arid environments, such as those found in the Jazirah of Northern Syria, are likely to lead to large ranges in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in animal tissues as has been observed in Iran and Turkmenistan (Bocherens *et al.*, 2005; Bocherens *et al.*, 2000). Concern with changes in the environment and the climate has become progressively more central to archaeological research in the Near East with efforts to reconstruct palaeoenvironments and link them to specific cultural responses (Henry, 1997). Reconstructions of local environments, which accompany many settlement studies, are based upon the modelling of modern microenvironments in the context of regional palaeoclimatic reconstructions (*Ibid*). Climatic differences can cause changes to the $\delta^{13}\text{C}$ of plants; this climatic effect is brought about through the influences of temperature and/or relative humidity on the photosynthesis of plants. Both a plant's rate of carbon fixation and rate of stomatal conductance¹¹ are affected by these environmental factors or water stress. Both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ are climate sensitive (Grupe and Peters, 2008; Van Klinken *et al.*, 1994). The connection with climate is however a rather general one, mediated through plant isotopic values, the herbivore's dietary selection, and the vegetation composition of the area (Hedges *et al.*, 2004). One of the problems of such research is that even when animals are fed isotopically homogeneous diets, the isotopic composition of their tissues can differ significantly due to different biochemical synthetic pathways (Gannes *et al.*, 1997).

Several archaeological questions can be answered through analysis of past diet including the adaptive response of animals to climatic and environmental changes. Stable isotope ratios in animal tissue can not only be used to reconstruct diet, but they also inform us about animal management practices, the palaeoenvironment and possibly the adaptive response of animals to climatic and environmental changes

¹¹ Stomatal conductance refers to the speed at which water evaporates from pores in a plant's leaves

(Gannes *et al.*, 1997; Heaton *et al.*, 1986; Thompson *et al.*, 2005; Schwarcz *et al.*, 1999). In this study the main focus is on palaeodiet and what this can tell us about ovicaprid herding practices. As stable isotope analysis can also detect environmental changes in some cases, this will be the second focus of this chapter.

7.2 Tell Sabi Abyad material

7.2.1 Methodology

Bones from sheep and goats were selected from archaeological levels B1 to A12. As the number of bone fragments that could positively be identified as either sheep or goat was very small, ovicaprids were also selected. Obviously this is not ideal as sheep and goats have different feeding behaviours (see chapter 3) and the combining of isotope data from these two different species may obscure any patterns that may otherwise have emerged. The method will not completely negate the results however as in the study by Pearson *et al.* (2007) no distinction could be made between the diets of sheep and goats at either Çatalhöyük or Aşıklı Höyük. A selection of other species was also included in this study including domestic cattle, domestic pigs, equids (most probably onager, see chapter 6) and gazelles to act as comparisons. Only bone fragments with good surface preservation of compact bone tissue were selected for isotope analysis. In total 136 faunal bones were sent to the Centre for Isotope Research in Groningen.

Collagen extraction and isotopic analysis was undertaken and the stable isotope concentrations were measured by IRMS (Isotope Ratio Mass Spectrometry) at the Centre for Isotope Research in Groningen. The collagen was extracted from the bone fragments by the lab technicians at Centre for Isotope Research in Groningen and a Masters student from Leiden University (S. Hofmeester) using the following protocol:

1. A small sample of compact mid-shaft skeletal bone was taken for sampling. The extraction of the collagen from the bone was undertaken using a modified Longin (1971) method.
2. The bone samples were repeatedly treated with 2-4% HCl solution (depending on the amount and quality of the material) to remove the mineral content of the bone.
3. After removal of the mineral component the remaining residue was rinsed with demineralised water until a pH of 7 was reached.
4. The sample was then treated with an alkali (1% NaOH) treatment to remove any humic substances.
5. The sample was once again rinsed with demineralised water to neutral (pH 7).
6. A 2-4% HCl solution was applied once again and the sample was again rinsed to neutral.
7. The solution was slightly acidified and heated in an oven to $\pm 90^{\circ}\text{C}$ over a period of 5-18 hours to dissolve the collagen.
8. The dissolved collagen was then filtered through a $50\mu\text{m}$ mesh and dried.
9. The carbon and nitrogen stable isotope ratios of the samples were then measured by IRMS (Isotope Ratio Mass Spectrometry)

The isotopic content of materials is expressed in the delta (δ) values, which is defined as the deviation (per mil) of the rare to abundant isotope ratio from that of a reference material (Mook 2006). For carbon, the reference material used was the calcium carbonate in the shell of fossil belemnite from the Pee Dee Formation (so-called PDB) in the USA. For Nitrogen, the reference is ambient air (AIR). The absolute rare isotope contents of these standards can be found in textbooks such as Mook (2006). The analytical error is $\pm 0.1\text{‰}$ and $\pm 0.2\text{‰}$ for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, respectively.

Prehistoric specimens with very low collagen concentrations have highly variable C:N ratios, very low carbon and nitrogen concentrations in collagen, and stable isotope ratios unlike collagen (Ambrose, 1990; Schoeninger *et al.*, 1989). All prehistoric bone has undergone diagenesis in the prehistoric depositional environment (see chapter 5). Diagenesis may affect the stable isotope values of the protein in the collagen, especially where only low concentrations survive (Styring *et al.*, 2010; Nelson *et al.*, 1986). It is important not to include samples negatively affected by diagenesis to ensure that the biological signature has not been altered as this may severely affect the results of a study (Schoeninger *et al.*, 1989). Diagenic alteration of the isotopic composition of collagen must be discounted before dietary or environmental interpretations can be made (Ambrose, 1990). Once the samples had been processed, the following

criteria were used to assess the preservation of the collagen. The C:N ratio was calculated (C%/N% multiplied by 14/12). The accepted range of anatomic C:N values for well-preserved prehistoric specimens is c. 2.9-3.5 (*Ibid*). Values outside this range are likely to have suffered diagenic alteration causing changes to the organic composition and should be eliminated from the dataset as their $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values might have been shifted substantially and their use in dietary reconstruction might lead to erroneous conclusions (DeNiro, 1985; Schoeninger *et al.*, 1989). Also as a general rule the carbon content should be around 30-40% and the nitrogen content around 10-15% for the results to be reliable, although sometimes lower values are acceptable (Rutgers *et al.*, 2009).

7.2.2 Results

The faunal bone collagen was generally poorly preserved and many samples failed, did not meet high enough collagen yields, or fall within the accepted range of anatomic C:N values to be considered reliable. In total 136 faunal bones were sent to the Centre for Isotope Research in Groningen of which only 35 (c. 25%) passed the preservation criteria to be used in this study (table 7.1). This extremely low success rate is due to low collagen content perhaps as a result of the aridity of the region, which can lead to collagen destruction shortly after burial (Bocherens *et al.*, 2000; Van Klinken, 1999). Isotope studies on material from Anatolia have revealed similar problems with collagen preservation (Richards *et al.*, 2003). The extremely low success rate makes interpreting the results of this study difficult.

Table 7.1: Stable carbon and nitrogen results for cattle, equid, gazelle, ovicaprids and pigs.

Species	Bone ID	13C	15N	C%	N%	level	C:N ratio
Cattle	15065	-18.96	8.35	33.1	11.9	A3	3.25
Equid	18911	-19.33	4.49	36.5	12.6	A1	3.38
Equid	15122	-19.77	4.20	38.9	14.3	A2	3.17
Equid	15104	-18.94	6.12	32.9	11.1	A2	3.46
Gazelle	15107	-20.16	5.45	30.7	11.3	A2	3.17
Gazelle	18260	-18.29	7.28	39.4	15.3	A9	3.00
Gazelle	18173	-19.07	7.96	35.9	12.3	A9/A8	3.41
Pig	Pig 3	-20.09	9.08	30.3	10.5	/	3.37
Sheep	16243	-18.78	7.63	31.6	11.0	A4	3.35
Sheep	3025	-19.72	6.56	40.0	13.2	A5	3.54
Sheep	18657	-18.82	7.83	40.4	13.9	A5	3.39
Sheep	18213	-15.71	11.44	38.2	12.7	A9	3.51
Sheep	18269	-20.01	5.78	33.7	11.5	A9	3.42
Sheep	15627	-19.16	8.41	36.0	12.2	B2	3.44
Sheep	12715	-18.56	9.56	39.7	14.9	B6	3.11
Sheep	15861	-19.44	6.19	38.3	13.0	A2	3.44
Sheep	15756	-18.80	8.09	41.7	14.5	B3	3.36
Goat	17518	-18.31	9.37	40.8	14.7	A10	3.24
Goat	13095	-18.89	8.08	39.0	14.2	B6	3.20
Sheep/Goat	16157	-18.74	7.58	39.2	14.5	A1	3.15
Sheep/Goat	18944	-17.12	7.86	36.4	14.4	A1	2.95
Sheep/Goat	14129	-18.44	9.69	34.2	12.6	A1	3.17
Sheep/Goat	16726	-17.88	9.51	37.1	13.5	A1	3.21
Sheep/Goat	17782	-19.97	7.90	30.2	11.2	A10	3.15
Sheep/Goat	15285	-20.41	5.99	40.4	14.0	A2	3.37
Sheep/Goat	15127	-18.58	8.63	41.0	14.4	A2	3.32
Sheep/Goat	15073	-19.20	8.02	36.4	14.1	A4	3.01
Sheep/Goat	16382	-19.57	6.15	36.7	13.1	A4	3.27
Sheep/Goat	18097	-18.93	8.47	40.6	13.6	A9	3.48
Sheep/Goat	18137	-17.59	8.66	39.6	15.1	A9	3.06
Sheep/Goat	18268	-17.77	7.24	34.4	12.1	A9	3.32
Sheep/Goat	12816	-19.34	7.39	34.1	11.5	B4	3.46
Sheep/Goat	13580	-18.32	7.45	36.8	12.2	B5	3.52
Sheep/Goat	12937	-18.03	7.65	41.2	15.5	B6	3.10
Sheep/Goat	13971	-18.72	7.66	37.9	13.3	B7	3.32

7.2.3 Interpretation

No isotopic differences were detected between the sheep and goat as separate species (table 7.1 and figure 7.1). All values fit within a similar range and the sheep, goats and ovicaprids will from now on be considered together. The sampled population ranges in carbon from -20.41 to -15.71‰ (4.70‰ difference) and in nitrogen from 5.78 to 11.44‰ (5.66‰ difference). This isotopic variability is assumed to equate to dietary variability and therefore infers there was a degree of dietary variability. These data illustrate a considerable isotopic variability in plant foraging by ovicaprids with a substantial proportion of C_4 plants in the diet of some animals compared to a more exclusively C_3 plant diet of others. Following Pearson *et al.* (2007), a cut off of $\delta^{13}C = -18\text{‰}$ is assumed to indicate the consumption of C_4 plants. This implies that the majority of the sample population at Tell Sabi Abyad had a diet dominated by C_3 plants with approximately 20% also eating C_4 plants.

Table 7.2: Isotope variation by species

Levels	n	$\delta^{13}C$				$\delta^{15}N$			
		mean	sd	min	max	mean	sd	min	max
Sheep	9	-18.78	1.25	-20.01	-15.71	7.94	1.76	5.78	11.44
Goat	2	-18.60	0.41	-18.89	-18.31	8.72	0.91	8.08	9.37
Ovicaprid	16	-18.66	0.89	-20.41	-17.12	7.86	1.00	5.99	9.69
Cattle	1	-18.96	/	/	/	8.35	/	/	/
Gazelle	3	-19.17	0.94	-20.16	-18.29	6.89	1.30	5.45	7.96
Equid	3	-19.35	0.42	-19.77	-18.94	4.94	1.04	4.20	6.12
Pig	1	-20.09	/	/	/	9.08	/	/	/

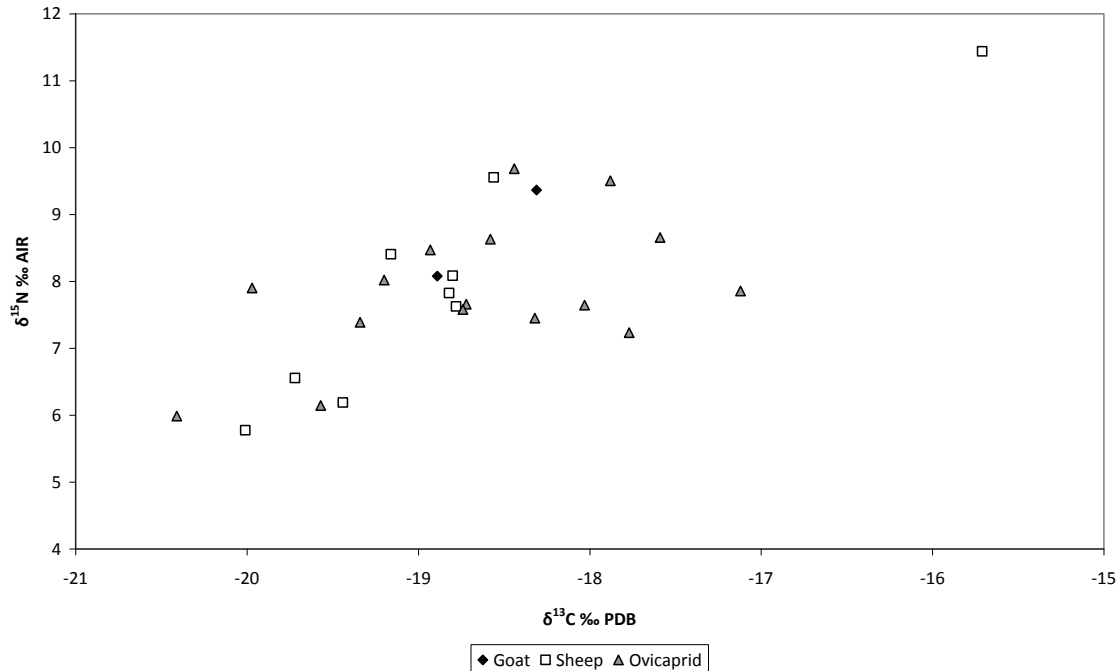


Fig 7.1: Sheep, goat and ovicaprid stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) values of bone collagen from Tell Sabi Abyad

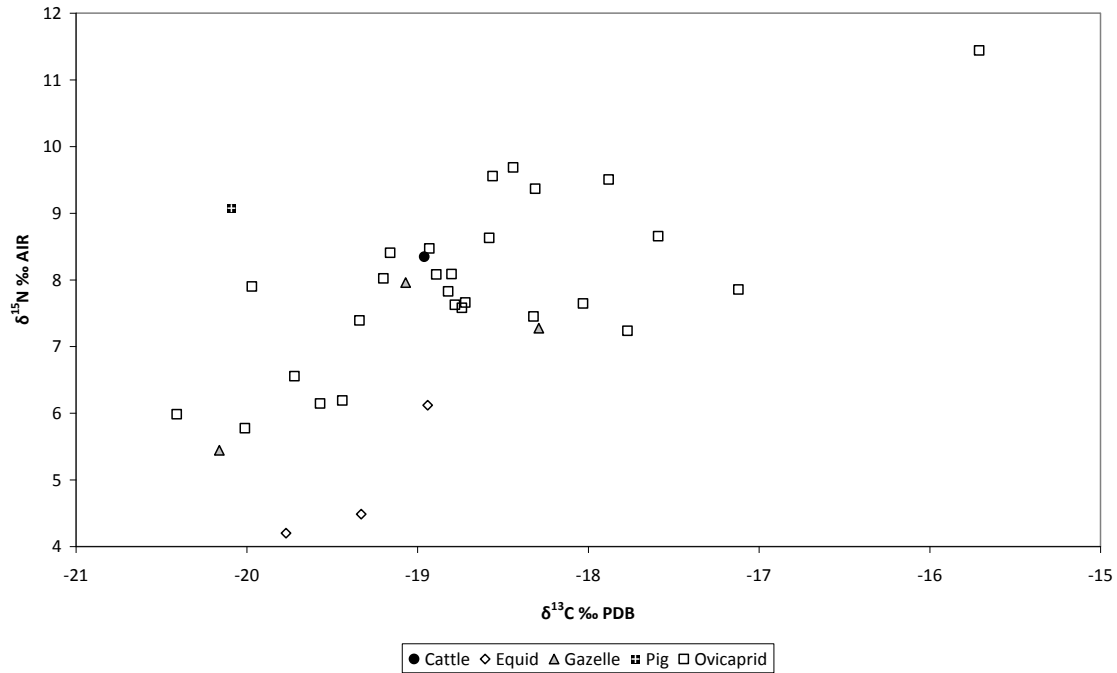


Fig 7.2: Ovicaprids, cattle, equid, gazelle and pig stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) values of bone collagen from Tell Sabi Abyad

Looking at the average $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ for the species cattle, equid, gazelle, pig and ovicaprid it can be seen that there are some differences between the species (table 7.2 and figure 7.2). The wild herbivores of the steppe, equid and gazelle, show slightly more depleted $\delta^{13}\text{C}$ values than for domestic cattle and ovicaprids, although they still fit within the isotopic range of these domestic animals. This suggests a diet of almost exclusively C_3 plants for the equids and gazelles while there was a substantial proportion of C_4 plants in the diet of some of the ovicaprids. Equids are also more depleted in $\delta^{15}\text{N}$ which is more difficult to explain. The more enriched $\delta^{15}\text{N}$ values in the domestic ovicaprids could however be a result of the animals being fed fodder from crops that were fertilised with animal dung and therefore enriched in nitrogen (Bogaard *et al.*, 2007). The single successful cattle sample fits well within the range of the domestic ovicaprids. With only one successful $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ value from cattle at Tell Sabi Abyad it is not possible to go into any detail about the diet of these animals or any possible herding/feeding strategies. The one successful pig sample shows a relatively depleted $\delta^{13}\text{C}$ value when compared to the domestic ovicaprids and a relatively enriched $\delta^{15}\text{N}$ value, although still within the range of ovicaprids. The lower $\delta^{13}\text{C}$ value seen in this one sample fits with samples from wild boar at archaeological sites in Iran (Bocherens *et al.*, 2000), Turkmenistan (Bocherens *et al.*, 2005) and Egypt (Thompson *et al.*, 2005). This is probably due to their omnivorous diet and their preference for exclusively C_3 plants such as fruits, tubers and other fleshy parts (Bocherens *et al.*, 2000, Bocherens *et al.*, 2005).

The ovicaprid isotope data will now be analysed by animal exploitation phase to see if there were any temporal differences in diet. Unfortunately, due to the very small sample sizes by level the data could only be grouped into three broad arbitrary phases: A10-A3 (levels running up to the end of the A sequence), A2-A1 (the levels immediately before the end of the A sequence) and the B levels (table 7.3 and figure 7.3).

The sample population in levels A10-A3 ranges in carbon from -20.01 to -15.71‰ (4.30‰ difference) and in nitrogen from 5.78 to 11.44‰ (5.66‰ difference). The range of the sample population in phase A2-A1 is smaller with carbon from -20.41 to -17.12‰ (3.29‰ difference) and nitrogen from 5.99 to 9.69‰ (3.70‰ difference). There is a further narrowing of the isotopic, and therefore dietary, variability in the B

levels with carbon from -19.34 to -18.03‰ (1.31‰ difference) and nitrogen 7.39 to 9.56‰ (2.17‰ difference). This narrowing of variability is clear in both the $\delta^{13}\text{C}$ values and the $\delta^{15}\text{N}$ values by phase. With such small datasets for each phase, any interpretations of this apparent narrowing of diet must be cautious. The narrowing in the range of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values after the A sequence could suggest a reduction in the variability in the diet at this time, although this could of course be merely an illusion caused by the small data set. There is apparently less contribution of C_4 plant species to the diet as no samples were over the assumed cut-off value of $\delta^{13}\text{C} = -18\text{‰}$. If the reduction in variability is real this could perhaps reflect the foddering of animals on C_3 crop species.

Table 7.3: Isotope variation in ovicaprids

Levels	n	$\delta^{13}\text{C}$				$\delta^{15}\text{N}$			
		mean	sd	min	max	mean	sd	min	max
B	8	-18.73	0.43	-19.34	-18.03	8.03	0.71	7.39	9.56
A2-A1	7	-18.66	1.06	-20.41	-17.12	7.92	1.47	5.99	9.69
A10-A3	12	-18.70	1.23	-20.01	-15.71	7.92	1.52	5.78	11.44

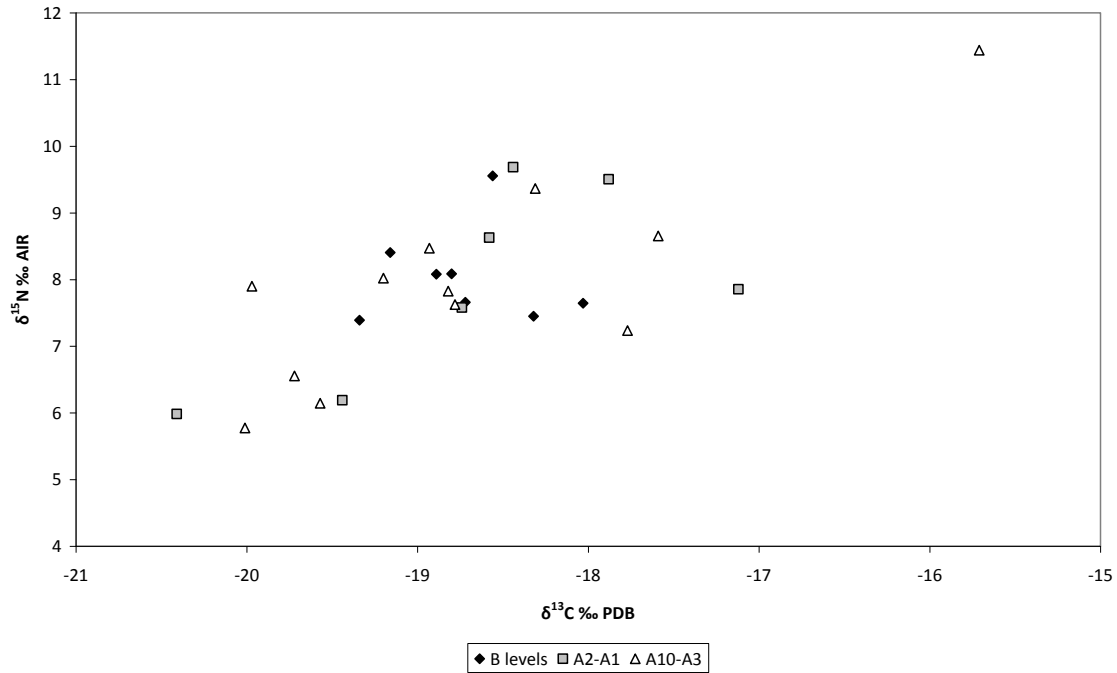


Fig 7.3: Ovicaprid stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) values of bone collagen from Tell Sabi Abyad

How does this small Tell Sabi Abyad data set compare to the data of Pearson *et al.* (2007) from the sites of Çatalhöyük and Aşıklı Höyük in Turkey, one of the few comparable datasets? The sampled population from Çatalhöyük ranges in carbon from -20.24 to -15.09‰ (5.15‰ difference) and in nitrogen from 5.28 to 11.09‰ (5.81‰ difference). These data are very similar to those from Tell Sabi Abyad which suggests that the range of plants eaten was very similar. This was not entirely the case when Tell Sabi Abyad was compared to Aşıklı Höyük which had individuals ranging in carbon from -19.56 to -17.67‰ (1.89‰ difference) and in nitrogen from 4.48 to 9.89‰ (5.41‰ difference). These data indicate that the animals from this site had far less dietary variation and very little contribution from C_4 plants to the diet. This suggests that the ovicaprids from Tell Sabi Abyad had a diet more similar to ovicaprids herded at Çatalhöyük than the ovicaprids at Aşıklı Höyük (fig 7.4). This was to be expected as the ovicaprids from Aşıklı Höyük are only proto-domestic and perhaps only loosely herded (Buitenhuis, 1997) while the

ovicaprids from Çatalhöyük are fully domestic (Russell and Martin, 2005) as they are at Tell Sabi Abyad. At Çatalhöyük there is a move from a diet essentially uniform in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values to a pattern of individually variable diet from around 7300 BC onwards. It is hypothesised by Pearson *et al.* (2007) that the increase in diet range reflects an increase in the significance of pastoralism with herders moving separate flocks over more extensive territories around the village where they came into contact with multiple isotopically distinctive plant biomasses. If this is the case then the opposite is true at Tell Sabi Abyad; the decrease in diet range could reflect a decrease in the significance of pastoralism after 6200 BC. With such a small isotope dataset from Tell Sabi Abyad such an interpretation must however be treated with caution as the narrow data range may simply be the result of a very small sample.

Table 7.4: Isotope variation in ovicaprids by site

Levels	n	$\delta^{13}\text{C}$				$\delta^{15}\text{N}$			
		mean	sd	min	max	mean	sd	min	max
Çatalhöyük	60	-17.98	1.01	-20.24	-15.09	9.39	1.27	5.28	11.09
Aşıklı Höyük	68	-18.78	0.80	-19.98	-15.32	8.50	1.01	4.48	11.50
Tell Sabi Abyad	27	-18.70	0.97	-20.41	-15.71	7.95	1.27	5.78	11.44

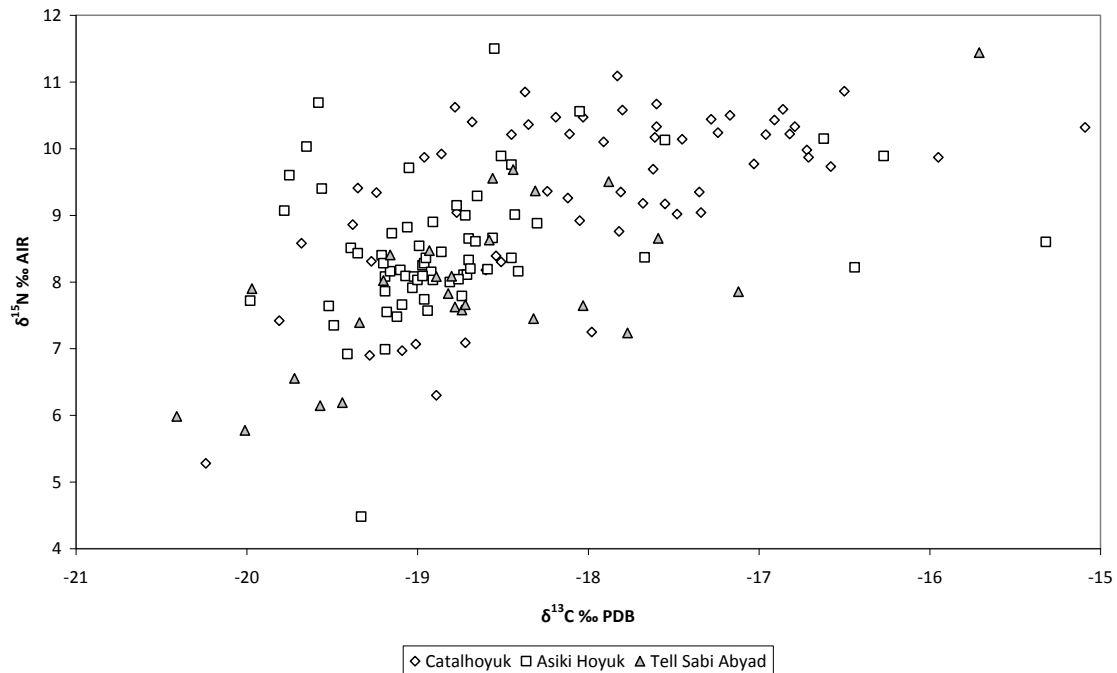


Fig 7.4: Ovicaprid isotope results of Çatalhöyük, Aşıklı Höyük and Tell Sabi Abyad

7.2.4 Discussion

The ovicaprids at Tell Sabi Abyad show large variations in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ showing that the ovicaprids came into contact with multiple isotopically distinctive plant biomasses and had a varied diet including C_4 plants. This is particularly the case in levels A10 to A3 (6750 – 6375 BC). Pearson *et al.* (2007) suggest that such variation indicates pastoralism and/or that the way in which animals were pastured varied considerably among contemporary flocks. With this in mind, I would argue that the results from Tell Sabi Abyad probably represent a population of sheep and goats herded around the local landscape, with perhaps individual flocks feeding on slightly different pasture. The isotope data indicate that a form of mobile pastoralism was taking place in the late seventh millennium BC but whether there is enough variation within the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values to warrant the conclusion that a broader scale of form

pastoralism was taking place remains unclear. In order to determine this, more palaeobotanical samples from within the Balikh valley, and perhaps beyond, would need to undergo carbon and nitrogen stable isotope analysis. Through time there is a decrease in the variability in the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of the ovicaprids. This is certainly true of the B levels (6225 – 5995 BC) and could perhaps suggest an increase in the anthropogenic control of their diet related to practices such as foddering. The flocks could alternatively be pastured in a more uniform way. The traditional zooarchaeological analyses (chapter 6) do not support a hypothesis that there was a reduction in pastoralism.

In general the $\delta^{15}\text{N}$ values of the wild herbivores at Tell Sabi Abyad (gazelle and equid) are lower than those of the domestic animals (cattle and ovicaprids). This was also the case at archaeological sites in Iran (Bocherens *et al.*, 2000) and Nevali Çori where these differences were put down to the domestic animals being intentionally nourished by their owners (Grupe and Peters, 2008). The elevated $\delta^{15}\text{N}$ levels in the ruminants could also be caused by their particular gut bacteria as hypothesized by Steinhour *et al.* (1982). The $\delta^{13}\text{C}$ values were lower in the wild fauna suggesting that unlike the domestic herds, they did not feed on C_4 plants.

One of the aims of this study was to see if any signals of climate change could be picked up from the stable isotopes. As discussed earlier, both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ are climate sensitive but there are no changes in the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of ovicaprids from Tell Sabi Abyad that point directly and uniquely to climate change as a cause. Pearson *et al.* (2007) argue that climate variation would result in the unidirectional variation in carbon and/or nitrogen isotopic variation, with values either becoming more negative or positive over time. The small sample of isotopic data from Tell Sabi Abyad does not lend itself to such interpretations and it is not possible to support or rule out climate variation within the sequence. Of course, if the effects of the climate change were more subtle and nuanced rather than catastrophic then perhaps the apparent increase in the foddering of the animals seen from around level A1 (6225 BC) onwards was an animal management strategy undertaken to cope with a decrease in quality grazing pastures available locally due to an increase in aridity.

7.2.5 Conclusion

The aim of this chapter was to investigate patterns of ovicaprid herding at a local scale through the analysis of stable carbon and nitrogen isotopes. A large sample of animal bones was selected but unfortunately the collagen preservation of these 8000 year old bones was not as good as was hoped. One of the questions asked of this study was whether the bone material was well preserved enough to yield good quality collagen to be studied? Despite the overall poor quality of the collagen, 35 good samples (approximately a forth) were recovered giving a direct insight in to the diet of these Late Neolithic animals. Despite the small sample, stable isotope analysis of some of the fauna at Tell Sabi Abyad has given us an insight into the individual diets of ovicaprids in the Late Neolithic (6750 - 5995 BC) of Northern Syria, with some additional data from other species. The results of this study did provide enough information about the diet of the ovicaprids to allow tentative interpretations about herding practices in this area and period. Although it is not clear as to whether the flocks of sheep and goat were herded over large distances in a form of pastoral nomadism in the period of 6750 – 5995 BC, it is clear that a form of pastoralism was taking place and that a wide range of distinct plant biomasses were in general grazed on by the flocks of sheep and goat at Tell Sabi Abyad.

Chapter 8 Retracing the Steppes

8.1 Temporal changes in animal exploitation

8.1.1 Introduction

One of the main aims of this research project is to explore animal exploitation in the Late Neolithic at Tell Sabi Abyad. Relatively little is known about this period, especially in Northern Syria and the Balikh Valley. The analysis of the faunal material at Tell Sabi Abyad from c. 6900 – 5900 BC has revealed several clear temporal changes in animal exploitation to be explored further. An analysis of the faunal data by level revealed several trends in animal exploitation and the levels could be grouped into ‘animal exploitation phases’. Though there were subtle changes in animal exploitation in each level, in general eight broad phases were noted:

- I: Levels A12-A10 (c. 6865 – 6675 BC)
- II: Levels A9-A5 (c. 6675 - 6455 BC)
- III: Levels A4-A3 (c. 6455 – 6375 BC)
- IV: Level A2 (c. 6385 – 6330 BC)
- V: Level A1 (c. 6335 – 6225 BC)
- VI: Levels B8-B4 (c. 6180 - 6015 BC)
- VII: Levels B3-B1 (c. 6040 - 5995 BC)
- VIII: Level C (no radio carbon dates)

Although these phases are somewhat arbitrary, each ‘phase’ is distinguished by significant differences in the animal management strategy. Within each phase however, it is often possible to see the gradual development in animal management strategies through the individual levels. There are clearly subtle developments in animal husbandry occurring continuously through time from 6900 to 5900 BC. The certain more noticeable transitions allow the grouping of levels into phases. The most dramatic changes were centred around levels A1 and B8, i.e. c. 6225 BC. In general these phases are not mirrored by the pottery phases and apparently there were different rhythms of change in progress. Some boundaries do however seem to overlap with the pottery phases (see chapter 2 and Nieuwenhuyse in prep.), namely the boundaries between levels A10 and A9, and A1 and B8. This could suggest that there were some broad cultural changes operating in several distinct elements of the culture. The general animal exploitation strategy employed in each phase is briefly summarised below.

I: Levels A12-A10 (c. 6865 – 6675 BC)

In these, the oldest levels analysed, it is domestic animals, in particular sheep, goats and pigs, which are the main focus of the animal based subsistence system. Ovicaprids represent 73.6% of the assemblage. Pig proportions are highest in these levels at 16.4% of the identified fauna. Cattle are also exploited but the proportion of these animals is low, 6.0%. In this phase they appear to be at least proto-domestic or culturally controlled i.e. still essentially morphologically wild but with an age profile that does not reflect a hunted population, but a managed population with a clear culling strategy implemented. Although aurochs may still be hunted in these levels the majority of cattle exploited appear to be under human control. Meat production is the main aim of the animal husbandry of sheep, goats, cattle and pigs. It is usually assumed that hunting would be most prolific in the older levels with a gradual disinvestment in hunting through the Late Neolithic. At Tell Sabi Abyad however hunting plays only a very minor role in these the oldest levels analysed, comprising only 3.3% of the exploited fauna. Large game such as onagers and gazelle were exploited only to a very minor degree, as was the case with small game such as hares and birds.

II: Levels A9-A5 (c. 6675 - 6455 BC)

In levels A9-A5 large game, especially gazelle, were more important to the subsistence economy than in the previous levels, with the proportion of wild game increasing from c. 3.3% to 12.4%. There was also a wider range of small game exploited. Despite an increase in the exploitation of wild animals, domestic

sheep, goats and pigs make up the bulk of the animals exploited. Ovicaprid proportions do not change while pig proportions are significantly lower than in levels A12-A10 at only 8.9%. The process of cattle domestication continues in these levels. This is evident in the decreasing size of the animals and the more targeted prime meat production animal management strategy (see section 6.5). Animal husbandry remains focused on meat production.

III: Levels A4-A3 (c. 6455 - 6375 BC)

In these levels the trend for an increasing reliance on large and small wild game continues with an even higher percentage (20.3% from onager and gazelle based on bone weight) of meat coming from a wide range of wild sources. Despite this diversification, domestic animals, including sheep, goats, cattle and pigs, remain the staple food source with similar proportions of sheep, goats, cattle and pigs as in levels A9-A5. Meat production remains the main aim of domestic animal husbandry.

IV: Level A2 (c. 6385 - 6330 BC)

In level A2 there is a significant drop in the exploitation of all wild animals to just 4.5%. Domestic sheep, goats and cattle are the most important species in this level with domestic pigs still present although there is a decrease from 11.6% to 8.2% of the identified fauna. Cattle proportions increase from 3.6% to 13.2%. This is the first phase in which cattle proportions exceed those of pigs. Meat production remains the main aim of domestic animal husbandry.

V: Level A1 (c. 6335 - 6225 BC)

In this level there is an increase in the dominance of domestic sheep and goats with both cattle and pigs proportions decreasing. Ovicaprids are most dominant in this level at 83.2% of the assemblage. Sheep and goats apparently begin to be exploited more for their secondary products such as milk and fibres (hair or wool) (see section 6.3). The proportion of pigs drops to 3.3% and the proportion of cattle drops to 4.9%. The continued drop in the number of pigs seems to mark the failure or abandonment of the husbandry of these animals. Why the proportions of cattle decrease in this phase is unclear. It is a glitch in terms of the general trend for an increase in cattle numbers through time from 6900 to 5900 BC. By this stage cattle domestication has resulted in morphologically domestic animals, with most cattle being far smaller than an aurochs. These cattle were farmed for their meat with no evidence of secondary product production. Wild animals remain present only at low proportions (8.4%) although there is a slight increase from level A2.

VI: Levels B8-B4 (c. 6180 - 6015 BC)

In levels B8-B4 pigs are almost completely absent from the assemblage (2.8%). Wild fauna are only present in low proportions (6.6%). Animal husbandry is almost completely reliant on sheep and goats (78.3%) farmed for meat, milk and wool, and domestic cattle farmed for their meat, with the proportion of cattle in these levels increasing to 12.2%.

VII: Levels B3-B1 (c. 6040 - 5995 BC)

In these levels cattle are present in very high proportions, 24.1%, with proportions of ovicaprids particularly low (59.1%). Although ovicaprids still dominate the assemblage in terms of NISP, in terms of bone weight and therefore meat weight, cattle are more important; cattle making up 49.1% and ovicaprids making up only 33.1% of the bone weight. Pig proportions see a slight revival, increasing to 6.3%. Wild fauna proportions increase to 10.1% of the NISP.

VIII: Levels C (c. no radiocarbon dates)

This was not the target period of this research and the sample size in these levels is very small. The C levels see an increase in the proportions of ovicaprids and pigs, as well as wild fauna, which increase to 12.7%. Faunal material from this period has been studied by Cavallo (2000), and this data will be used to increase the amount of information available from this period (see section 8.7.2).

8.1.2 Summary

The main changes seen through time are an increasing reliance on domestic fauna such as sheep, goats and cattle with increasing specialisation in the husbandry of these animals. Domestic sheep and goats are managed more and more with secondary products in mind, particularly from 6225 BC, while a more targeted prime meat production strategy is implemented in the cattle husbandry. Cattle appear to be in the early stages of domestication by c. 6900 BC with morphologically domestic cattle being herded for prime meat production by c. 6225 BC. Domestic pigs are the exception with the numbers of these animals gradually dwindling until their husbandry was abandoned in level A1. Hunted animals are present in all levels but are only really exploited to any degree from levels A9 to A3, the entire first half of the seventh millennium. Why wild animals were exploited in these levels but not in the previous levels A12 to A10 is unclear. From c. 6395 BC onwards wild animals were no longer a significant part of the subsistence economy.

8.2 Intra-site spatial differences in animal exploitation

8.2.1 Introduction

In order to try and reconstruct the economic processes and activities taking place on site, it is important to consider the contexts in which the bone material was recovered, and to discuss how representative this sample is. Cultural practices such as butchery and bone working can leave distinct patterns in the faunal record, as can carcass utilisation and disposal strategies (Maltby, 1985). There are three broad classes of deposition to consider first coined by Schiffer (1972) and defined by Meadow (1980) as: primary disposal which involves waste deposition at the locus of its creation resulting in undisturbed living or activity surfaces; secondary disposal which involves the removal of contemporary waste from its locus of origin to dumping areas which can cause the mixing of refuse resulting from discrete activities; and finally tertiary deposition which is defined as the re-deposition of previously deposited waste in a different spatial and temporal context.

Understanding any spatial patterns in the deposition of the faunal remains is crucial in order to interpret site use and activity areas. In section 6.2.4 the distribution of animal bones across the site of Tell Sabi Abyad is analysed. The results of this analysis will now be discussed and elaborated.

8.2.2 Contexts

The vast majority of bone material (88% of the NISP, 43173 bone fragments) could be associated with a certain type of context, the rest of the material was derived from mixed contexts. It is apparent from the analysis carried out in section 6.2.4 that the vast majority of bone material appears to come from the re-filling of features and as such is likely to be secondary or perhaps even tertiary deposits. This would make detecting any individual activities practically impossible. This data will now be assessed in more depth to see if this really was the case.

The majority of material in all levels was recovered from open areas (62% of the site total) (table 6.8). There was some variation between the levels: levels A12-A10 having an unusually high amount of bone material derived from within platforms and building construction layers, level A1 having a high percentage of bones derived from room fills and levels B8-B4 having a high percentage of bone derived from ovens. These differences could in theory go some way to explain the differences between the levels but this does not appear to be the case. An analysis of species proportions by context showed that there was very little difference between the main context types of open areas, pits and room fills. Although the species proportions in less common contexts often varied from those of the contexts with larger sample sizes, the sample sizes of faunal remains derived from these less common contexts, such as platforms, construction layers and ovens, are so small in comparison to the main context of open areas that differential species proportions in these small contexts is unlikely to affect the overall results. The differing proportions of bone material recovered from various contexts is purely a factor of what was by chance excavated, not cultural differences in depositional practice. Although the sample sizes from room fills were larger and more comparable to open areas, simply due to larger areas by chance being excavated, the analysis of the

faunal material by context showed that there was no noticeable difference between room fills and open areas. The difference between the levels is therefore apparently not based on spatial differences in animal exploitation but temporal ones.

The top six species proportions were also calculated by context (see summary table 8.1). Cattle remains were most common in gutters, hearths and bins but the sample sizes in these contexts are so small that the actual number of cattle bones present is very low, and no valid conclusions can be drawn about structured deposition of cattle bones or specific activities. Pig remains were most common in burials, on floors and in platforms. Pig remains were even more prevalent than ovicaprid remains in burials perhaps suggesting that these remains were in some way specifically selected for burial in the grave pit, but as the sample sizes from these contexts are so small it is again impossible to draw any concrete conclusions.

Table 8.1: Species proportions of the top six species by context (site total)

Context	Ovicaprid	Suid	Bos	Gazelle	Equid	n
Basin	95.5%	0.0%	0.0%	4.5%	0.0%	22
Bin	61.9%	0.0%	33.3%	0.0%	4.8%	21
Burial	43.1%	47.1%	7.8%	2.0%	0.0%	51
Construction	77.7%	14.9%	5.7%	1.2%	0.5%	579
Floor	69.8%	20.9%	2.3%	2.3%	4.7%	43
Gutter	68.9%	0.8%	28.7%	0.0%	1.6%	122
Hearth	54.3%	8.6%	25.7%	7.1%	4.3%	140
Open Area	80.0%	8.7%	8.0%	1.9%	1.4%	10488
Oven	88.2%	1.2%	6.5%	3.7%	0.4%	245
Pit	84.9%	4.8%	6.9%	2.0%	1.4%	1622
Platform	79.2%	13.9%	6.1%	0.7%	0.0%	423
Room Fill	81.4%	5.3%	5.9%	2.8%	4.7%	3059
Vessel	100.0%	0.0%	0.0%	0.0%	0.0%	134
Total	80.5%	7.9%	7.6%	2.1%	1.9%	16949

The analysis of the faunal remains by context at Tell Sabi Abyad (see also section 6.2.4) showed that there was very little difference in the material deposited by context, with the species proportions being fairly uniformly distributed across the main feature types. There was no clear evidence of any particular activity areas. It is presumed that different activities would be undertaken in outside areas than in inside areas, with animal culling and butchery a prime example. Not only are most rooms far too small to have housed such activities, it also seems unlikely that such messy processes would be carried out in living or sleeping areas. That no difference in the faunal material from different contexts was detected suggests that the majority of faunal material found and analysed was derived from secondary or even tertiary deposits of waste i.e. the mixed waste from many different activities. This resulted in practically all contexts being made up of almost entirely homogenous material.

Body part proportions

One of the most important assumptions made by many archaeologists is that the spatial patterning of archaeological remains may reflect the spatial patterning of past activities, depending on the depositional circumstances (Schiffer, 1972). Clearly this is not always the case and the proveniences of artefacts at a site do not always correspond to their actual locations of use. There is in reality little known about how artefacts come to rest where they are uncovered in an archaeological excavation, or about how they relate to and reflect the behaviour of people in the past (Murray, 1980). An archaeological context includes all the materials found at the site, regardless of whether they are in specialised discard locations (Schiffer, 1972).

Differences in body part proportions are often used as a way to detect differential use of spaces i.e. kill sites versus residential sites, primary butchery areas versus cooking areas. There are of course many

reasons why body part proportions vary, both within and between species, and within and between sites. These are summarised in table 8.2 based on the suggestions offered by Binford (1978: 9-10).

Table 8.2: Suggestions offered to account for different body part proportions (based on Binford, 1978: 9-10)

Suggestions offered to account for differing proportional frequencies observed at a single site between anatomical parts of a single species	Suggestions offered to account for differences noted between species in the proportional frequencies of anatomical parts at a single site
1: Removal or destruction of some parts as a function of their use as tools or as raw materials for tools 2: The differential destruction of parts during butchery 3: The differential transport of anatomical parts from kill sites to sites of consumption 4: The differential destruction of anatomical parts during consumption by man: a) direct eating of soft bone parts b) destruction of bone parts as a result of marrow extraction c) destruction of bone parts as a result of pounding bones for the extraction of bone grease 5: The differential destruction of bone parts on sites of consumption by domestic dogs 6: The differential destruction of anatomical parts on kill sites or abandoned living sites by scavengers	1: The differential degree of butchering of different species at kill sites as a function of their size and portability 2: Differences between domestic and wild forms, resulting in domesticated forms being butchered at the site of consumption and wild forms being butchered at kill sites 3: Differential destruction of parts from different species as a function of differences in the size and strength of analogous anatomical parts 4: Differential food preferences for analogous anatomical parts from different species

Possible causes of differential body part proportions seen in the archaeological record all have some basis in ethnographically recorded behaviour, but there still remains a lack of knowledge of the particular effects that might be expected to result from any one of these activities, never mind a combination of them. Faunal assemblages, particularly on long-lived sedentary sites, are not the result of one event but instead the culmination of multiple, repeated, sequential strategies based on multiple decisions made by past communities, ultimately converging at one location (Binford, 1978: 477-478). Both human actions and decisions in the past, and post-depositional processes play a role in what we find archaeologically. Most assemblages are aggregate measures of many separate events that reflect activities over some period of time (Lupo, 2006). It would be very naïve to assume a monocausality in the interpretation of assemblages of animal remains modified by man (Binford, 1981: 87). It cannot be assumed that all modifications arose from a single behaviour, such as butchery, marrow extraction, grease processing, or tool production. Instead it must be realised that the bone fragments had a life history during which they were components of a cultural system (*Ibid*). This is certainly the case at a long-lived site such as Tell Sabi Abyad, making distinguishing independent activity areas practically impossible. Add to this the complication that many deposits are secondary or even tertiary in origin and it becomes very apparent that distinguishing particular activities archaeologically can be beyond the reach of current methodologies.

The major challenge to zooarchaeologists seeking behavioural or cultural significance in differences in body part proportions is taphonomy. Not all bone fragments have the same chance of surviving the

various taphonomic processes, and skeletal elements have different survival patterns, both between the different elements and between species, with bone density and age playing major roles in taphonomic loss (see chapter 5 and Nicholson, 1996; Lyman, 1994; Ioannidou, 2003). Of prime importance is identifying the extent to which patterns identified in the archaeological record can be explained as the result of taphonomic processes (Arbuckle *et al.*, 2009). The taphonomic analysis of the Tell Sabi Abyad material indicated that the surface preservation was generally very good but that bone fragmentation was very high. Levels of gnawing were very low (see section 6.2.3). The preservation of the material was therefore relatively good. This does not rule out the possibility that low density bone fragments were destroyed. One way to measure the survival of low density elements is the humerus index: the abundance of the fragments of the proximal humerus, a low density fragment, as a percentage of the distal humerus, a high density fragment. The humerus index for the ovicaprids at Tell Sabi Abyad is 13.3. This value shows that there has indeed been a preferential survival of higher density fragments with the likely destruction of many low density parts, including juvenile bones. This value is comparable to other sites in the Near East (Arbuckle *et al.*, 2009) and therefore Tell Sabi Abyad is no more taphonomically biased than other sites of this time period.

At Tell Sabi Abyad there is little to no difference in the distribution of body parts by level. This is particularly the case for domestic ovicaprids and cattle where all body parts are present in almost equal proportions in all the main contexts excavated (open areas, pits and room fills). This in itself represents a pattern and suggests that whole carcasses of cattle, sheep and goats were present and processed on site in all levels. This is to be expected for an economy based on domestic animals as they could be brought to the site alive before being slaughtered and processed. The presence of whole carcasses of cattle in all levels supports the hypothesis that the cattle were domestic in all levels. Although not all elements of the domestic pig carcasses were present in any context, no clear patterns emerged when analysing the body part proportions by context.

In the absence of destructive taphonomic processes, it is often assumed that the abundances of different skeletal parts of hunted fauna are a result of selective transport and discard (Lupo, 2006). Binford (1978) made two general propositions:

1. The greater the distance over which meat is to be transported, per unit of time, the more radical will be the removal of low-utility anatomical parts.
2. The greater the bulk of material to be transported, per unit of time, the more radical the removal of low-utility anatomical parts will be

These theories are only really applicable to wild hunted species as domestic animals are assumed to be killed and butchered at the site of consumption. At Tell Sabi Abyad the majority of animals exploited are domestic and as such, the following discussion can only be applied to a small fraction of the faunal assemblage, the wild game exploited.

It is proposed that when distances between kill sites and residential sites were great, there was a selection for the transportation of the body parts of large prey associated with the most meat (Lupo, 2006). Of course meat is not the only consideration as marrow, grease and blood would have been important sources of calories and a valued resource. Binford (1978), based on ethnographic studies of the Nunamiut, developed the 'Modified General Utility Index' or MGUI as a way of measuring the utility of skeletal elements in terms of the total amount of meat, marrow and grease associated with each body part. He determined that the bones with the most meat utility were the femur, ribs, sternum, pelvis and thoracic vertebrae; the bones with the best marrow were the tibia, metacarpal and metatarsal; and the bones with the best grease were the femur and the humerus. In general terms the limbs can be considered to be of high utility and the skulls and feet of low utility. Despite the early promise of applying the MGUI to archaeological material, it became apparent that destructive taphonomic phenomenon, site formation processes, and methodological biases in excavation techniques can create false profiles or obscure true profiles (Lupo, 2006).

Lupo (2006) used central place foraging models to examine how field processing and transport costs influence human decision making in the hunter-gatherer communities of the Hadza of Africa. She concluded that trade-offs were made between field processing and transport costs that minimise waste, and that these decisions were made within the contexts of available cooking technology, the amount of meat stored, a high degree of meat-sharing, unpredictable or high-risk hunting returns, and seasonal variability in the availability of animal fat relative to lean meat. Can we see any evidence for different processing and transport costs of species at Tell Sabi Abyad?

Although there was in general very little difference between the faunal material recovered from different contexts at Tell Sabi Abyad, there were some clearly discernable patterns in the body part proportions by context for onager and gazelle remains. Mostly high utility remains (fore and hind limbs) of onager were recovered from pits while both high and low utility elements were recovered from open areas. This implies that pits contained mostly deposits of waste derived from meals while open areas contained waste derived from all activities, including butchery and meals. Femurs were particularly present in room fills. This high utility bone is a good source of meat marrow and grease. This suggests some structuring of deposition with perhaps primary butchery waste deposited in open areas and more specific waste deposited in pits (secondary butchery and/or food preparation?) and room fills (cooking, marrow extraction?). There is also differential distribution of gazelle remains by context with, once again, most parts of the skeleton being present in the open areas, the high utility forelimbs being more common in room fills (perhaps the remains of meals?) and relatively low utility metapodials being the most common elements recovered from pits. These interpretations should however be viewed with caution as very small sample sizes are available for both onager and gazelle in both pits and room fills and these patterns may be more a result of sample size than evidence of particular activities and structured deposition.

Refuse

Societies not only produce refuse but also define it and decide how to dispose of it in a way they deem appropriate (Gumerman, 1997). Different species may be treated and disposed of differently. These culturally defined refuse strategies are sadly not apparent in the faunal data. Animals bones can enter archaeological contexts by several different pathways: animals must be procured (either through hunting, trade, or from domestic herds), culled, butchered and prepared, used (either for tool production or for sustenance), and finally discarded. Bones can enter the archaeological record at any one of these stages and the issue can be complicated by recycling, storage or transport (fig 8.1).

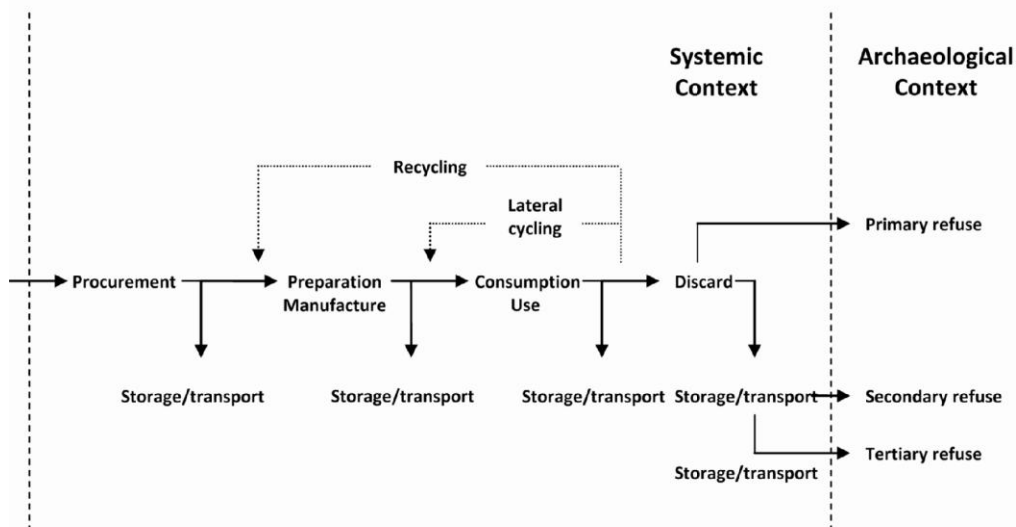


Fig 8.1: Flow model for viewing the life cycle of animal based products (based on Schiffer, 1972).

Human activities lead to the production of waste including bones. Not all these bones will be left in the original activity location. In fact this is quite rare. Much of the bone refuse, especially in areas which are inhabited continuously, may be swept up and deposited in a disposal area distant from the activity areas in which they actually became waste (Meadow and Zeder, 1978). Ethnographic studies have shown that most sedentary, or semi-sedentary, societies discard refuse outside their use location, particularly if this is within dwellings (Murray, 1980). The systematic removal of this primary refuse through the cleaning of activity areas means that refuse is often discarded away from the place of origin, forming middens of secondary refuse. This certainly seems to be the case at Tell Sabi Abyad where the majority of bone material recovered from all contexts appears to be secondary or tertiary deposits and not associated with any one activity. Such secondary disposal procedures may serve to mix the results of individual activities and to sort the bone material by size or durability (Meadow and Zeder, 1978). In other words, taphonomic factors come into play. Variability in the archaeological record is the ultimate source of information for all archaeological inquiry (Tani, 1995). A certain amount of this variability is determined by formation processes rather than past human behaviours and recent research in archaeology has increased our awareness of the various processes that can affect the spatial ordering of the remains from which we draw behavioural inferences (Stahl and Zeidler, 1990). Following the activities that lead to bone disposal, such as butchery and consumption, any number of taphonomic processes may significantly alter the nature of the faunal assemblage (Meadow and Zeder, 1978). These factors are discussed in detail in chapter 5 and include: scavengers such as rodents and canids dragging off, modifying or completely destroying bones; exposure to the elements and everyday day activities in a busy settlement leading to trampling and destruction of some remains; natural processes of erosion; and the re-depositing of bones by the digging of pits or foundation trenches, by building walls and by levelling off buildings at the site (*Ibid*). These spatial and temporal disturbances frequently occurred at sites occupied for long periods and this is certainly the case for the Late Neolithic levels at Tell Sabi Abyad. Large scale levelling is, for example, attested at Tell Sabi Abyad in Operation III, an activity that could significant mix faunal deposits (see chapter 2).

Although it is assumed that different activities took place in open areas than inside houses and buildings at Tell Sabi Abyad, there is little evidence of these activities in the faunal data. During excavation it was noted that some floors inside buildings were plastered, often with many layers of plaster applied through time. Rooms were apparently regularly swept clean of refuse and often re-plastered. The remains of discrete activities were not left in-situ and the residues of these activities become mixed in refuse areas. Much of this refuse found its way into open areas and pits but abandoned dwellings were also used as middens. This means that the refuse found in any one context is very unlikely to represent the refuse of any one activity. This was also the case at Operation I (Cavallo, 2000: 100) where the faunal material is said to come from mainly secondary and tertiary deposits and are therefore not directly related to the use of structures in which they were found.

This fits with the general hypothesis proposed by Schiffer (1972):

“...with increasing site population (or perhaps site size) and increasing intensity of occupation, there will be a decreasing correspondence between the use and discard locations for all elements used in activities and discarded at a site.” (Schiffer, 1972: 162).

Although this is not true of all sites (see Domuz Tepe: Kansa *et al.*, 2009b) and cultures do not always follow such predictions, this certainly does seem to generally be the case for the Late Neolithic levels at Tell Sabi Abyad.

8.3 Animal domestication, husbandry and herd management

8.3.1 Introduction

The faunal analyses undertaken in chapter 6 have shown that domestic animals formed the basis of the animal subsistence strategy at Tell Sabi Abyad in the Late Neolithic. The consistently high proportion of domestic sheep and goats seen throughout the assemblage demonstrates that domestic animals always formed the basis of this subsistence system c. 6900 - 5900 BC. Domestic cattle and pigs were also important with the early importance of domestic pigs and the later importance of domestic cattle showing that there were changes in the proportions of domestic species exploited. This shows that although domestic fauna as a group remained dominant in all levels there were changes in the composition of the livestock and the animal husbandry strategies employed.

8.3.2 *Animal domestication*

In the earliest levels analysed, levels A12-A10, the species of sheep, goat and pig are all fully domestic at the site, evident both morphologically and in terms of animal management. Sheep and pigs may have been domesticated in-situ at the site some time much earlier than the levels analysed here, probably in the PPNB period, but to determine this for certain would require an analysis of faunal data from some of the older levels recently uncovered (levels A13 and A14 were uncovered during the 2009 excavations with the natural soil level still not reached). These animals may also have been brought to the site as fully domestic herds. Wild boar were probably still available in the vicinity of the site as some very large individuals were detected in the sample. The presence of wild sheep locally cannot be ruled out but it is very unlikely that wild goats were easily accessible. Wild goats are not native to the Balikh valley and may have been brought to the area as domestic animals from the Zagros Mountains or the Southern Levant in the eighth millennium BC.

As the domestication of the aurochs apparently took place in the levels analysed, this process will be considered in more detail. The domestication of the aurochs was underway by c.6900 BC, levels A12-A10, with the animals clearly being culturally controlled and managed by humans for their meat. This fits with data from Tell Sabi Abyad II (c. 7200 – 6700 BC) where cattle are thought to be within the very early stages of incipient domestication (Van Wijngaarden-Bakker and Maliépaard, 2000). Morphologically domestic cattle were not obviously visible until the end of Sequence A, when cattle smaller than an aurochs dominated the population. In all levels, several bone fragments of large individuals were recovered which could belong to hunted aurochs rather than domestic cattle. This is however very difficult to determine definitively as the early domestic populations were still very large and these large bone fragments could come from domestic bulls. Aurochs may have inhabited the riverine forest that is presumed to have followed the path of the Balikh River in the Balikh Valley, and so could be hunted very close to the site (see chapter 3 for palaeobotanical review). Differentiating between the processes of diffusion and local domestication is difficult, particularly if the dispersal of managed animals occurred during the earliest stages of the domestication process when phenotypic divergence is weakly expressed or completely lacking (Arbuckle and Makarewicz, 2009). Where local, wild populations were brought under human control, the expectation is that these faunal samples would be characterised by a gradual shift in skeletal morphology and biometrics, a process which may take some time as the introduction of management practices and anthropogenic selective pressures slowly transform wild populations into phenotypically domestic ones (*Ibid*). This seems to be the case in the Late Neolithic levels at Tell Sabi Abyad and therefore local domestication can be hypothesised. The presence of both large aurochs sized individuals and smaller individuals, and the mortality profiles reflecting at least cultural control of these animals in levels A12-A10 points to in-situ domestication in these levels or a short time before. It is however, not until the end of Sequence A that the majority of cattle are morphologically domestic in size and show a classic age profile of a domestic population targeted towards prime meat production. This suggests that the process of cattle domestication took altogether more than 700 years. This long time delay from the initial stages of domestication and culturally controlled animals, to the appearance of morphologically distinct animals, may suggest that in the early stages of domestication the inhabitants of Tell Sabi Abyad continued to supplement their cattle breeding stock with wild animals. If very small herds of domestic cattle were present in these early stages of domestication this may have been necessary to prevent inbreeding. The presence of some very large individuals throughout the sequence certainly suggests that this may have been the case. Wild cattle may have served as a readily available propagation

pool to be dipped into at regular intervals to replenish the domestic stock (Becker, 2000). The successive reduction in the size of cattle through time suggests that although the first (proto)domestic animals may have been able to mate with the locally available aurochs, through time the animals were more closely managed and isolated from the wild populations.

Why the Late Neolithic inhabitants of Tell Sabi Abyad decided to tackle the domestication of such a large and temperamental beast is unknown. It has been suggested that the assumption that prehistoric cattle would have been formidable beasts to domesticate due to their size and fierce behaviour needs re-evaluation. As Russell (1988: 21) rightly points out, our knowledge of the aurochs' wild behaviour is primarily derived from so-called "reconstituted" aurochs from back-breeding experiments. The results of these experiments suggested that the ancient wild aurochs was fierce, temperamental, agile and extremely shy, but in the absence of age and sex specific behavioural data, it is not possible to characterise all aurochs by such behavioural traits (*Ibid*). Mature males in many herd species often exhibit such aggressive behaviour, particularly during mating season, but these animals are not the principle component of pastoral subsistence herds, the females and their young are. Very few stud males are needed and, presumably, behavioural modifications in young males would have resulted from their rearing in association with humans, facilitating their future control and exploitation as studs (*Ibid*). Although the Neolithic herders may have accrued a significant body of pastoral knowledge through the herding of sheep and goats, cattle have different physiology and nutritional requirements which may have initially posed significant management challenges (Makarewicz, 2009). Although cattle would have provided a lot of meat, they would have also been much more costly and economically risky to keep because of their high food and water requirements and lower birth rates (Kansa *et al*, 2009b).

Arbuckle and Makarewicz (2009) argue that the addition of domestic cattle to the Neolithic subsistence economy facilitated the development of new economic and social systems that took advantage of the large packages of animal products, including meat, blood, skin, and renewable milk and traction, offered by managed cattle herds. There is however no evidence of milk production or the use of cattle for traction in the Late Neolithic levels at Tell Sabi Abyad. The appearance of images resembling cattle bulcrania (stylised cattle heads with long horns) on pottery dated from 6200 BC onwards suggests that these animals, wild and/or domestic, had some role in the imagery of the people of Tell Sabi Abyad and therefore perhaps their cultural identity and ideology (see figure 8.2). These representations of bulcrania are a common image seen on painted pots from this period, not just at Tell Sabi Abyad, and Nieuwenhuys (2007: 219) argues that from 6200 BC onwards painted ceramics were a medium with which social identities were actively shaped, negotiated and reproduced. Pottery decorations in the Late Neolithic are considered to have been symbolic systems which helped to regulate society, with the standardised designs perhaps being regarded as conventional symbols, transmitting messages (Verhoeven, 2002a; 2002b). The ritual aspect of cattle must therefore be considered. Finds of clay and stone cattle figurines, deposits of cattle skulls and horncores, and bulcrania installations throughout the Levant, Northern Mesopotamia and Anatolia also suggest some non-secular meaning associated with cattle, leading to talk of a "bull cult" related to vitality, life-force and fecundity (Verhoeven, 2002a; 2002c). Whether this has any truth in it or not, it can be argued that all animals, and the food they provide, have ideological, symbolic, and social meaning beyond their economic uses (De France, 2009). At Tell Sabi Abyad there were several cattle bones deposited in a manner that suggests deliberate deposition: a large cattle femur deposited within a human inhumation (fig 8.3) and several intact cattle horncores (fig 8.4). There were clearly key social meanings to these deposits. It can be argued that the domestication of cattle and the appropriation of these animals as property creates not only a new source of wealth and base for power but also one with particular properties that have crucial social implications (Russell, 2002). Cattle are often considered the feast animal of choice (see for example at Çatalhöyük: Hodder, 2006: 49; Domez Tepe: Kansa *et al.*, 2009). They not only provide vast quantities of meat, requiring division between large groups of people or processing for storage, but they arguably also carried prestige because they were a long-term and risky investment requiring substantial resources to raise to maturity, and may have served as one of the earliest forms of capital (Kansa *et al*, 2009a).



Fig 8.2: Example of a bucrania painted on a Halaf pottery sherd



Fig 8.3: Large cattle femur deposited on a disarticulated human skull within complete adult inhumation



Fig 8.4: Complete horncore found in level A2/A3 room fill

8.3.3 Animal husbandry and herd management

The domestic livestock consisted of sheep, goats, pigs and cattle. These four species account for 89.7% of the total identified remains. The importance of domestic animals fluctuates through time but remains very high. Domestic animals are most important in levels A2 to B4 (c. 6385 – 6015 BC) and are of slightly less importance in levels A9 to A3 (c. 6675 – 6375 BC) (fig 8.5 and 8.6). The changes are in general subtle in nature but the differences in the proportions of wild and domestic species (based on NISP) between

levels A4-A3 and A2, levels A2 and A1, levels A1 and B8-B4, and levels B8-B4 and B3-B1 are statistically significant using the F-test (see appendix 11).

The emphasis of animal husbandry is on ovicaprids in all levels when looking at the NISP (fig 8.7). If bone weight is taken into account it is apparent that cattle are equal in importance to ovicaprids in levels A2, the B and C levels (fig 8.8). The importance of ovicaprids seems to decrease slightly over time with the exception of level A1 when there is a revival in ovicaprid husbandry. The importance of cattle increases over time, again with the exception of level A1 (c. 6335 - 6225 BC) when there is a sudden decrease in the both the number and weight of cattle bones recovered. The decline in cattle numbers in this level bucks the general trend and is difficult to explain. It does not seem to be a factor of the contexts analysed because as discussed earlier, there is little to distinguish the contexts in terms of species proportions. Level A1 represents the last occupation level in the A sequence, before the shift to sequence B with its associated changes in settlement and material culture. Does the decreased proportion of cattle in the sample reflect a real reduction in the number of these animals? Does this reduction in the proportion of cattle therefore represent some disruption in the successful husbandry of domestic cattle? This is difficult to say with certainty, but it is clear there is a temporary reduction in the relative importance of cattle in this period. In contrast, a steady decline in pig husbandry through time is seen in terms of both bone weights and NISP.

There are obviously important changes in terms of the role and exploitation of domestic livestock through time. The analysis of the faunal data has revealed transformations in the husbandry of all domestic livestock, particularly cattle and pigs. The domestication process of the aurochs was in its infancy in levels A12-A10 (c. 6860 – 6690 BC) with morphologically domestic cattle present by level A2 (c. 6385 - 6330 BC). In terms of potentially exploitable biomass, cattle husbandry can be considered to be more profitable than that of ovicaprids as a far greater amount of food is available from each carcass (Seguí, 2000). One cattle carcass can feed many more people than that of a sheep or goat. Herd security and meat production were the apparent foci of cattle husbandry with most animals being culled before they reached three years of age in all levels. From level B8 (after 6200 BC) onwards there is a shift to a more intensive selection for prime meat production. Domestic pig husbandry was well established in the oldest levels analysed, A12-A10, where they were bred for their meat. There is however a gradual disinvestment in the husbandry of these animals and an apparent abandonment of pig husbandry occurring around level A1 (c. 6335 - 6225 BC). Pigs could have been abandoned in favour of animals capable of also producing secondary products, i.e. cattle, sheep and goats as part of an increasingly important pastoral economy.

Ovicaprid husbandry is the one stable aspect of the Late Neolithic economy. Both domestic sheep and domestic goats were herded in all levels, where they were managed for both meat production and secondary product exploitation, at least from level A1. The majority of animals were culled between two and three years of age suggesting that meat production was the one of the main aims of sheep and goat husbandry. Milk production and herd security become more important from level A2 onwards (after 6385 BC), reflected in the increased number of adult animals living to four years of age or older. From level A1 onwards there is a shift to a mixed economy of both meat and milk, and perhaps fleece, production. In all levels it is apparent that herd security was of utmost importance. The maintenance of ovicaprids for their meat in modern Syrian villages is of secondary importance, with their main role being as sources of wool and dairy products (Akkermans, 1993: 235). Animals are only slaughtered on special occasions and meat forms a small part of the diet. It is likely that this was also the case in the Late Neolithic. The ovicaprids were probably kept in mixed herds which were moved around the local environment. Isotope data revealed no evidence for long-distance pastoral nomadism (see Chapter 7).

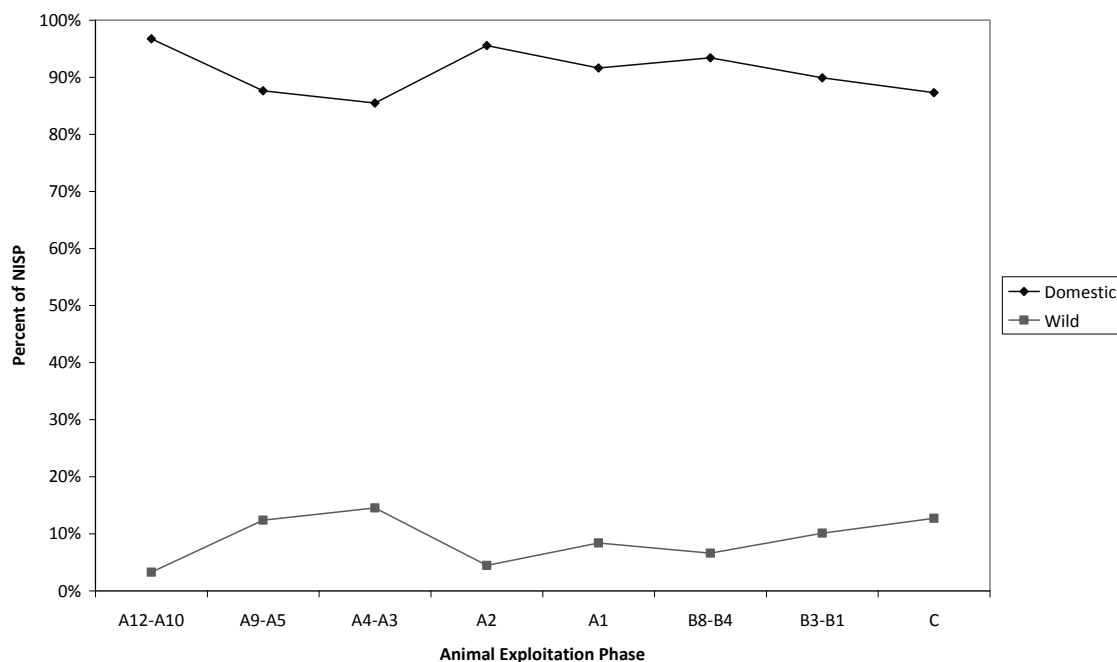


Fig 8.5: Proportions of domestic and wild animals by animal exploitation phase (based on NISP)

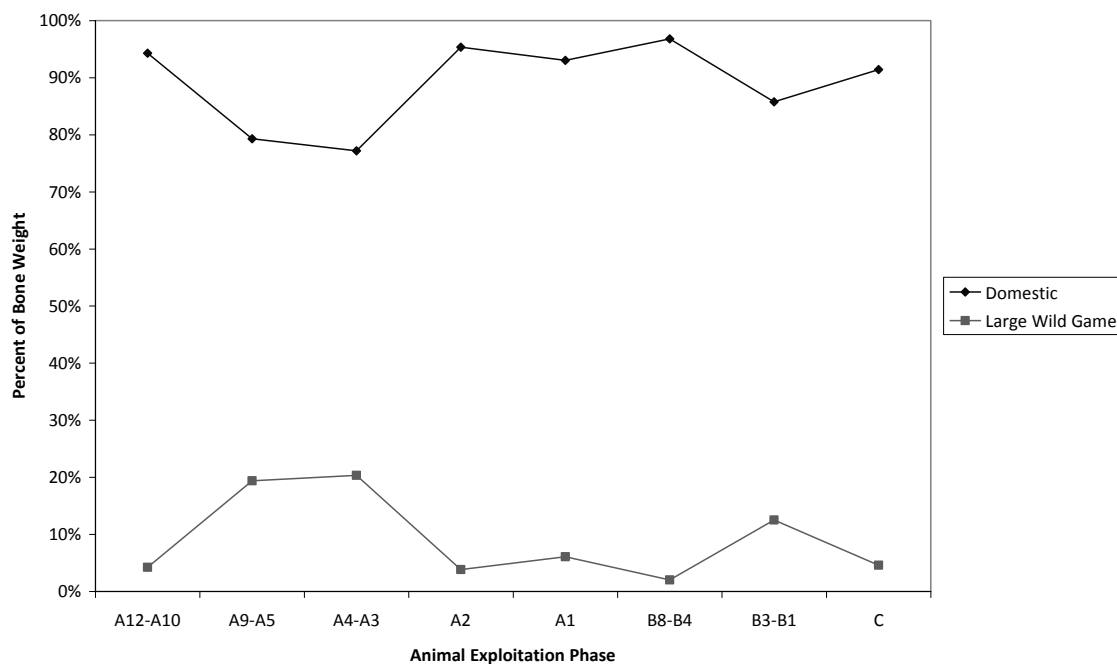


Fig 8.6: Proportions of domestic and large wild game by animal exploitation phase (based on bone weight)

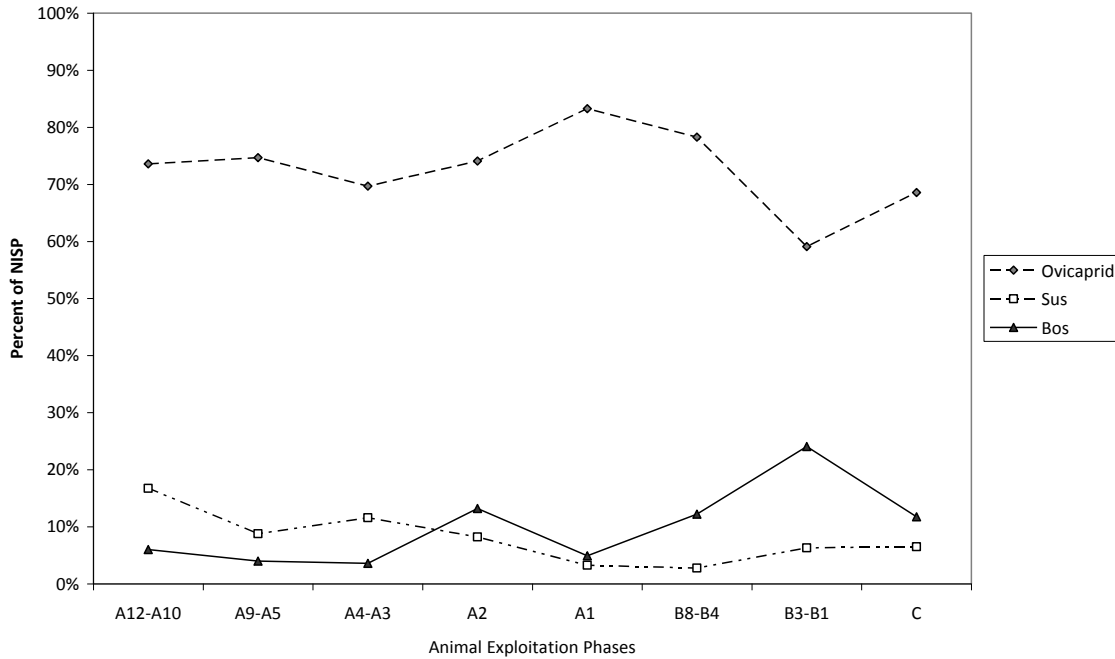


Fig 8.7: Proportions of ovicaprid, pig and cattle by animal exploitation phase (based on NISP)

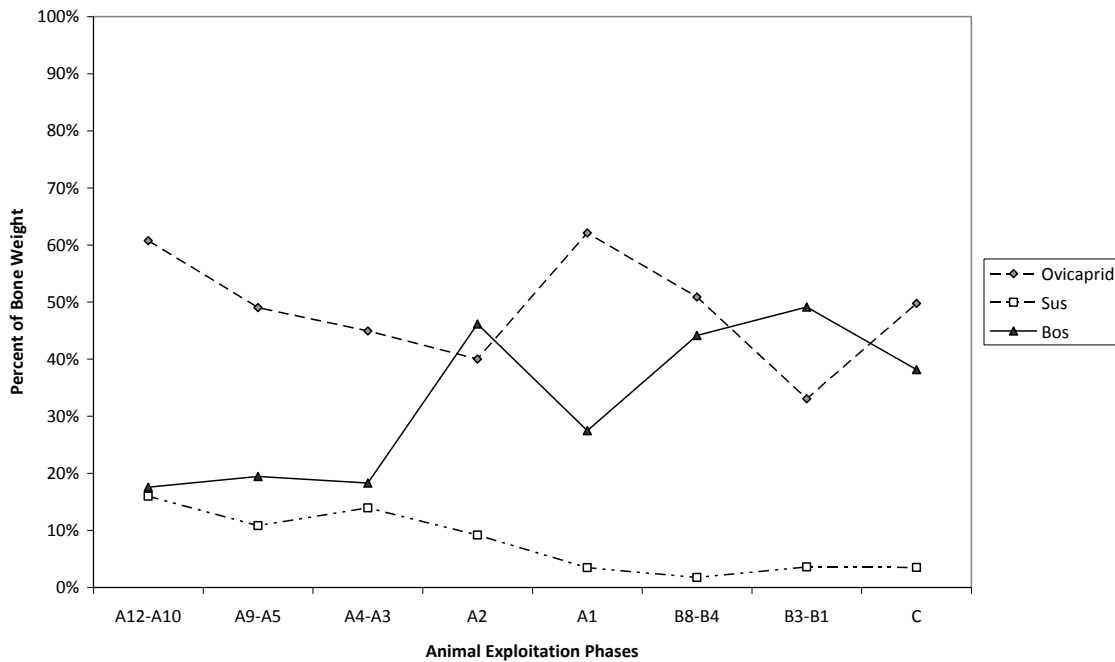


Fig 8.8: Proportions of ovicaprid, pig and cattle by animal exploitation phase (based on bone weight)

The herders at Tell Sabi Abyad would have been aware of the risks involved in pastoralism and would have had clear opinions about the way herds should be managed, bearing in mind the rate of growth of the animals and what culling practices could be implemented without harming the future productivity of the herd. It is clear from the mortality profiles of sheep, goats and cattle that herd security was of primary importance. In a marginal area, where droughts were probably common, it was imperative that the

herding strategies did not put the herd as a whole at risk. The culling practices would have had to have been carefully managed so that herd numbers were not reduced too much. One of the major ways to evade the negative consequences of disasters such as droughts and disease is to try to keep the size of the herd as large as possible, given a particular environment and a particular number of persons to look after the herd (Dahl and Hjort, 1976: 129). The main way to conserve stock numbers is, of course, to avoid killing your animals, particularly the female animals. Pastoralists practice a type of conservation when they manage herds, selecting the number of males to be kept specifically for breeding while killing off the rest before they reach sexual maturity (Gilbert, 1975). This ensures that herds are kept large enough to reduce the risks of unexpected herd deaths, but also keeps the herds down to sizes which are manageable by the herders and that the available pasture can support (*Ibid*). Increased female survivorship of sheep and goats over that of males at Tell Sabi Abyad is apparent from the analysis of the size of the animals and the bone fusion data (see section 6.3).

When tackling the question of the form of pastoralism taking place at Tell Sabi Abyad in the Late Neolithic it is important to attempt to quantify the size of the herds maintained and the number of people needed to herd these animals. It is very difficult to estimate herd size in the past. We know nothing about the size of herds or the holdings of individual households (nor in fact do we know much about who or what a 'household' consisted of). It seems probable that individual households might have only owned quite modest numbers of animals and that the slaughter of these animals would not have been undertaken lightly. Herd security was certainly very important at Tell Sabi Abyad. Apart from the basic numbers required to secure the reproduction of each species, the size of herds is largely defined by human demands. Ethnographic studies have shown that traditional pastoral economies in the Sudan, Somalia and parts of Africa consider a herd of 50 to 60 sheep and goats to be a minimum for a household of four to six people, provided that other food sources are available (Dahl and Hjort, 1976: 220). The nomadic Bassen people of southern Iran also consider 60 animals to be the minimum required for subsistence (*Ibid*). If we assume the population of Tell Sabi Abyad consisted of only 30 to 50 people (based on estimates outlined in Akkermans, 1993: 166) then the minimum sheep and goat herd size would be 300 to 500 animals. Verhoeven (1999: 212) argues that that population in the late seventh and early sixth millennium (based on the Operation I Halaf settlement) was larger, at 60 to 120 people. A population this size would need a herd of 600 to 1200 sheep and goats to fulfil subsistence needs. Kaneda (in prep.) suggests a relatively small population in the Late Neolithic at Operation III with an estimate of 30 to 50 people living at the site in Sequence A (Kaneda *per comms*). The above estimate of the sheep and goat herd size is not based on the actual weight of the sheep and goat bones uncovered at the site but is based on ethnographic data. This is because it is extremely difficult, if not impossible, to directly link the weight of the sheep and goat bones to the actual weight of the animals and consequently the possible contemporary herd size. The percentage of bone weight to animal weight changes with different breeds, with age and sex, with the annual and the seasonal fluctuations in weight and so on (Vigne, 1991). There are no standards that can be reliably used and variations in the ratios between skeleton weight and animal weight are too great to substantiate such a method, not to mention the huge issues of site areas recorded, preservation and taphonomy. The number or weight of recovered bones can not reliably be converted into numbers of live animals that existed at any one time and therefore using ethnography to estimate herd size is as valid a method of as any.

As a general estimate, a 600 strong herd of sheep and goats will be assumed in the following speculations about herd management. This may seem very large but this number of animals could easily be lost in the vast landscape around the site (fig 8.9). Grazing availability puts a limit on the number of animals that can be kept near a settlement. Add to this the distinct possibility that much of the land around the site may have been cultivated, and you have to ask yourself the question of where exactly these herds of animals were kept? Akkermans (1993: 216) argues that the area of cultivated land may have been rather restricted in the vicinity of Tell Sabi Abyad, with perhaps a circle with a radius of about 650 m from the centre of Tell Sabi Abyad being farmed. This would mean that it may have been necessary to move the animals to around one kilometre outside of the village to be grazed, at least at certain times of the year. By spreading the animals out into different areas and ecological zones the overexploitation and

degradation of the areas around the settlement could be avoided and the animals would be kept away from the precious crops.



Fig 8.9: Modern herd of ovicaprids with Tell Sabi Abyad in the background

The 600 sheep and goats hypothesised to be kept in the seventh millennium at Tell Sabi Abyad, were probably herded in several smaller herds. The maximum size of a herd depends on a number of factors such as the availability of grazing, the density of settlement in the area, the speed at which the domestic stock move, the distance between water sources and the availability of labour (Dahl and Hjort, 1976: 254). Other factors such as the how often the animals need access to water, how often the animals need to be milked and whether the animals need protection from predators also needs to be considered.

With herds of possibly 600 animals in total, the concept of herd-ownership at the Late Neolithic village of Tell Sabi Abyad also needs to be considered. In the above calculations of herd size it is assumed that about 60 animals would be kept by each family or household unit. These small household herds could have been herded separately, but perhaps some of these herds were herded together as this would be far more labour efficient. These animals may have been kept by the community as a whole, with everyone working together regardless of direct family ties, although it is likely that the members of the small community at Tell Sabi Abyad in the Late Neolithic were all connected by some form of kinship link or other. The decisions about where and when to graze and water these herds may have then depended on mutual agreements made by the heads of the households. This may not have been the case however; one of the alternatives is that herding may have been a specialised activity performed by only a few families who had large herds of animals while other families specialised in plant cultivation. This seems to be the case in the post 6200 BC levels at Operation I (Cavallo, 2000) but whether everyone in the pre-6200 BC village at Tell Sabi Abyad was involved in both animal husbandry and agriculture, or whether there were specialists in one or the other of these subsistence forms, with exchange between the different subsistence systems, is difficult to say. In many traditional communities the concept of herd-ownership is often a relative one, with the individual members of a community or household having different rites and claims towards that household's stock (Akkermans, 1993: 240).

What about labour costs? For agriculture at least, preparing the fields for cultivation and bringing the harvest in would have involved large workforces, with probably the whole community being involved. What about stock rearing? Ethnographic studies have shown that herd sizes of 200-250 sheep and goats are the maximum that can be managed by a few individuals (Dahl and Hjort, 1976: 255). It has been

estimated that it would take three herders to maintain a flock of 100 sheep and goats (McCorriston *et al.*, 1997) with the labour input hardly increasing when herd size increases. This would imply that the 600 sheep and goats at Tell Sabi Abyad would need to be split into at least three herds of around 200 animals each. Flocks of this size have several advantages. Large herds allow the production of considerable amounts of meat and milk (see table 8.3) with fairly small labour costs and with often higher return rates than all but the most favourable of agricultural environments (Russell, 1988: 35). As outlined above, large herds also spread the risks of catastrophic events. The risks of inbreeding are also reduced; one ram to every five ewes is considered sufficient for optimum reproduction of herds ranging from 60 to 200 ovicaprids (Gilbert, 1975) with at least 25 rams required in order to avoid inbreeding (Akkermans, 1993: 240). A similar sex-ratio is seen for the ovicaprids at Tell Sabi Abyad (see section 6.3.8).

Table 8.3: Total yearly yield of calories and protein from a flock of 100 small stock

Goats	Meat including edible offal (21 animals)		Milk total 2450 kg (35 animals)		Milk and Meat taken together	
Individual live-weight (kg)	Total yield of kcal	Total yield of protein (kg)	Total yield of kcal	Total yield of protein (kg)kcal	kcal	protein (kg)
40	606,160	65.1	1,847,300	90.7	2,455,460	155.8
27	410,508	44.1			2,257,808	134.8
10	152,040	16.2				
Sheep	Meat including edible offal (25 animals)		Milk total 2450 kg (39 animals)		Milk and Meat taken together	
Individual live-weight (kg)	Total yield of kcal	Total yield of protein (kg)	Total yield of kcal	Total yield of protein (kg)kcal	kcal	protein (kg)
20	2,017,500	50.0	2,340,000	130.7	4,357,500	180.7
15	1,513,125	37.5			3,853,125	168.2
10	1,008,750	25.0				

Based on Dahl and Hjort, 1976: 219 Table 9.4

The different forms of pastoralism are discussed in chapter 3. The four broad types of pastoralism discussed were: village-based herding (proximate and distant), transhumant, semi-nomadic and nomadic. It seems unlikely that large scale transhumance was taking place in the Late Neolithic at Tell Sabi Abyad. Isotope data suggests perhaps only a local form of pastoralism with no evidence of large scale nomadic movements (see chapter 7). This does not mean that the animals were left to graze around the settlement however, nor does it rule out the periodic use of local seasonal pastures. Animal production and subsistence levels are primarily set by the nutritional plane of the available grazing. Moving animals around the landscape to find good grazing is the best way to ensure that the animals' nutritional needs are met all year round. This is not always easy as the low but highly variable precipitation rates in the Near East make forecasting of seasonal grazing conditions difficult and unreliable (French, 1970: 50). It is likely that the sheep and goats were herded some distance away from the settlement at Tell Sabi Abyad at least for some periods of the year, in order to find good grazing and to avoid the animals damaging the fields of crops and gardens. Traditional pastoralists are aware of the fragility of the steppe environment and they move their herds in spring and autumn to allow the areas to recover between grazing (Sanlaville, 2000: 13). With the onset of the winter rains animals may have been moved away from exhausted summer pastures and driven out to graze on the new grasses out in the steppe, with herds being returned to graze near the settlement and the Balikh River in the spring to wait out the dry season. The herds may also have been herded back towards the agricultural fields after the harvest to feed on the crop stubble left in the fields. The most critical period is the very end of the dry season when grazing is very scarce, especially after crop residues have been exhausted (Legge, 1989).

Modern herders in the area graze their animals away from the settlement but close enough that at least part of the flock can be brought back to the settlement for milking everyday (Akkermans, 1993: 241). The normal grazing range of ovicaprids is around 10 kilometres a day, but when not grazing, herds can be moved up to 40 kilometres to new sources of water and pasture (Betts and Russell, 2000: 31). The faunal evidence from Tell Sabi Abyad suggests a form of village-based pastoralism was taking place. This does not preclude mobility and some elements of the group may have been very mobile, perhaps being

involved in the trading of goods (Milner, 2005: 33). This is very likely to be the case for the Neolithic community at Tell Sabi Abyad (Akkermans and Duistermaat, 1997; Verhoeven, 1999).

Ethnographic evidence from recent pastoralists indicates that killing for meat is rare and that, instead, milk products were developed for food (Ryder, 1981: 182). The sheep and goats at Tell Sabi Abyad were managed for both milk and meat with milk becoming more important from c. 6225 BC. This increased focus on secondary products may have gone hand in hand with the development of a form of pastoralism. It does not seem likely that a highly specialised form of long distance mobile pastoralism was taking place in the Late Neolithic at Tell Sabi Abyad but a small-scale form of mobility, moving the herds around the local landscape, would probably have been necessary to maintain both the herds and the cultivated fields. In a non-degraded state, the steppe vegetation around the site may have fed about one sheep or goat per hectare (Akkermans, 1993: 249) so depending on the size of the herds of domestic animals, a fairly large area around the site would have to be utilised as graze. If the estimate of a herd size of 600 heads of sheep and goats throughout the Late Neolithic is correct, then an area of around 600 hectares (6 km²) would be required over the year to provide enough graze for these animals¹². Within the vast desert steppe available these needs could be met quite easily as the nearest contemporary sites are a few kilometres away and the areas north and east of the settlement were apparently uninhabited at this time (Akkermans, 1993: 249). There were presumably some territorial claims upon the land surrounding the community at such a long lived site as Tell Sabi Abyad. There are differences in the grazing requirements of sheep and goats with sheep being selective grazers that need areas where grass regenerates at regular intervals, whereas goats can survive on browse such as thorny bushes. Despite their differences, sheep and goats are often kept in mixed herds due to the many practical advantages of this herding strategy. Sheep have a tendency to stray and are less intelligent than goats; having goats in the herd keeps the sheep in check by acting as flock leaders (Dahl and Hjort, 1975: 250; Russell, 1988: 76; French, 1970: 51). A mixed herd will graze more efficiently and combining them means that a smaller labour input is needed when compared to herds of one or the other animal (Dahl and Hjort, 1976: 269). It is highly likely that the sheep and goats at Tell Sabi Abyad were herded together in this way; the mortality profiles certainly suggest that they were managed in the same way.

So far the herding of the domestic cattle has not been considered. The remains of far fewer of these animals were present at the site and it is likely that the herds of cattle were quite small. It has been stated that a family can live comfortably on a herd of 20 cattle and can subsist on less (Dahl and Hjort, 1976: 176 and references within). This would equate to a herd of 200 cattle at Tell Sabi Abyad (based on 10 families). Watering a large herd would be difficult and time consuming however and it seems unlikely that such a large herd could be managed by the inhabitants of Tell Sabi Abyad, particularly in the initial stages of domestication. Cattle require considerably more and also higher quality pasture and water, and would therefore be more difficult to cater for and manage in the desert steppe. A large herd might also soon exhaust the grazing in such a marginal area and would require constant access to new pastures. This figure also does not take into account the presence of large herds of sheep and goats which would already be fulfilling many of the subsistence needs. With these animals forming the basis of the animal based subsistence economy far fewer cattle may have been required.

In the oldest levels A12-A10 (c. 6865 - 6675 BC), cattle domestication was in its infancy and it is likely in these levels that very few domestic cattle were present. These animals may have been fairly loosely controlled in small herds. The continued presence of animals large enough to be aurochs during the initial stages of domestication, suggests that the domestic herds were not isolated from the local populations of aurochs and that there was inter-breeding between these two groups. When keeping small herds this would have been a good way to reduce inbreeding in the domestic population. It is clear that the cattle herds slowly increased in size through time (based on increasing NISP and bone weight proportions). Cattle herds grow very slowly, with annual growth rates of 3 to 4% percent (Dahl and Hjort, 1979: 20) compared to 26% for sheep and up to 41% for goats under favourable conditions (Dahl and Hjort, 1976:

¹² This may have included cultivated fields used for grazing after the harvest

98, 103). With this growth rate, it would have taken many decades to build up herd size (a typical herd of cattle could double in about 24 years i.e. a human generation (Dahl and Hjort, 1976: 259)). This could be supplemented by the continued procurement of young calves from the wild, as least in the initial stages of cattle domestication.

If we assume a constant number of 600 sheep and goats through the levels (ignoring seasonal fluctuations) then it is perhaps possible to estimate the number of cattle present based on ratios of bone weights. (table 8.4). This can only be done if several fairly substantial assumptions are made:

1. That bone weight directly reflects live body weight
2. That the bones analysed in each level directly reflect the living populations in these levels and therefore the proportions of these animals in these levels.

For this calculation the weight of one ovicaprid will be taken as 40 kilograms and the weight of one cow will be taken as 200 kilograms. For example, in levels A12-A10 if there are 600 sheep and goats in the herd and each animal weighs 40kg then the total weight of the herd would be 24,000kg. If sheep and goats make up 77.6% of the live sheep/goat and cattle combined herd weight (based on bone weights and the assumptions above) then the total weight of the herds would be 30,928kg and the cattle herd would weight 22.4% of this i.e. 6928kg. If we assume each head of cattle weighs 200kg then this equates to roughly 35 cattle in the herd.

Table 8.4: Estimations of cattle herd size based on bone weights

A12-A10	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	77.6	24000	600
cattle = 200kg	22.4	6928	35
Total	100.0	30928	
A9-A5	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	71.5	24000	600
cattle = 200kg	28.5	9551	48
Total	100.0	33551	
A4-A3	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	71.0	24000	600
cattle = 200kg	29.0	9782	49
Total	100.0	33782	
A2	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	46.4	24000	600
cattle = 200kg	53.6	27720	139
Total	100.0	51720	
A1	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	69.3	24000	600
cattle = 200kg	30.7	10628	53
Total	100.0	34628	
B8-B4	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	53.5	24000	600
cattle = 200kg	46.5	20841	104
Total	100.0	44841	
B3-B1	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	40.3	24000	600
cattle = 200kg	59.7	35601	178
Total	100.0	59601	
C	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	56.5	24000	600
cattle = 200kg	43.5	18447	92
Total	100.0	42447	

Using these calculations it is clear that cattle herd size was very small in the oldest levels with perhaps only 35 animals present. This rises slightly in levels A9-A3 to around 48 animals. There is there then a considerable increase in herd size in level A2 with an estimate of 139 cattle. There is a sudden drop in cattle numbers in level A1 (c. 6335 - 6225 BC). Why the cattle herd is apparently more than halved in this level is unclear. The cattle numbers then recover in the B levels. Could this apparent decimation of the

domestic cattle herd be the result of some catastrophe – disease or climate change? This will be discussed further in section 8.7. Of course these estimates must be used with extreme caution but they do suggest that cattle herd size was very small in the oldest levels and during the initial stages of domestication. The very small cattle herd size inferred for some of the levels would suggest that there would have to be an exchange of breeding cattle with other communities or cross breeding with wild populations to prevent inbreeding. In the initial stages of domestication the breeding stock may well have been replenished with aurochs, as is perhaps indicated by the continued presence of large individuals in these levels (see section 6.5.7). If fresh breeding stock was sourced from wild populations, these animals would need to be taken when very young so they could be controlled by the herders. Herd size in general increased through time with the exception of level A1 when numbers are dramatically reduced. As level A1 is contemporary with the 8.2k climate event it is tempting to draw the conclusion that drought at this time may have negatively affected the cattle herds. This would however be highly speculative at this stage.

How were the cattle herded? Ethnographically, larger stock are often taken considerable distances from the settlements during the day (Dahl and Hjort, 1976: 237). If this was the case for the cattle at Tell Sabi Abyad then they could have been herded together with the sheep and goats. Cattle are grass eaters and they need frequent watering (every 2-3 days) and move slowly, preferably within an area of 10-12 kilometres from the settlement and within walking distance of water (Dahl and Hjort, 1976: 269). As such the range of grazing is more restricted for cattle than it is for mixed herds of sheep and goats. In hot weather, cattle herds are generally limited to foraging within one day's walk of water sources while sheep and goats can be taken a three days walk away from water (Russell, 1988: 59). This means that it may have been more effective to herd the cattle and ovicaprids separately, with cattle herded close to the village, and close to the tributaries of the Balikh, while the ovicaprids were taken further out into the steppe. The amount of labour required would however be greater as more people would be required to tend these separate herds.

Cattle are more demanding than ovicaprids in terms of their water needs and are less well adapted to the often harsh conditions of the steppe environment. Sheep and goats also reproduce and mature much more quickly than cattle which grow and mature much more slowly. The rapid rate of reproduction of sheep and goats allows a larger annual cull with less impact on the average productivity of the herd. Keeping herds of cattle and mixed herds of sheep and goats would be complimentary. Diversity in the composition of the herds allowed the Late Neolithic inhabitants of Tell Sabi Abyad to exploit the full potential of their environment, with some animals browsing and others grazing. The keeping of a range of livestock species is a good way to reduce the risk of total loss. It also promotes a more complete use of environmental resources and a more even access to food (Dahl and Hjort, 1979: 18). Sheep and goats were the steadfast domestic species at Tell Sabi Abyad. These animals convert quite poor pasture into consumable meat and milk with a greater efficiency than cattle do under the same conditions.

Finally domestic pig husbandry must be considered. For most of the A sequence, levels A12 to A3 (c. 6865 – 6375 BC), domestic pigs are the second most common species in the assemblage. These animals have very different requirements to the pastoral sheep, goats and cattle. Pigs are omnivorous and can eat pretty much anything. Rather than needing pasture, they can scavenge on food refuse and other organic matter but they also need watering often. Pigs are notoriously difficult to herd or drive making it very difficult to move them, and it has been said that the keeping of pigs denotes a sedentary way of life (Zeuner, 1963: 260). These animals are not well adapted to arid areas: the range of temperatures they can endure is quite narrow and they need vegetation cover (Brentjes, 1973; Harrison, 1968: 375; Haber and Dayan, 2004). Akkermans (1993: 242) suggests that pigs in the Halaf period were kept around the settlement, most probably in the shelter of the riverine thickets of the Balikh and the Nahr Turkman, which may have originally passed right by the settlement. This also seems the most plausible means of keeping domestic pigs in the levels analysed here. The pigs could be left to roam and forage freely in these thickets with only limited human management necessary to keep the animals from straying into cultivated fields. The number of pigs kept in each animal exploitation phase was estimated in the same way as was performed for cattle (table 8.5). Using these calculations it is clear that only small numbers of

pigs were kept, with the largest herd of pigs present from levels A12-A2 at between 80 and 100 pigs. Pig numbers then rapidly decline to perhaps only 19 pigs in level A1 and 11 pigs in levels B8-B4. How many pigs were kept is difficult to determine but it appears that only small numbers of these animals were kept and that these numbers decreased dramatically sometime around c. 6225 BC, perhaps representing the abandonment or collapse of pig husbandry. The large size and maturity of some of the pig remains in levels A3 and A2 (see section 6.4) may suggest a reversion to hunting wild boar in these levels. Pig numbers begin to increase again in levels B3-B1 and the C levels, but numbers remain relatively low.

Table 8.5: Estimation of pig numbers based on bone weights

A12-A10	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	79.2	24000	600
pig = 70kg	20.8	6316	90
Total	100.0	30316	
A9-A5	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	81.9	24000	600
pig = 70kg	18.1	5290	76
Total	100.0	29290	
A4-A3	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	76.4	24000	600
pig = 70kg	23.6	7430	106
Total	100.0	31430	
A2	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	81.3	24000	600
pig = 70kg	18.7	5520	79
Total	100.0	29520	
A1	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	94.7	24000	600
pig = 70kg	5.3	1353	19
Total	100.0	25353	
B8-B4	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	96.8	24000	600
pig = 70kg	3.2	802	11
Total	100.0	24802	
B3-B1	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	90.2	24000	600
pig = 70kg	9.8	2610	37
Total	100.0	26610	
C	Percent of bone weight	Weight of herd (kg)	Estimate of herd size
s/g = 40kg	93.4	24000	600
pig = 70kg	6.6	1690	24
Total	100.0	25690	

How time consuming would herding all these animals be? Pig husbandry is assumed to have involved little labour as only small numbers of these animals were kept and it is supposed that the pigs were left to forage near the settlement. The herding of the pastoral animals may have involved a little more labour. Herding tasks under conditions of extensive herding primarily consist of the time spent in driving animals to and from available natural pasture, and the time spent in guarding grazing herds, watering animals and searching for strays (Russell, 1988: 16). Once a pastoral herd has been driven to pasture and begins to feed, the subsequent guarding of that herd does not require continuous herding labour (Russell, 1988: 83). Although herding is a continuous task, much of the time can be spent in other activities including socialising, foraging for food items and hand tasks such as wool spinning (McCorriston *et al.*, 1997; Russell, 1988: 84). As outlined above, it has been estimated that it would take three herders to maintain a flock of 100 sheep and goats with the labour input hardly increasing when herd size increases (McCorriston *et al.*, 1997). Although this may be true for most of the year, there are certain seasons when more labour may have been needed. Traditionally herds are subdivided by age and sex at certain times of the year. Effective pastoral herd management during, and just subsequent to, the delivery and mating seasons of species requires the herds to be divided in order to regulate the breeding of females, minimise conflicts resulting from competing males, to regulate the distances that the relatively weak young must

travel, and to adjust grazing to maximise milk and meat production according to the changing physiological, morphological and behavioural attributes of the different age and sex classes in the herd (Russell, 1988: 77; Betts and Russell, 2000: 26; Dahl and Hjort, 1976: 135). If herds of cattle and ovicaprids were herded separately this would of course further increase the amount of labour required. It has however been noted that small groups of cattle require little herding; if females are separated from their calves during the day the cattle will always return of their own accord to the place where their young are kept (Dahl and Hjort, 1976: 247).

Another issue to consider is the question of where animals could have been kept for the times of the year this may have been necessary. During lambing season the pregnant females and newborns may well have required penning, supervision and additional protection from predators. Goats do not cope well in cold, wet weather and in winter months goats are usually penned at night in modern day pastoral systems (Betts and Russell, 2000: 30; French, 1970: 80). There is no evidence from the excavations at Tell Sabi Abyad for any forms of animal enclosures. This may simply be because enclosures are not recognised as such during excavation. It could also suggest that if such enclosures exist then they are outside of the areas excavated, perhaps on the periphery of the settlement or at the foot of the tell. Another alternative is that temporary structures were used that left no archaeological trace. A prominent feature of the material culture of contemporary pastoralists in the Near East is their use of square or rectangular “black tents” made of woven hair (Russell, 1988: 17). Herd animals are often corralled within tent complexes and it is certainly possible that similar stock enclosures were also employed by the earliest pastoral populations of the Near East (*Ibid*).

8.4 Environmental exploitation and the relationship between the fauna and its natural environment

8.4.1 Introduction

In this section the relationship between fauna, particularly wild fauna, and the natural environment at Tell Sabi Abyad will be discussed. The presence of certain wild fauna can imply the presence of certain environments and habitats in the local vicinity and this information can be used to partially reconstruction the local environment. The hunting of wild fauna will be discussed in detail and their role in the subsistence economy considered. Finally the relationship between the animal resources exploited, both wild and domestic, through the seasons will be examined.

8.4.2 The role of wild animals in the subsistence economy at Tell Sabi Abyad

At Tell Sabi Abyad, wild animals only supplement the food sources derived from domestic plants and animals. In comparison to domestic animals, the exploitation of wild fauna is not an important part of the economy. Hunting played a minor role in the animal based subsistence economy in all levels but there were clear temporal differences in the proportions of wild fauna in the assemblage. Only 10.3% of the identified bones were from wild species. Wild species were present in the highest proportions (14.5%) in levels A4-A3 which also had the widest variety of wild species present (29 species). Levels A9-A5 came a close second with 27 species present, making up 12.4% of the assemblage. In all other levels only around ten species were present and the proportion of wild faunal was generally low. The lowest proportions were encountered in levels A12-A10 (3.3%) and A2 (4.5%). Although hunting was limited in all levels, a wide range of animals were exploited in levels A9-A3, including a plethora of birds and small game. In later levels onager and the gazelle, the large game of the steppe, predominate.

In the oldest levels analysed (A12-A10) hunting was obviously not an important part of the subsistence economy. In levels A9-A3 hunting appears to have been a more regular activity, and far more species were exploited. Gazelle were an important food source in these levels with meat from these animals matching that produced by the domestic pigs or cattle (based on bone weights). Between levels A3 and A2 the role of hunting in the subsistence economy is significantly reduced, small game in particular are no longer exploited and apparently only occasional hunting of gazelle and onager persisted. Wild fauna remain at a very low proportion of the total fauna throughout level A1 and levels B8-B4, before increasing

again in levels B3-B1. How can we explain these fluctuations in both the range of animals exploited and the number of animals hunted? Wild fauna were also practically absent from Tell Sabi Abyad II (c. 7200 – 6700 BC) (Van Wijngaarden-Bakker and Maliapaard, 2000), which together with the evidence from Operation III suggests that hunting was not important to the villages in this part of the Balikh valley at the end of the eighth millennium BC. If hunting did not play a large role in the subsistence base of the farmers at the end of the eighth millennium BC, why was there a sudden increase in hunting at the beginning of the seventh millennium BC? Diversification in food sources and the use of wild resources is often used by small-scale agriculturalists to stabilise agricultural productivity (O'Shea, 1989), and in times of resource stress lower ranked game¹³, such as small game, may be increasingly exploited (Munro, 2004). Could the higher proportions of hunting seen in levels A9-A3 therefore be an indication that the agro-pastoral economy was under stress? Could the broad climate event causing a deterioration in climate starting 8600 years ago (Rohling and Pälike, 2005) be a factor? Whether these two things are linked is difficult to determine; the increase in hunting seems to start c. 6675, just before the onset of the event and there is very little hunting at the peak of the event around 6225 BC. The proportions of wild faunal started to decrease some time after 6375 BC, well before this peak in climate deterioration. The climate change does not appear to be the main factor and there must have been other, cultural, reasons for the changing proportions of hunting, although deterioration in climate could have perpetuated certain trends. For example, drought conditions may have eventually led to the dispersal of wild animals out of the area resulting in a decrease in the proportions of wild fauna in the assemblage. Alternatively, given the sedentary character of the agricultural system, wild resources may have become depleted over time regardless of climate change. There is however a slight resurgence in hunting after c. 6000 BC (levels B3-B1 and C).

It is clear that the percentage of wild fauna is in general very low in the Late Neolithic levels at Tell Sabi Abyad, but this may underestimate the importance of wild animals. The importance of small game such as hares and birds to the subsistence economy may be underestimated by abundance data due to poor recovery of these small bones in the hand collected sample (Makarewicz, 2009). These percentages may also fail to appreciate the time spent out in the landscape, either engaged in other activities, or in planned hunting expeditions (Whittle, 2003: 90). Although tending domestic animals may have been a more constant commitment, hunting could have been more expensive in terms of concentrated effort, particularly in the levels where the proportion of hunted animals in the assemblage was relatively high (levels A9-A3 for example).

Food derived from hunting is a supplement and a complement to that derived from animal husbandry strategies (Seguí, 2000). Hunting provides an immediate return as apposed to the delayed return of animal husbandry and herders wishing to maintain high productivity often supplement their diet by hunting, with only the limited slaughter of their own domestic stock (Betts and Russell, 2000: 29). This was likely the case at Tell Sabi Abyad, with the exploitation of wild plant and animal resources supplementing the mixed agro-pastoral economy. Most of the hunted animals were probably eaten, although some of them may have arrived at the site already processed, bear foot bones were for example probably brought to the site attached to prepared skins (see section 6.8.4).

8.4.3 *The hunting of wild animals at Tell Sabi Abyad*

A variety of wild animals were identified from the faunal remains including 14 species of wild mammal, 16 species of bird, 1 reptile species, amphibians and molluscs. The majority of the mammals recovered would happily survive in a steppe environment (onager, gazelle, hare, and gerbil) with some species preferring riverine forest environments (deer). The bird species identified can be found in three broad habitat types: open steppe, woodland, and water (see table 8.7).

¹³ Those game that produce the lowest return for the energy invested in pursuit and processing.

Wild animals were obviously exploited from all environments available locally including the open steppe, the predominant environment around the site, the riverine forest along the banks of the Balikh and the Balikh itself. Although wild animals were only exploited at low levels, it is clear that the Late Neolithic inhabitants would not pass up the opportunity to hunt animals where they were locally available because wild fauna were present in all levels. The spectrum of wild animals available locally or seasonally probably offered the subsistence system some risk reduction and flexibility (Kansa *et al*, 2009b). Hunting could contribute meat and fat to the villagers' diets, particularly in certain seasons of the year when other food sources are scarce (see section 8.4.6).

There are two broad types of animals that were hunted: large game and small game. How were these animals hunted? The hunting strategies applied to these two groups would be very different. Large game such as onager would probably involve hunting in groups with spears or bows and arrows. There is no direct evidence of hunting from the faunal remains identified here but, in an earlier report on the faunal remains from Tell Sabi Abyad Operation I (c. 6100 – 5700 BC), an aurochs scapula was recovered with an arrowhead still embedded in the bone (Cavallo, 2000: 120), this evidence, together with painted ceramics from the sixth millennium BC from Tell Sabi Abyad depicting people with bows and arrows (Niewenhuyse, 2007: 20), suggests that large game were hunted using flint tipped projectiles. Very few flint or obsidian arrowheads or projectile points have however been recovered from Tell Sabi Abyad, with the exception of a cache of 56 tiny double-edged transverse arrow heads recovered from Operation I (Copeland, 1996). How do we reconcile this evidence with a rarity of projectiles present in the lithics assemblage (see chapter 2 and Astruc and Russell in press; Copeland, 1996)? Of course we can only speculate about hunting methods but it is possible that animals that existed in large herds such as gazelles and onagers could be chased into corals. At some point, perhaps as early as the middle of the Neolithic period, man started to develop and construct artificial corralling systems for the tactic of herding, cornering and killing prey (Rosen and Perevolotsky, 1998). One example of a form of coral are the so-called desert kites that have been identified in the deserts of Jordan, Syria, Israel, and Sinai. These types of traps could be placed along known animal migration routes and used to kill large numbers of animals. Projectiles would however still be necessary to kill the animals. Points may also have been made out of perishable materials, wooden spears for example. The rarity of flint projectile points and presence of large numbers of clay sling missiles could suggest that these could have been one of the main hunting tools, especially for hunting small game. Larger game would however be very difficult to hunt in this way. Small game such as hares and birds could be hunted individually using traps, nets, snares, or a slingshot. Trapping systems for directing, restraining, capturing and killing of birds and small game are ubiquitous among hunters (Rosen and Perevolotsky, 1998). This form of hunting could easily have been carried out by women and children. Of course each species would have required a method of hunting tailored to the characteristics and habits of the animal. It is likely that a plethora of different hunting practices took place depending on several factors: the animal being hunted, the preparation involved (i.e. a planned hunt or opportunistic hunting with whatever tools were at hand), the season etc. The low number of stone hunting implements at the site may suggest that hunting of larger game was a specialised activity carried out by only a few members of the community and therefore the distribution of points may be limited to a certain areas of the site (Akkermans, 1987), such as the cache found in Operation I (Copeland, 1996) but as yet unexcavated at Operation III.

The abundance of different skeletal parts is often assumed to represent selective transport and discard by hunters, built on fundamental decisions about what explains human transport decisions and how those decisions are reflected in meaningful and measurable ways in the archaeological record (Lupo, 2006). Whole carcasses of onager were apparently brought back to the site when the hunting of these animals was at its peak (levels A9-A3 c. 6675 – 6375 BC). When the hunting of these animals diminishes (in the B and C sequence) it appears as if only the high utility bones were brought back to the site from the kill site. This may suggest that these animals were hunted at a greater distance from the site than in the previous A levels and that it was no longer feasible to bring the entire carcass back to the site. Instead, primary butchery took place at the kill site and only the high utility parts of the carcass were selected for transport. The same appears to be true of the gazelle remains, with whole carcasses only present and

completely processed at the site in the A levels. This suggests that meat was not scarce in the B sequence as under conditions of food scarcity maximising the utilisation of available food would be expected to take president, regardless of the labour costs involved in the transport of the carcass (Binford, 1978:44). It is likely that with the increasing dominance and reliance on domestic species, wild resources were no longer a necessary staple, but instead, an added bonus.

8.4.4 *The natural environment and the habitats exploited*

Regular encounters with wild animals, as well as tending to domestic herds, must have taken people into every part of their environment (Whittle, 2003: 89). The analysis of the faunal remains recovered from the excavation of the Late Neolithic levels at Tell Sabi Abyad can inform us about the local environment: which environmental habitats were available locally, which habitats and environments were exploited, and to what extent?

Both botanical and faunal analyses have suggested that several environments were locally available: desert steppe, riverine forest, and a freshwater river. To what extent these three main habitats made up the landscape around the site is difficult to say definitively. Based on more recent times, it is apparent that desert steppe is predominant but based on reports from the 20th century it is clear that the riverine landscape would have been much more predominant than we see today, with extensive areas of marsh in the lower reaches of the Balikh (Wilkinson, 1998; Mallowan, 1946) and riverine forests of poplar and ash (Van Zeist and Waterbolk-van Rooijen, 1996).

Table 8.6: Habitats of hunted species

Desert Steppe	Riverine forest	River/Marsh
Crane	Fallow Deer	Amphibian
Falconid	Redwing	Duck
Fox	Roe Deer	Gull
Gazelle	Song Thrush	Melanopsis costata
Gerbil	Thrush	Melanopsis praemorsa
Great Bustard	Wood pigeon	Oyster Catcher
Hare	Woodcock	Rail
Mustelid		Ruff
Onager		Teal
Partridge		Tortoise
Rock Dove		Unio tigridis
		White-fronted Goose
		Xeropicta
Number of Species		
11	7	13
Percentage of Wild Assemblage		
74.5%	1.3%	24.2%

The animals from Tell Sabi Abyad represent a variety of ecological niches suggesting that there was a diverse range of environments close to the site. An analysis of the wild species exploited by the inhabitants of Tell Sabi Abyad shows that they exploited animals from all the environments available locally (table 8.6). Thirteen of the hunted species could be found in the river or marsh environments, eleven from the desert steppe and seven from the riverine forest (although this increases to nine if wild boar and aurochs are included, the presence of which cannot be ruled out). When looking at the percentage of the wild fauna exploited from each habitat however it is clear that the vast majority of the wild fauna were desert steppe dwelling animals (74.5%). The large and medium sized game of the desert steppe (an ecotope located on the higher terraces and beyond), the onager and the goitered gazelle, were the main focus of the hunting activities.

8.4.5 *Environmental exploitation*

It has been hypothesised that anthropogenic environmental degradation began as early as the Neolithic (for example at Ain Ghazal: Rollefson *et al.*, 1992). Whether this was the case at Tell Sabi Abyad is difficult to determine. It is clear that there was a decrease in the importance of wild animals through time. Whether this decrease is due to a choice not to hunt and to concentrate on the domestic fauna, or due to a reduction in the presence of wild fauna available to hunt due to a human influence on the environment

and overgrazing by large herds of domestic animals, or environmental degradation caused by climate change, is a question that cannot be answered by the faunal data alone. Akkermans (1993: 249) suggests that the direct impact of the inhabitants of Tell Sabi Abyad on the surrounding environment was limited, with the vast regions north and east of the site probably left more or less in their natural state. The faunal data analysed here does not provide any evidence to support or dismiss this. The reduction in the proportion of wild species, and the variety of species, exploited could be the result of anthropogenic environmental degradation in the area or it may merely be a matter of human preference and a choice to concentrate on domestic animals. The botanical data could add more information to this debate but it is unfortunately not available at this time.

8.4.6 Seasonality

By analysing the faunal remains and considering the resources available to a community, models of yearly resource cycles may be constructed (Milner, 2005: 33). There would have been a strong seasonality in the fresh food available locally. There are two main ways to assess seasonality: identifying the presence of seasonally available species, and examining physiological events that occur at certain periodic intervals (*Ibid*). Was there any seasonality seen in the hunting activities? Foxes were probably trapped and butchered at or near the site while hares could be snared out in the steppe, but both of these animals would be available all year round. In terms of the other hunted fauna, a seasonal pattern in hunting is however apparent. The analysis of the faunal material and research into the modern distribution and behaviour of the wild animals in the sample suggests that hunting took place primarily in the autumn and winter. An analysis of the age of gazelles at death suggests that the hunting of these animals took place mainly around the month of September, probably during the herd's annual migration south. Migratory birds are also often used as seasonal indicators. The presence of many wintering birds in the avian fauna points to a concentration of hunting in the autumn and winter months. Hunting may have occurred in autumn because there was more freedom to hunt once the arduous and time agricultural activities were completed. This may also have been the time that large herds were moving around the steppe, with male and female herd groups of onager coming together for the mating season and herds of gazelle and onager perhaps passing quite close to the site in their annual migrations. Autumn would have been an important time in terms of stocking the winter stores and the opportunity to hunt wild animals for meat would have been too good to miss. Hunting in autumn and winter would not be constrained by agricultural activities and the meat and fats procured from these hunting trips could have significantly added to the winter stores. The bones could be processed for marrow and grease extraction, with the presence of fat residues inside ceramic residues suggesting these fats were stored (Evershed *et al.*, 2008). The immediate returns of meat and fat from hunted fauna would also allow the herders to reduce the number of domestic stock culled for meat, thereby increasing the productivity of the domestic herds. These hunting trips may perhaps have been carefully organised and appear to have targeted gazelle in particular (gazelle being the dominant wild fauna).

The exploitation of domestic animals also follows seasonal patterns. Although control and breeding of animals is a year round occupation with animals requiring daily attention, the production of animal products is also closely tied to seasons. The annual cycle of prehistoric herders, given the nature of the environment and the requirements of the herds, would have involved a seasonal cycle involving penetration into the steppe in the winter and spring and a retreat to fresh pasture near permanent water sources in the summer (Betts and Russell, 2000: 31). The slaughtering of animals for meat may have been tied to seasons (for example, the culling of unwanted males after the end of the lactation period) or to seasonal feasting events. The production of milk is tied to the seasonality of breeding, birthing and lactation period (Outram and Mulville, 2005). It is clear that the programming of the agricultural and animal husbandry practices had to consider the sequence of the productive and unproductive cycles, and in terms of domestic animals the availability of food for herds, and that these variables are all determined by seasonal rhythms. In this way, domestic resources are just as seasonal as wild ones. The patterns of seasonality are summarised in table 8.7.

Table 8.7: Seasonality summary

	Spring	Summer	Autumn	Winter
Agriculture	Harvest		Sowing	
Herding		Movement of ovicaprid and cattle herds to permanent water sources and feeding of herds on crop stubble		Possible spilling of herds/penning of animals. Movement of (parts of) the ovicaprid herds further out into steppe to find new pasture. Foddering of animals kept at the settlement.
Animal husbandry	Birthing season and beginning of milk production period for ovicaprids.	Milk production	Milk production Pre-winter slaughter of weaned male ovicaprids	End of milk production, beginning of mating season, culling of prime meat cattle
Hunting			Hunting season	Hunting season

As Kansa *et al.* (2009b) outline, all agro-pastoral activities would have taken place in seasonal cycles based on the long-term resource management goals, the availability of certain resources at different times of the year, and the time required to process and prepare certain products for storage. The balance of activities undertaken at various times of the year would have been fluid, and changeable with regard to shifting social relationships, environmental conditions and changes in herd structure (*Ibid*). The most productive season would be spring, with the bringing in of the harvest and the birthing season of domestic animals, as well as milk production, coinciding. In the hot, dry summer months the cycles of crop planting and grazing would have become intertwined, with fallow fields with crop stubble being used for grazing and being fertilised by animal dung in the process, thus enriching the soil for future crop production. As the autumn months began the next year's crop would be sown and storage of foods for the winter months probably became of prime importance. Milk products could be fermented and meat dried for storage, as well as grains and vegetables. Hunting also peaks in this season, coinciding with the annual migrations of animals. In the winter the herd animals would probably be moved further out into the steppe to find new pasture and several recently weaned and prime meat age domestic stock, as well as unproductive females, would be culled for fresh meat to reduce the number of animals that need to be maintained through these months.

It is clear that people in the Late Neolithic were tightly bound to their natural environment and the seasonal fluctuations within this environment. The resources available, particularly those derived from wild flora and fauna, were fundamentally a factor of the local environment and the time of year, and the people surviving in these conditions would have been very aware of what was available when. Their reliance on domestic crops and animal husbandry did not set them apart from their environment and they were still inextricably linked to nature. All decisions made about what crops to sow and harvest, and when and where to graze their domestic animals were dictated to them by the natural setting, the climate and the seasonal fluctuations in the availability of resources.

8.5 Food processing

8.5.1 Introduction

Food production and preparation activities can be identified through the contextual distribution of faunal remains. An analysis of food incorporates the residues of consumption and the by-products of processing and preparation (Gumerman, 1997). In this section the zooarchaeological data will be considered with food processing in mind. Can we see any evidence for the different stages of food preparation such as culling and butchery, and what can we extrapolate about methods of cooking and eating habits? Methods of conservation and storage will also be considered. Secondary products such as milk may also have been an important food source and may have gone through processing techniques in order for it to be stored; secondary products will be considered in section 8.6.

8.5.2 Food processing

The processing of meat involves several stages which will all be considered here: killing of the animal, butchering the carcass, cooking of the meat, eating and conservation of animal based products (meat, fat etc).

Culling and Butchery

With hunted animals it is safe to assume that the animals were killed away from the settlement out in the surrounding areas. Domestic animals may have been culled at the site itself or somewhere on the periphery.

Animal carcasses require a certain amount of processing before the meat and fat can be consumed. Butchery is an important first step in processing meat and fats both for immediate consumption and for storage (Atalay and Hastorf, 2006). Butchery is not a one off event but a series of stages beginning with the death of the animal and continuing at various junctures until the animal is totally consumed or discarded (Binford, 1978: 48). Animals are often butchered according to a set of rules that differ from culture to culture and in different environments (Gumerman, 1997).

Hunted animals, especially very large game, may have undergone primary butchery at the kill site. Primary butchery can be thought of as those activities timed with the killing activities (Binford, 1981:127). This normally consists of dismembering the carcass and can include removal of any elements that are of low utility such as the head and feet. The carcass will then be processed further. This is known as secondary butchery, which can be thought of as processing activities which are timed with respect to achieving the goals of placing meat into storage and/or distributing and preparing it for consumption (Binford, 1981: 127). This normally consists of deboning and trimming the cuts of meat.

The primary butchery of large and medium sized game could have taken place off-site at the kill site. This is apparently the case with the onager and gazelle hunted in the later, post 6200 BC levels (B sequence). In the A sequence whole carcasses were brought back to the site. A whole gazelle carcass could easily be carried by one or two men. Onager are larger and were perhaps partitioned in some way before being carried back to the site, but apparently no parts were disposed of at the kill site in the A levels. The butchering of small animals such as hares and birds could have taken place within buildings and secondary butchery of haunches of meat from larger game could also have taken place inside, although there is no direct evidence of this in the faunal remains. The primary butchery of all wild and domestic medium and large mammals presumably took place outside the core of the settlement or in open areas. In all probability both primary and secondary butchery of domestic animals took place on site, presumably in open areas or at the peripheral edges of the site.

When an animal is butchered there are sometimes traces of the cutting and chopping activities left on the bones. Cutting with a stone tool often leaves a series of short parallel strokes. This was certainly the case at Tell Sabi Abyad although there were very few butchery marks on the faunal remains (only 0.2% of bones showed any signs of butchery marks. See section 6.2.3). Not all bones that have been butchered will have butchery marks, as the purpose of butchery is to reduce a carcass to transportable or consumable portions and not to mark the bone (Loyet, 1999). In theory a butcher does not want to hit bone as this can quickly blunt a stone tool and the lack of butchery marks on bones at Tell Sabi Abyad may be a sign that the butchers were quite highly skilled and were adept at filleting the meat off the bone without hitting the bone itself.

There are broadly speaking, four stages to the butchering of a carcass, all of which can leave marks on the skeleton: skinning, dismemberment, filleting (for either consumption or storage, which usually involves still further dismemberment) and marrow extraction (Binford, 1981: 106). The orientation and location of butchery marks can suggest at which stage these marks were made. Although there were relatively very few butchery marks present on the Tell Sabi Abyad faunal material those marks that were detected were clearly derived from the activities of skinning and dismembering the carcasses. There are actually very few

places on a carcass where the manipulation of the skin would bring the butcher in direct contact with the bone, the head and the lower legs (Binford, 1981: 106-107). Several cut marks were discovered on the lower legs of sheep, goats, pigs and cattle, and around the horncores of sheep and goats at Tell Sabi Abyad, all indicative of skinning. The remaining butchery marks were located at and around joints, indicative of dismemberment. The majority of the bone material was fragmented in antiquity with bones being broken open for marrow extraction and smashed into small pieces for grease production.

After skinning and butchering was complete the meat was either cooked to be eaten immediately or processed so that it could be stored.

Cooking and eating

In terms of food preparation and cooking, analyses should examine the labour that goes into processing and cooking food, who does the cooking for whom, and the technology of cooking (Gumerman, 1997). As important as what was eaten is how it was eaten i.e. the type of cooking processes employed and the type of heat used (Atalay and Hastorf, 2006). Food preparation can be done privately within families but eating can be public and collective, and vice versa (Whittle, 2003: 30). Cooking methods are rarely discussed in faunal reports despite the fact that cooking methods and practices are crucial in forming and reproducing social networks (Goody, 1982). Cooking methods almost always become part of the expression of cultural or social identities. This is true today and was almost certainly the case in the Late Neolithic. Cooking technologies in the Late Neolithic include the 'hot rock' method of cooking, the use of hearths and ovens, and the use of containers such as basketry or ceramic vessels.

Cooking could have been performed through boiling by placing hot clay balls or stones in to containers such as baskets, skins or pottery vessels, or through grilling and roasting meat. Whether something is boiled or roasted, and the types of containers used in food preparation, can be expected to leave subtle traces on the bone material (Binford, 1981: 136). There was evidence of roasting on very few of the faunal remains recovered from Tell Sabi Abyad. Roasting is evident on bones which are partially burnt, the un-burnt sections of the bone being protected from the flame by the meat being roasted and the exposed bone being burnt. An example can be seen in figure 8.10. That there is so little evidence of roasting suggests that meat was either filleted off the bone before roasting or that meat was cooked on the bone mainly through boiling. The low occurrence of cutmarks could suggest that the meat was removed after the joint was cooked or boiled. Meat could also have been grilled once deboned. A new kind of ceramic cooking vessel, perhaps imported from Turkey, is seen from 6200 BC onwards at Tell Sabi Abyad (Nieuwenhuyse, 2007). The so-called Dark Faced Burnished Ware (DFBW) ceramics were often reshaped in order to be used as a cooking pot: the neck was carefully removed and the breaks carefully reshaped into a new rim. The resulting mouth shape was then used as a cooking pot with many of these vessels showing abundant traces of soot suggesting that pots were placed directly over a fire and used to boil foodstuffs (Nieuwenhuyse, 2007). There were many large and small, shallow fire places especially in the A levels, usually concentrated in open areas around the architecture (fig 8.11). These fire-pits were perhaps used communally. One of the central routines of life is the act of eating. The consumption of food involves not only what is eaten but also the gathering of people to eat, the serving of the participants and the clearing away of the meal (Gumerman, 1997; Goody, 1982).



Fig 8.10: Ovicaprid thoracic vertebrae showing signs of roasting.



Fig 8.11: Fire pits in an open area outside a building (G5)

Food is clearly not just a matter of satisfying the needs of the body (Whittle, 2003: 22). What and how different groups eat is a cultural fact that can only be explained by culture history and environmental factors (Steward, 1973: 8). The way in which resources are looked after and brought to the point of consumption is a social matter (Whittle, 2003: 30). Food can be consumed in many different ways, either very privately or very publicly, in the form of feasts for example. There was no direct evidence of feasting revealed through the analysis of the faunal remains of the Late Neolithic levels at Tell Sabi Abyad Operation III. This does not mean that it did not occur. The slaughter of an adult cow would provide around 200 kilograms of meat, fat and offal providing enough food to feed many mouths. A single cow carcass can produce 200 kilograms of meat, fat and offal, which equates to over 1,708,000 kcal (based on 854 kcal per 100 grams of beef including offal, fat and raw meat). This would be sufficient to feed 100 people for over 8 days based on a daily calorie requirement of 2000 kcal per person. Ethnographic studies have shown that cattle herders rarely slaughter their cattle to supply food for the family alone, instead they tend to be part of a ceremony or celebration with meat shared among a number of participants (Ryan, 2005). Cattle might have been kept in the Late Neolithic, among other reasons, as a means of

participation in public consumption. These animals may only have been slaughtered on special occasions when many people were present, i.e. a feast. This may have involved not only the inhabitants of the village at Tell Sabi Abyad but perhaps also people from nearby villages such as Tell Damishliyya. Sharing is vital for the maintenance of group unity and such meals were probably taken in a communal central space (Whittle, 2003: 33). Such communal activities could not have taken place in buildings at Tell Sabi Abyad as all rooms are far too small, with barely the capacity to seat a handful of people on the floor. Such communal activities may have taken place in the open 'yard' areas around buildings with their many fire pits. Sharing between groups can be a valuable form of exchange to maintain social ties and acting as a form of 'social storage'. The general trend for an increasing proportion of domestic cattle in the Operation III material goes hand in hand with the establishment of region-wide interaction networks of "feasting" pottery (from 6200 BC onwards) (Nieuwenhuyse, 2007: 226). The consumption of food, whether in feasts or everyday meals, is tied to the symbolic formation of identity and meals, and the individuals who shared them were linked in multiple relationships depending on age, gender, status or other variables (De France, 2009).

Conservation and storage

Storage refers to a practice whereby 'time utility' is gained from resources; storage extends the time frame in which consumption is possible beyond the time during which the resource is directly procurable (Binford, 1978:91). In order for many foods to be stored they must be processed in some way to conserve them and prevent spoilage. Food conservation and storage would have been an extremely important part of the subsistence strategy at Tell Sabi Abyad. During the cold winter months through to spring the inhabitants would have relied on stored grains, legumes, nuts, dried fruits and dried or smoked meat. There would be very little fresh food available in these months with the exception of fresh meat. We know that food had to be stored in some manner for consumption in the lean months but there is very little, if any, evidence of the nature and extent of these conservation methods. Meat was presumably filleted off the bones and either dried, smoked or salted to conserve it for storage. There is no direct evidence of salting taking place and it is unclear as to where the inhabitants of Tell Sabi Abyad would have sourced salt as there are no local salt sources. Although the waters of the Balikh are today brackish, this is due to extensive use of the waters for irrigation and it is likely that the water was much fresher in the past. In summer however, evaporation of water in natural depressions or man-made hollows could have left a salt crust which could have been collected and used. Smoking could have taken place by placing thin strips of meat on racks above a smoking fire. Drying was probably the easiest method of conserving meat. Thin strips of meat could have been dried in open areas during the very hot dry summer and early autumn when the meat could dry quickly and easily. Hunting of wild animals appears to have taken place predominantly in the autumn and some of the meat from these hunts was probably processed to be conserved and stored for use throughout the winter and early spring.

Fat would have been an important source of calories and could also be stored for winter. Fats can provide twice the amount of energy compared to equal quantities of either carbohydrate or protein (Outram and Mulville, 2005). In subsistence economies sources of fat are likely to be very highly valued; this is especially the case in marginal environments where the full exploitation of fat resources may make the difference between survival and starvation (*Ibid*). Fat and grease could be extracted from bones by breaking the bones into small pieces and boiling them to release the fats, which could then be stored in small ceramic vessels for use in the winter months. The high levels of fragmentation seen in the Tell Sabi Abyad faunal material could in part be due to this process. Large animal bones were particularly smashed up, indicative of grease processing. Animal fat residues have been detected on ceramic pot sherds from Tell Sabi Abyad using the residue analysis technique (Evershed *et al.*, 2008), further supporting the hypothesis that fats were processed and stored in pots.

8.5.3 Summary

Food is intrinsically social with social relations often being defined and maintained through food (Gumerman, 1997). The study of food is the study of nutrition, behaviour, human-landscape interaction and socialisation into a community (Atalay and Hastorf, 2006). Food should therefore not be analysed

solely for the purpose of describing diet and nutrition but should also be looked at as a social and perhaps ritual element of past societies, intimately involved in developing and maintaining everyday social relations (Gumerman, 1997 and references within). Food is not just about calories and nutrition but is also linked to social politics played out in daily meals and communities feasts (Atalay and Hastorf, 2006).

As Gumerman (1997) states:

“A comprehensive exploration of the various stages in the food system – from production to disposal – greatly expands our understanding of food and its relationship to complex societies”

8.6 Secondary products

What we consider secondary products and how we go about detecting them in the archaeological record is outlined in chapter 3. The faunal remains, in particular those of sheep and goats, will now be analysed with the models developed by Vigne and Helmer (2007)¹⁴ in mind. This new range of models takes a holistic approach to animal husbandry which I think is very appropriate for use in understanding Neolithic animal exploitation strategies based on the age and sex of animals. What does this then mean for the faunal analysis of Tell Sabi Abyad?

For most of the A sequence, levels A12-A2 c. 6865– 6330 BC, the mortality profiles of sheep (and goats) reflects “meat type B” production i.e. the culling of animals when they are fully grown but still relatively young with tender meat, c. 24 months old (see section 6.3.6). Milk production can not be ruled out in these levels however, as milk could have been taken on a small scale for domestic consumption, while the young livestock were reared until their first or second winter when they were culled for meat (Halstead, 1996). In levels A1-B4 (c. 6335 - 6015 BC) there is an increased emphasis on “milk type B” production, i.e. the production of milk with the lamb (or kid) still present so as to allow milk let-down and the culling of some females because of decreased milk yield or lamb production at two to four years of age. Fleece production can also be inferred from the presence of animals over four years of age. From levels B3 onwards (after 5995 BC) this move to secondary product production is even more clear with milk and fleece production perhaps taking priority over meat production in sheep and goats. The mortality profiles of cattle do not suggest that milk production was a specific aim in the husbandry of these animals, although neither can it be ruled out. In areas where pasture is sparse sheep and goats become the preferable animal for milk production as their nutritional needs can be met more easily than cattle (French, 1970: 38). Where nutritive levels are low, a small animal has a better chance of securing its maintenance needs than a larger one, and it is more likely to obtain enough surplus nutrients to permit a modest level of milk production (*Ibid*). In the marginal desert steppe of the Balikh valley, sheep and goats were the best species to exploit for secondary products. Sheep and goats can bear their first offspring from around two years of age and breed once a year (Russell, 1988: 61-62). In contrast, cattle are generally only bred from three years of age and can breed only every 14-24 months (*Ibid*). As milk production relies on the production of young and the subsequent lactation period, sheep and goats would be a much more reliable source of milk. In small scale production in hot and cold areas goats can be at least as efficient, if not superior to, cows (French, 1970: 53). Sheep and goats are also easier to milk than cattle (Whittle, 2003: 93).

What does the move to milk production mean in terms of nutrition and to what scale did milk production occur? A balanced strategy involving the use of meat, milk and other secondary products is the most efficient use of domestic stock (Betts and Russell, 2000: 26). One estimate is that 131 small sheep could produce enough milk to sustain a family of two adults, two adolescents and two young children with perhaps 25 kg of milk produced per ewe per lactation (Halstead, 1996). Redding (1981:168) suggests that an average Middle Eastern ewe under extensive husbandry yields approximately 45 kg of milk per lactation with goats producing as much as 77 kg. This is of course based on modern animals and yields may have much lower in the first primitive breeds of domestic sheep. It has been stated that wild

¹⁴ See chapter 3

lactating females only produce enough milk for their immediate offspring, this is true, but it is also the case that milk production changes to comply with the changing requirements of the young and this mechanism can be exploited by humans. Yields of secondary products can therefore be quite easily enhanced through a close understanding of animal behaviour (Betts and Russell, 2000: 26). Both the quantity of milk produced and the duration of lactation can be favourably altered through human milking activities (Bette and Russell, 2000: 27). Redding (1981: 131-132) hypothesises that a flock of 100 ewes would contain 61 milk yielding females and a herd of 100 female goats would contain 59 milk yielding females. If we assume a 600 strong herd of ovicaprids at Tell Sabi Abyad (see section 8.3.2) contains 450 female sheep and goats (based on 3:1 male to female ratio) the herd would contain approximately 270 lactating females each producing 25kg of milk (based on the lowest estimate of Halstead, 1996). In total this would equate to 6750 kg of milk each year, a significant addition to meet the nutritional needs of the herders. The length of lactation is 90-120 days in sheep and up to 210 days in goats with daily yield being similar in both species (Redding, 1981: 169, 172). Milk would therefore only be available for around six months of the year, through spring and summer and possibly into the autumn months.

Both sheep and goats are good milk producers. While goats are generally thought to be better milk producers than sheep in terms of output (French, 1970: 38), sheep milk has the highest fat content (7.5% compared to 4.5% in goat milk and only 4% in cow milk) and as such is very nutritious (Ryder, 1981: 195). Milk also contains protein, minerals, vitamins and carbohydrate (Outram and Mulville, 2005). It is by its very essence a complete food. The judicious use of the sheep and goats for milk throughout the animals' lifespan would have many benefits in terms of the regular nutrients available to the human population from this foodstuff, without decreasing the herd size as is necessary in accessing nutrition from meat.

The move to milk production in the late seventh millennium, sometime around 6225 BC, at Tell Sabi Abyad is corroborated by residue analysis. Several pottery sherds from Tell Sabi Abyad, dated to 6500 – 6000 BC, have been shown to have milk residues present (Evershed *et al.*, 2008). Residue analysis can only detect processed milk so it is clear that the herders of Tell Sabi Abyad were not only milking their animals but also processing milk, and quite likely also storing the milk products. Ryder (1981: 195) argued that the processing of milk was likely to have been discovered as soon as milk began to be exploited. Based on the evidence from Tell Sabi Abyad this certainly seems to be the case. Whether this was because this made the milk easier to digest (Outram and Mulville, 2005; Russell, 1988: 31; Betts and Russell, 2000: 28) or whether milk was processed simply to increase its shelf life remains unclear. Although milk is perishable when fresh it can be stored for short periods through processing. Presumably, the Neolithic pastoralists, like their modern descendents, would have preserved their milk resources, perhaps in the form of cheeses, so that it could be stored for winter. A food store of this type is a considerable buffer against famine and stored fats are both highly palatable and nutritious (Legge, 2005). Such food stores are potentially a powerful social lubricant as items of gift and exchange (*Ibid*). Indeed, the evidence for exchange of pots, some which have been dubbed “cream bowls” due to their similarity to an ethnographic parallel used for drinking milk (Nieuwenhuyse, 2007: 149), is strong from 6225 BC onwards (Nieuwenhuyse in prep.). The presence of perforated pottery sherds (fig 8.120) has been used as evidence of cheese production with these ceramic sieves being hypothesised to be curd strainers (Copley *et al.*, 2005), although this could also have been done using basketry.

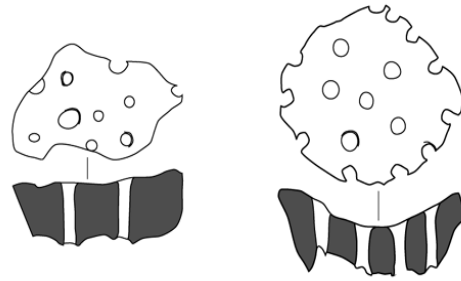


Fig 8.12: Perforated pottery sherds

Modern ethnographic information relating to herders has shown that pastoral management techniques necessary for herd reproduction and neonatal survival in domestic stock are related to the methods used in milk production (Tani, 2005). An understanding of the biology and instinctual behaviour of the herd animals is important to successful animal management systems (Ryan, 2005). The day to day management of a herd requires an intimate knowledge about how to assist in the birth and feeding newborn animals, how to deal with rejected lambs, and make surrogate mothers let down their milk by adopting so-called 'milk-ejection reflex inducing devices' (Tani, 2005). This ability to stimulate the milk let-down reflex allowed humans to obtain milk for themselves as well as orphaned animals (Tani, 2005; Ryan, 2005). Recent domestication experiments have shown that animals may be readily conditioned to milking (Russell, 1988: 18). Milking was not necessarily a natural consequence of domestication but a result of the experience, ingenuity and innovation of prehistoric pastoralists gained through herding experience passed down through the generations. Animals were presumably first domesticated for their meat with milk exploitation only being possible once herd management had advanced in its complexity and the herders began to understand the breeding cycles of the animals and the nuances of lactation. In order to exploit an animal for milk you must understand when an animal produces milk, and the mechanisms involved in the letting of milk down to the udders. It is expected that a close association with their herd animals would have eventually taught the herders all they needed to know (Ryan, 2005). It is likely that the Late Neolithic herders at Tell Sabi Abyad would have had this experience and used it to exploit their herds for milk.

At the same time as there is a move to milk production in ovicaprid husbandry at Tell Sabi Abyad, there is also an increasing importance placed on older animals, which can be interpreted as an interest in fleece production. The wild ancestor of the sheep has a very short, hairy outer-coat composed of bristly fibres known as 'kemps' which obscure a fine woolly undercoat (Barber, 1991: 21; Ryder, 1981: 183). Primitive sheep were considerably more kempy than woolly (Barber, 1991: 22). The wool could however have been plucked from the sheep during the annual moult, a process that gives an extremely fine product as the kemp fibres moult a bit later than the wool fibres (Barber, 1991: 29; McCorriston *et al.*, 1997). This is probably how wool was collected in the Neolithic. These woolly fibres could be used to make felt or spun to make wool. Felt is frequently formed naturally during the moult, even in wild sheep. Wool has a scaly surface and it is these minute scales that give wool its ability to felt (Barber, 1991: 20). The natural matting of the fleece may have provided the inspiration for humans to use sheep wool in the form of felt (Ryder, 1981: 202). Felt can also be made from goat hair (French, 1970: 161). Felt is a non-woven cloth made by matting and condensing the wool fibres (Barber, 1991: 20) and it is probably the oldest fabric known to man. When the leap from felt production to spun wool production was made is unknown. The

skills of weaving and basketry were well developed before animal domestication (Ryder, 1981: 202), the idea of spinning threads in wool and weaving these fibres into cloth was just another step.

At Tell Sabi Abyad there is apparently a move towards a husbandry strategy that included fleece production around 6200 BC. This is corroborated to some extent by a concurrent increase in the number of spindle whorls at this time, not only at Tell Sabi Abyad but at many other sites in northern Mesopotamia (Akkermans *et al.*, 2006; Rooijakkers, 2005: 21,25). Spindle whorls are common in the B levels but rare in the A levels. Spindle whorls can be used to spin a variety of fibres including wool, hair and flax (fig 8.13). Although these spindle whorls could in theory have been used for flax linen production (McCorriston *et al.*, 1997) it is unlikely as flax is difficult to spin in this way (Rooijakkers, 2005: 31). Flax stems requires considerable treatment in order to release the fibres whereas wool fibres can be spun straight from the fleece, and this makes it likely that wool was in fact the first fibre to be spun (Ryder, 1981: 203). The presence of weaving technology does not imply woolly sheep, just as sieves alone do not imply the presence of milk (Greenfield, 2005). I am certainly not suggesting that woolly sheep were present at Tell Sabi Abyad in the late seventh millennium BC. Instead I suggest that the natural hairy fleece of the primitive domestic sheep, and perhaps goats, could be used for either spinning or felt production and would have been another valuable resource available to these late Neolithic pastoralists. The first domestic sheep would, like their wild ancestors, grow a naturally woolly undercoat in winter and in springtime this coat would be shed, becoming available to humans who could pluck and gather this wool for spinning or felting.



Fig 8.13: Reconstruction of spindle whorl use (provided by Rooijakkers per comms) and examples of spindle whorls found at Tell Sabi Abyad

It is very difficult to separate out the advent of the use of domestic animals for secondary products from a strategy of herd security simply on the basis of slaughter profiles (Greenfield, 2005). The analysis of these slaughter profiles together with the analysis of sex profiles and other archaeological evidence at Tell Sabi Abyad, as well as residue analysis, allows a complete picture to be built up about the possible use of milk and fibre at the site through the different levels. At Tell Sabi Abyad it is likely that sheep and goat dairying occurred on a small scale as part of a broad mixed economy particularly from c. 6225 BC onwards. There is no evidence for cattle milk exploitation in any level from the mortality profiles of these animals, but neither can we rule out the occasional exploitation of milk from these animals. Fibre exploitation of sheep, and possibly also goats, is also very likely from 6225 BC. Based on Sherratt's (1983) "Secondary

Products Revolution” hypothesis, the rising importance of secondary product exploitation would result in an expansion in the use of secondary product livestock such as cattle and ovicaprids and a decrease in the representation of species kept only for primary products such as the pig. This is certainly the case at Tell Sabi Abyad with the abandonment of pig husbandry coinciding with the rise of domestic cattle and the increase in secondary product exploitation seen in both sheep and goats from 6225 BC onwards. The people of Tell Sabi Abyad apparently increasingly diversified their domestic animal based subsistence strategy, moving away from prime meat production alone. Although there is no evidence for the intensified and specialised secondary product exploitation seen in later prehistory, it is clear that the domestic animals at Tell Sabi Abyad were not only used for their meat but that their ‘secondary products’ such as milk and fibre were also critical to the operation of the community and influenced production strategies particularly from c. 6225 BC onwards.

8.7 Integration with previous research

8.7.1 Introduction

An important aspect of this research is to see how the results of the analysis of the Late Neolithic fauna of Tell Sabi Abyad fits with previous studies at Tell Sabi Abyad, and at other contemporary sites in the Balikh Valley. As outlined in chapter 3, there are very few comparable Late Neolithic sites in this region so reference to some sites located in the upper Euphrates Valley, the lower Euphrates Valley and the Khabour basin will also be included. The faunal remains from these sites will now be reviewed again and compared with the results of this research.

8.7.2 Tell Sabi Abyad Operation I

The proportions of the main six species from Tell Sabi Abyad I Operation I are compared to the contemporary Operation III levels analysed in this research project. Sequences B and C of Operation III are roughly contemporary with the levels uncovered at Operation I. It is clear from figure 8.14 that the species proportions in the B and C levels at Operation III are not significantly different to those roughly contemporary levels at Operation I. This is confirmed by a F-Test (probability that the species proportions are not significantly different = 0.877). Visually there are some slight differences, notably in the ratio of cattle to pig, with a higher proportion of pig bones being recovered in Operation I. There are also comparatively more gazelle recovered from Operation I. The A levels in Operation III appear to have similar proportions of pigs and onager as the levels at Operation I. There are however comparatively more cattle in the B and C levels at Operation III and in the levels at Operation I.

Sheep and goats clearly formed the basis of the animal based subsistence system at both Operation I and Operation III. Cavallo (2000) suggests that at Operation I these animals were exploited for meat with secondary product production only becoming important in the sixth millennium. This is however based on Payne’s (1972) milk model, which as discussed earlier, is an unsuitable model to use to detect milk production in the extensive herd management practices of the Neolithic. The data from Operation III suggests that the move to milk and fibre production occurred earlier, around 6225 BC.

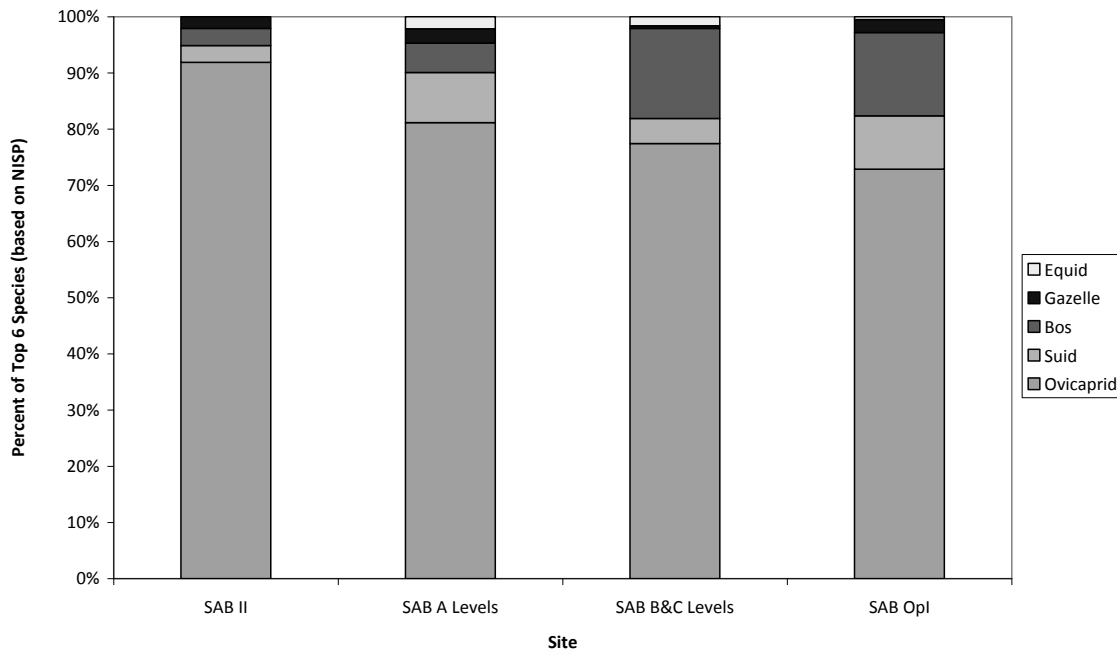


Fig 8.14: Comparison of Tell Sabi Abyad I Operation III levels to Tell Sabi Abyad I Operation I and Tell Sabi Abyad II.

The proportions of domestic pig in Operation I reflect those seen in the earlier A levels at Operation III rather than the contemporary B and C levels. The reduction in the proportion of domestic pigs at Operation III occurs c. 6225 BC and is followed by a revival in pig proportions from c. 6040 BC. The pigs at Operation I could also correspond to this revival. Cavallo (2000) states that pigs continuously increased in their importance at Operation I, outnumbering cattle by c. 5800 BC. A comparison of the length measurements of pig postcranial bone elements using the LSI method and wild boar of Çayönü as a reference, shows that the pigs seen in Operation III are generally the same size as the Operation I domestic pigs (fig 8.15). At Operation I the cattle were domestic. It is now clear that the domestication of these animals began c. 6900 BC in the earliest levels at Operation III. The continued presence of wild individuals suggests that the wild progenitors of these domestic animals were still locally available out in the landscape 1000 years after the process of domestication began. At both sites a decrease in the size of cattle through time is noted. A comparison of the width and length measurements of cattle postcranial bone elements using the LSI method and the aurochs of Mureybet as a reference, shows that the cattle seen in Operation III are generally heavier and taller than the cattle in Operation I (fig 8.16 and 8.17). This is seen in both the range of measurements and the mean values. This suggests that the decrease in size of the cattle seen at Operation III as a result of domestication continues in the later Operation I levels.

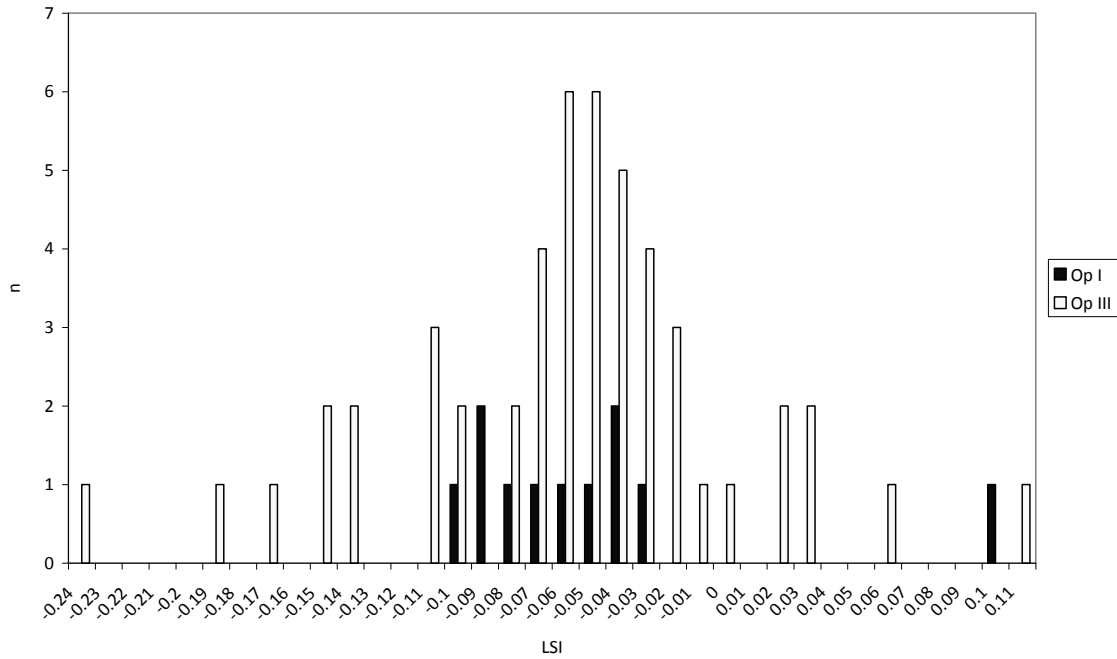


Fig 8.15: Comparison of Tell Sabi Abyad Operation III (SAB Op III) and Operation I (SAB Op I) pig length LSI values (SAB Op III mean = -0.06; SAB Op I mean = -0.05)

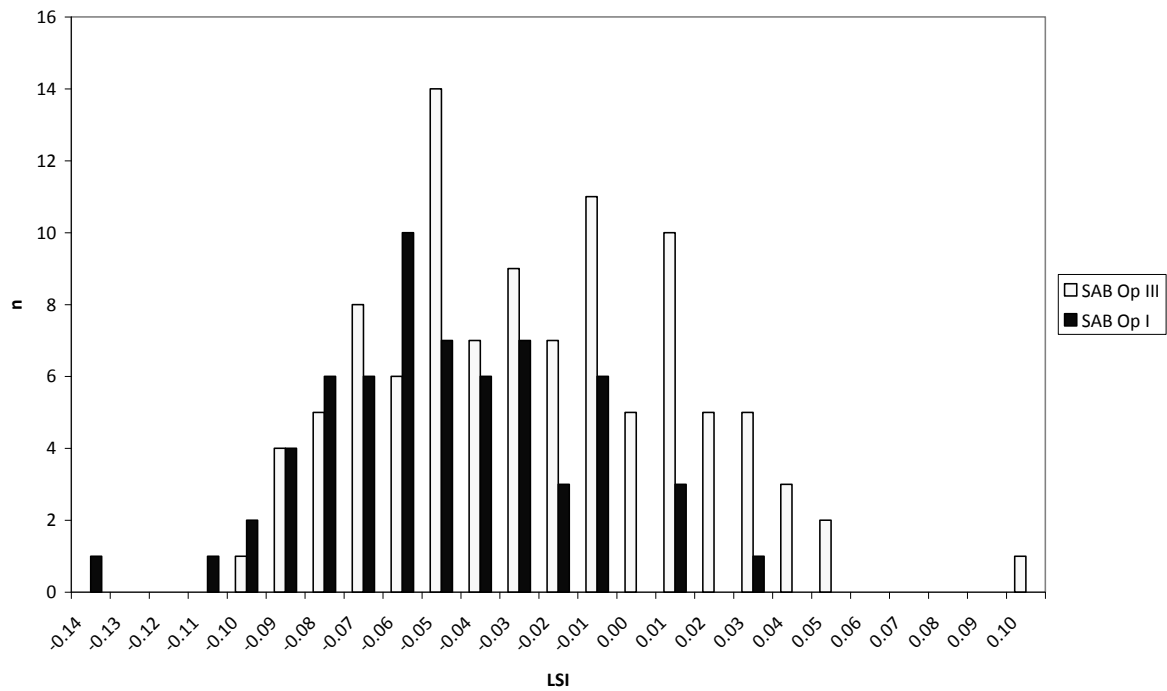


Fig 8.16: Comparison of Tell Sabi Abyad Operation III (SAB Op III) and Operation I (SAB Op I) cattle length LSI values (SAB Op III mean = -0.03; SAB Op I mean = -0.05)

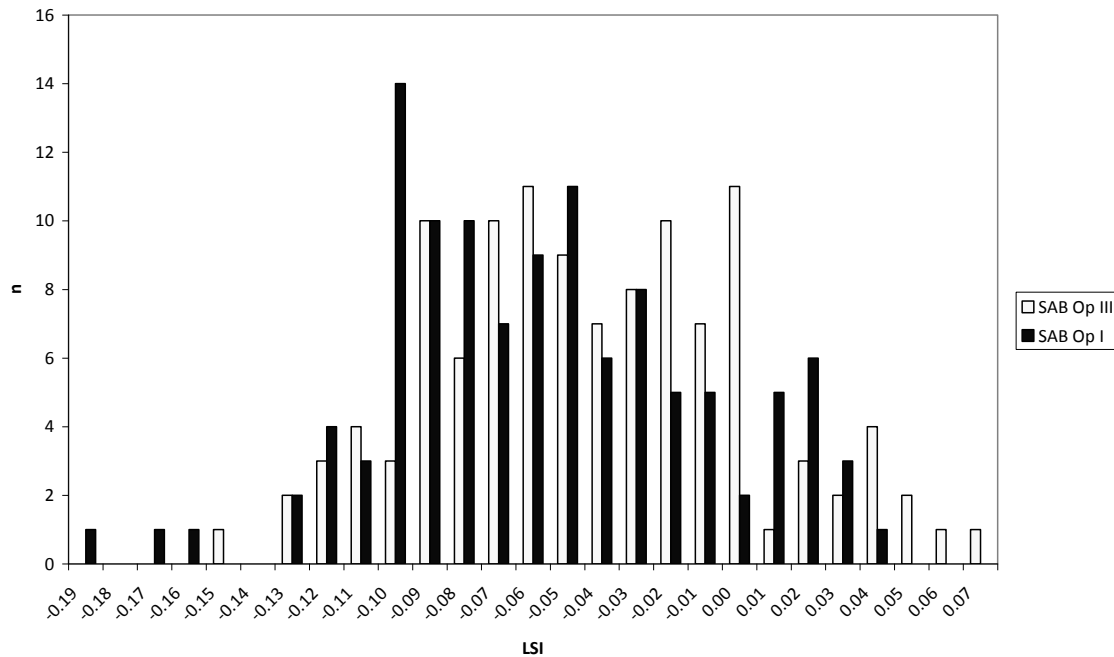


Fig 8.17: Comparison of Tell Sabi Abyad Operation III (SAB Op III) and Operation I (SAB Op I) cattle width LSI values (SAB Op III mean = -0.04; SAB Op I mean = -0.05)

The age profiles of cattle at both Operation I and III suggest the cattle were exploited specifically for meat with the main cull occurring when the cattle were three to four years of age, presumably as this represents the optimum culling age in terms of meat and fat return for primitive breeds of cattle.

Wild animals played only a very minor role in the subsistence economy at both settlements. The A levels at Operation III showed a greater diversity and proportion of wild fauna, including large game, small game and birds (especially in levels A9-A3), than in the later B and C levels at Operation III and in the Operation I levels. The results from Operation I corroborate the reduction in the hunting of these animals seen at Operation III, with the focus shifting to domestic animal husbandry at both areas of settlement on the mound. At both Operation I and III hunting is associated with a specific season, namely the autumn and winter months.

Reviewing the results of the faunal analysis at Operation I demonstrates that many of the trends seen in the pattern of animal exploitation in Operation III are continued at Operation I. The contemporary levels at these two areas of occupation show that in general the same species were exploited in the same way. The changes put into action in the seventh millennium levels at Operation III were continued in the sixth millennium at Operation I.

8.7.3 Tell Sabi Abyad II

The proportions of the six main species from Tell Sabi Abyad II are compared to the contemporary Tell Sabi Abyad I Operation III levels analysed in this research project. Tell Sabi Abyad II was occupied from c. 7200 and 6700 BC which roughly corresponds to levels A12-A10 at Operation III. It is clear from figure 8.12 that the species proportions in these two villages were somewhat different. This is confirmed by an F-Test (probability that the species proportions are not significantly different = 0.652). At Tell Sabi Abyad II the faunal assemblage is dominated by ovicaprids with very few other species present (Van Wijngaarden-Bakker and Maliépaard, 2000). While there were relatively large numbers of domestic pigs at Operation III they were practically absent from Tell Sabi Abyad II. These two contemporary villages were located very close to each other and it is difficult to explain these differences. Cattle were thought to be proto-

domestic at Tell Sabi Abyad II which fits with the assessment of cattle in contemporary levels at Tell Sabi Abyad, Operation III.

8.7.4 *Site comparisons*

The Tell Sabi Abyad faunal data was also compared to the contemporary levels at Tell Damishliyya (Balikh Valley), Tell Assouad (Balikh Valley), Tell Halula (Middle Euphrates Valley), Tell Seker al-Aheimar (Khabour Basin) and Tell Bouqras (lower Euphrates Valley) (see figure 3.3 and section 3.6). The A levels in Operation III are roughly contemporary with the levels uncovered at these sites. All the sites were dominated by domestic sheep and goats and these animals typically formed the basis of the animal exploitation strategy at all sites in the area (figure 8.16). Despite this common trend, there were clearly differences in the general pattern of animal exploitation at these sites, with one exception. The species proportions in the A levels at Tell Sabi Abyad are almost identical to those seen at Tell Damishliyya. These sites are in very close proximity and the faunal data suggests that a similar animal based subsistence system was in play. This is confirmed by an F-test ($p=0.930$). There is less of a similarity between Tell Sabi Abyad and Tell Assouad, Tell Halula, Tell Seker el-Aheimar or Tell Bouqras.

Domestic ovicaprid exploitation was taking place at all sites. At Tell Sabi Abyad, Tell Damishliyya, Tell Halula and Tell Seker el-Aheimar the mortality profiles of sheep and goats indicate a mixed exploitation strategy for meat and milk. Fibre production is also indicated at Tell Sabi Abyad and Tell Seker el-Aheimar. There is no indication of the husbandry strategies employed at Tell Assouad and at Tell Bouqras only a meat production husbandry strategy was apparently employed.

Pigs are only present to any degree at Tell Sabi Abyad, Tell Damishliyya and Tell Assouad, i.e. the sites located in the upper Balikh Valley. Why this is the case is unclear. Was this simply a reflection of dietary preference or perhaps a reflection of the micro-climate of the Balikh Valley and its location on the 200 mm isohyet? Pigs are domestic at Tell Sabi Abyad and Tell Damishliyya (Russell and Buitenhuis, 2008) and show signs of proto-domestication at Tell Assouad (Helmer, 1985)¹⁵. At Tell Halula indications of sus domestication are only present at the end of the sequence (Seguí, 2000). It is unclear as to the domestication status of the sus at Tell Seker el-Aheimar and Tell Bouqras (where very few sus remains were recovered). Could the relatively high proportions of the sus at the sites in the upper Balikh therefore be due to their domestication status? To answer this question a more complete analysis of the sites outside the Balikh Valley is necessary but unfortunately this is unavailable at this time.

There are also clear differences in the proportions of bos. Tell Bouqras has a comparatively very high proportion of bos, Tell Halula and Tell Assouad have relatively high proportions of bos present, and Tell Seker el-Aheimar displays a very low proportion of bos. Tell Sabi Abyad and Tell Damishliyya show very similar proportions, at around half the proportion seen at Tell Assouad. The cattle at Tell Sabi Abyad are domestic and this is presumably also the case at Tell Damishliyya, where the sample size was too small to determine this independently. In the analysis of fauna at Tell Assouad, Helmer (1985) states that due to the large size of the bos remains recovered, they probably represent aurochs not domestic cattle. At both Tell Halula and Tell Sabi Abyad proto-domestic or culturally controlled cattle populations began to appear from around 6900 BC, with fully morphologically domestic cattle present shortly after this time. At Tell Seker el-Aheimar very low proportions of bos were present, the domestication status of which is yet to be determined. Although the bos at Tell Bouqras are not much smaller than the aurochs at Mureybet, Buitenhuis (1988) believes these cattle to be domestic. These results show that cattle domestication was well under way at some sites in the region at the beginning of the seventh millennium BC but that wild aurochs were still present in the area. These domestic cattle were exploited at the different sites across to region to differing extents, with perhaps the inhabitants of some sites, for instance Tell Seker el-Aheimar and Tell Assouad, apparently not including domestic cattle in their subsistence system.

¹⁵ However, poor excavation (a very small sounding only) and dating at Tell Assouad means that the stratigraphy is unreliable and the faunal remains may be far older than stated in the faunal report.

Tell Assouad relies more heavily on the hunting of gazelle than any other site but the sites of Tell Halula, Tell Seker el-Aheimar and Tell Bouqras also have relatively high proportions of gazelle present. Gourichon (*per comms*) states that a major characteristic of meat procurement at Tell Seker el-Aheimar was the hunting of gazelle. With such a high proportion of gazelle remains present, this was clearly also the case at Tell Assouad. The relatively low proportions of gazelle at Tell Sabi Abyad and Tell Damishliyya suggests that the hunting of gazelle was not practiced by the inhabitants of these sites to the same extent as at other sites in the area.

The hunting of equids occurs at a very low level at all sites with only three equid remains recorded at Tell Bouqras. Other game such as hares and birds also apparently made up only a very small part of the animal exploitation strategies employed at all these sites

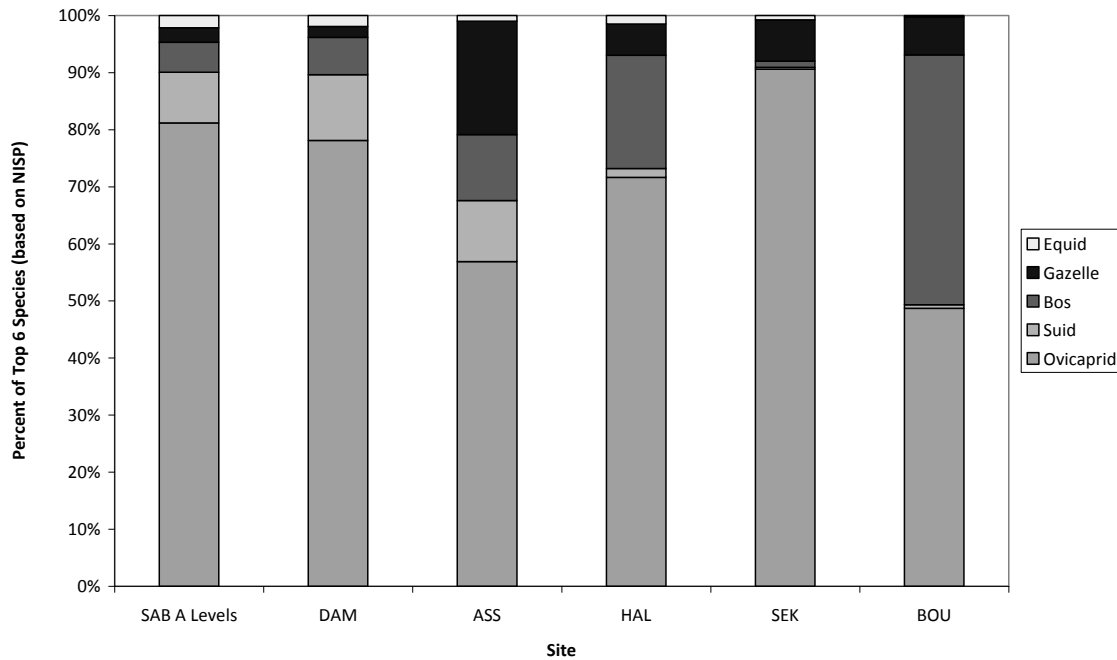


Fig 8.18: Comparison of Tell Sabi Abyad III Operation I A levels to contemporary sites in the vicinity.

8.7.5 Summary

At Tell Sabi Abyad there is evidence for a reduction in the exploitation of wild resources parallel to the increased focus on domestic, pastoral animals. It is clear that this was not an irreversible process nor did it involve all communities of this area in the Late Neolithic as some contemporary sites still show relatively high proportions of wild fauna, namely Tell Assouad (gazelle). Animal husbandry, and particularly that of sheep and goats, was the foundation of the animal based subsistence system, providing milk and meat, at most of the sites. The differences in the proportions of the main six species however show that there are clear differences between the sites. This demonstrates that the different settlements were to a certain extent, autonomous and practiced different animal subsistence and management strategies. The people at Tell Sabi Abyad and Tell Damishliyya were perhaps closely linked as the sites are in very close proximity and had analogous animal based subsistence systems. The lithic assemblages at these two sites are closely comparable which also suggests a similar subsistence economy (Akkermans, 1989; Astruc, in press). The inhabitants of these two small settlements may have had kin links and perhaps activities such as hunting were performed by these two communities working together. As we move further away from Tell Sabi Abyad it is clear that the settlements become less similar in terms of the animal based subsistence system. These differences may in part be due to differences in micro-climate, with perhaps more gazelle being available in the Euphrates and Khabour valleys and pig husbandry not possible further south. This

does not explain the very high proportion of gazelle present at Tell Assouad however¹⁶. This site is also located in the Balikh Valley, but unlike the inhabitants of Tell Sabi Abyad and Tell Damishliyya, the people at Tell Assouad apparently decided to focus more time and energy on hunting gazelle.

8.8 Animal bone and climate change: evidence of the 8.2k event

8.8.1 Introduction

One of the aims of this project was to assess the possible effects of a climate change on the inhabitants of the Late Neolithic village of Tell Sabi Abyad. The 8.2k event reached its peak c. 6225 BC and although proxy evidence of this event's effects in the Near East are scarce, proxy data from the Soreq cave in Israel (Bar Matthews *et al.*, 1999), the Dead Sea in Jordan (Migowski *et al.*, 2006; Enzel *et al.*, 2006) and the Eastern Mediterranean (Pross, 2009) indicate that the event's effects did indeed reach the Near East bringing cooler and more arid conditions. Climate modelling has also indicated that this event would have increased aridity in the Near East (Wiersma, 2008). The increase in aridity would certainly be the most critical consequence of the 8.2k event as water availability is one of the key climatic determinants for people living in arid areas such as the Near East. The scarcity of such a critical resource could result in the diminished effectiveness of the subsistence base to supply the fundamental needs of the community in question (Coles and Mills, 1998). This increase in aridity did not *a priori* lead to a drought, but in such a marginal area in terms of rainfall, it is extremely likely. Many researchers adhere to the theory that climate change rendered these marginal environments, where settlements had thrived, uninhabitable (Köhler-Rollefson, 1988). Such a major change in settlements may well have been related to changes within the social and ritual beliefs of people within a framework of regional environmental changes and local environmental degradation (Kuijt, 2000). A comprehensive program of radiocarbon dating has produced a set of extremely high quality dates for the stratigraphic levels identified in Operation III at Tell Sabi Abyad which show that some of the changes noted in the archaeological record did not precede the 8.2k event but were contemporary with the climate change. The effects of such environmental stress would not be uniform across any landscape. The challenge here is to assess how the 8.2k event affected the upper Balikh Valley, and in particular the animal based subsistence. The results of the faunal analysis will now be reviewed with this in mind.

8.8.2 Changes c. 6200 BC

The faunal analysis has revealed that several changes in the animal based subsistence system occurred over the millennium of study (c. 6900 – 5900 BC). These changes were often subtle but it is clear that things were always changing, both in terms of the wild animals exploited and the domestic animal management strategies employed. This research has revealed many changes, expressed as animal exploitation phases. As stated in section 8.1.1 these phases are somewhat arbitrary as the change was constant and did not occur abruptly at phase boundaries but can be seen as a gradual transition between the levels, with the clearest transitions occurring at around 6675 BC, 6385 BC, and 6225 BC. The changes between these phases can be described as differences in either the range of wild species exploited, the contribution of wild animals to the subsistence economy, the domestic animals exploited, the animal management strategies employed, or a mixture of these. Clearly these gradual changes were occurring as part of a steady development in animal management together with cultural choices for certain animals. How do we distinguish these gradual changes from any changes promoted by a change in climate due to the 8.2k event? There are clearly several changes in animal exploitation centred around 6225 BC, between levels A1 and B8, and this period of time does seem to be a one of greater change than that seen between the other levels. The changes occurring at this time include:

- In addition to meat production, a move towards milk and fibre production in the management of sheep and goats as part of a mixed economy.
- An increase in the importance of domestic cattle husbandry after a temporary reduction in cattle numbers

¹⁶ The high proportions of gazelle should be treated with caution because of the poor dating at Tell Assouad.

- The abandonment of domestic pig husbandry
- The continued decrease in the importance of hunted fauna to the subsistence economy and a decrease in the number of wild species exploited

Many of these changes did not occur abruptly or ‘overnight’ at 6225 BC. Instead, these changes can trace their roots to much earlier in the sequence, in the centuries preceding the event, in the gradual changes seen between levels A12-A2. It is however clear that there was an acceleration in the progression of these changes around 6225 BC. That many of these changes have their origins earlier in the sequence does not preclude climate change as a factor as Rohling and Pälike (2005) have shown that the 8.2k event was in fact only one specific component of a much broader climate anomaly dating to 8.6 – 8.0k BP. The main change at this time was a move towards the husbandry of only domestic pastoral animals, cattle, sheep and goats. The foundations for this move to pastoralism were laid well before 6225 BC but it is clear that it was only at this time that this subsistence system really took off. Was this the natural result of the centuries of previous developments seen in the animal based subsistence system or was this transition promoted by a degradation in the climate due to the 8.2k event?

The extent to which changes in the subsistence economy can be attributed to being the result of a climate induced deterioration of the environment, particularly drought, were outlined in chapter 4. Based on this review it is clear that a deterioration of an environment due to drought would at least limit the economic options open to humans, putting stress on the system perhaps leading to a vulnerability to resource failure, an inability to generate surplus and a difficulty in meeting subsistence needs over an extended period of time, with the longer the drought the longer it takes to recover (Armit, 1998; Dahl and Hjort, 1979: 12). In terms of the ability of domestic species to cope with aridity, it is clear that goats are the most well adapted to drought, followed by sheep, then cattle, with pigs being the least well adapted.

Can we see any of the effects of climate deterioration outlined in chapter 4, such as dramatic reductions in livestock numbers, an increase in the proportion of hardier animals such as goats and sheep and the loss of the more fragile young animals, in the Tell Sabi Abyad faunal material? The decline of domestic pig husbandry coincides with the timing of the climate event. Could there be a cause and affect relationship? Pigs are not well adapted to the steppe environment. They need wet, shaded environments, do not cope well with heat and need constant access to water. It is assumed that the domestic pigs at Tell Sabi Abyad were allowed to freely roam the riverine thickets along the Balikh and Nahr Turkman nearby the settlement. A drought may have caused a degradation of this riverine habitat making keeping pigs very difficult. It is of course also possible that the decline in pig husbandry was due to a cultural choice to concentrate on pastoral animals such as cattle and ovicaprids. In any case, cultural factors will have played a role in the human-animal interactions; this is not an “either-or” issue as the natural environment and climate changes would arguably always be mediated through such cultural filters. The domestic sheep and goats would have been the most resistant animals to drought, needing less water than both domestic cattle and pigs. These animals increase in importance in level A1, i.e. c. 6225 BC while cattle numbers see a temporary decline in their rise to supremacy and the drought-intolerant pigs almost disappear completely. Did drought conditions lead to the loss of many heads of cattle in level A1? Estimates of cattle numbers (see section 8.3.3) suggests that herd size may have been halved at this time. Cattle, and particularly calves, are generally unable to meet their water requirements simply by eating fresh plants and their water consumption is high compared to both sheep and goats which are able to meet much of their water needs through their food (Russell, 1988: 57). In good years there was presumably plenty of water available in the local vicinity from the Balikh River and its tributaries, but what about during successive drought years? Both cattle and pig herd numbers could well have been negatively affected by such a drought (estimates of pig numbers in section 8.3.3 also suggest they were dramatically reduced in level A1). The rise in sheep and goat proportions could be a reflection of the hardiness of these species in times of drought, but as outlined in chapter 4, these animals are not immune to the effects of drought. There is no direct evidence of a ‘catastrophic’ death of animals in any level, but it is uncertain as to whether this would be easy to detect in the predominantly secondary deposits present the site. It is also

possible that if pastoral animals were herded away from the site, animals may have died out in the landscape and not have been incorporated into the faunal assemblage.

It has been shown that drought is likely to affect the more susceptible younger members of the herd first with older animals being more robust in the face of difficult conditions (see chapter 4). If drought conditions did cause the loss of many heads of cattle this would take several good years to recover from. In level A1, the end of which coincides with the height of the 8.2k event, there is indeed a significant drop in cattle numbers based on NISP, bone weight and cattle number estimates. Sheep and goats have a rather more rapid rate of reproduction and such catastrophic losses could be recovered from much more quickly.

In addition to an increased mortality in the younger elements of the herd, variations in the potential milk production can also be expected (Dahl and Hjort, 1979: 15, 16). These effects are not just felt during the drought itself. During the drought milk production will be reduced due to a scarcity of (high quality) graze. When the rains return milk production does not start up straight away but is delayed until the next offspring is born (Dahl and Hjort, 1979: 16). What does this mean for milk production at Tell Sabi Abyad? Isotope evidence of foddering (see chapter 7) suggests that the Neolithic herders may have tried to secure milk production through the provision of food, as does the presence of barley, a traditional fodder crop, in the botanical assemblage. It has been noted that failed crops, which have not produced a seed head but have grown to a reasonable height, are a perfect food source for sheep, goats and cattle who can be led onto the failed crop field and left to feed (Métral, 2000: 135). This practice is common in the Near East today and can often lead to the herds being better fed and in a better condition than in years when the crop succeeds. This mixed blessing, the crop failing but the animal herds thriving, would have provided a means to survive crop shortage through the consumption of milk products and meat. This would evidently only be a very short-term “success” however.

It is easy to see that the consequences of a drought for a pastoral economy would be severe and complex. Not only are herd numbers reduced, so is herd security and the amount of meat and milk that can be produced. Pastoralists live under constant threats to their daily supply of food. Reducing potential loss, insurance and security are central themes in modern East African pastoral societies (Dahl and Hjort, 1979: 18) and this is likely to also have been the case for the earliest pastoral economies of the Neolithic. The keeping of more than one species of livestock by the herders at Tell Sabi Abyad not only promoted a more complete use of environmental resources and a more even access to food, but also reduced the risk of total loss.

Most of the proxy evidence points to an aridification of the Near East at this time. If the climate in the Late Neolithic was roughly similar to that seen today in the rather marginal area of the Balikh valley, then the inhabitants of Tell Sabi Abyad would have regularly experienced drought years. Drought years and crop failures would have been something the Late Neolithic farmers would have had to deal with several times in their lifetime. As such, we can safely assume that several coping mechanisms were in place to deal with years when food was scarce. Halsted and O’Shea (1989) suggest five possible responses to food stress: mobility, diversification, physical storage, exchange and social networks. Although the Neolithic farmers may have been able to cope with the ‘normal’ years of drought through the implementation of some or all of these coping mechanisms, coping with the long term environmental decline and drought caused by the 8.2k event would have been another matter entirely and would have severely tested these coping mechanisms.

Mobility was obviously an integral part of Neolithic life, with people moving around their local environments while herding their animals and on hunting expeditions. Longer distance movements are suggested by the presence of obsidian and basalt sourced from Turkish hinterlands (Akkermans, 1993: 207). It is clear that people were not restricted to the confines of their village, nor did the community represent a closed system economy. There are many examples of this with evidence of goods moving throughout the Near East, even if in only small numbers. In times of trouble mobility may have increased,

as ethnographic studies have shown it does in subsistence systems today (see chapter 4). The move to a pastoral economy at the time of the climate change at Tell Sabi Abyad may have been part of a strategy of increasing mobility. Mobility remains the most important pastoralist adaption to spatial and temporal variations in rainfall, and in drought years many communities make use of fall-back grazing areas unused in “normal” dry seasons because of distance or conflict (Morton, 2007). The shift from meat to milk production apparent in the husbandry strategies of sheep and goats at Tell Sabi Abyad could be seen as a form of storage as it ensures food supply without diminishing herd size. This also represents a diversification in food supply. These coping mechanisms could have been put into action in order to survive the ‘normal’ years of drought as well as the ‘abnormal’ successive years of drought as a result of climate change.

It has also been suggested that there was an increase in the size of the population at Tell Sabi Abyad after c. 6200 BC (based on population estimates for Operation I by Verhoeven, 1999: 212, Akkermans and Duistermaat, 1997). This may have resulted from the migration of people to the site from areas on the periphery. The location of the site next to a tributary of the River Balikh may have made it more robust in coping with a drought. Tell Sabi Abyad’s location in the vicinity of wadi confluences, with vast quantities of drainage water from the hinterland passing through in the wet season, puts the settlement in an area of well watered soils providing excellent farming opportunities. If climatic conditions before the onset of the effects of the 8.2k event were similar to those seen today, then the location of the site would have conferred the inhabitants many advantages in times of drought. People from settlements further away from permanent sources of water may have migrated towards Tell Sabi Abyad in times of water stress. The increase in the proportion of cattle, presumably representing an increase in the absolute numbers of cattle, after 6225 BC may also reflect an increase in population size: cattle are very large and need many people to eat them. Unless large numbers of people were present to eat the meat over a few days then there would be a lot of wastage or large quantities of the meat would have to be prepared for storage. The social model for Tell Sabi Abyad after 6225 BC is one of a mixed community of mobile pastoralists and sedentary agriculturalists with few people based in the village permanently (see chapter 2 and Akkermans, 1993; Verhoeven, 1999; Akkermans and Duistermaat, 1997; Nieuwenhuys, 2007). If the permanent population was only small then cattle may only have been culled at times of the year when the mobile parts of the population came back to the site, an event that may have been accompanied by a form of ‘feasting’.

Can we relate cultural behaviour with climate change at Tell Sabi Abyad? Well it is clear that many cultural changes occurred at Tell Sabi Abyad at the same time as any possible effects of the 8.2k event would have been felt but synchronicity does not equate to causality. These changes are apparent in not only the animal based subsistence economy but also in settlement structure and material culture (see chapter 1). Any aspect of culture may be related directly or indirectly to some features of the environment and we should be prepared to observe interactions between any pair of components in the culture system, and we should expect that these interactions will be complicated by feedback mechanisms with multiple implications arising from a single transaction (Jochim, 1981: 7). Any variable can affect any other leading to changes in culture that might not be anticipated to occur as a result of climate change.

One important aspect of successfully adapting to climate change lies in the perception of the affects of the event (i.e. drought), which includes the acknowledgement of the severity of the situation, as well as why it occurred (Rosen, 1995). Humanity interacts not directly with nature but with its perceptions of nature, and it acts on those perceptions (McIntosh *et al.*, 2000). Were the inhabitants of the settlement at Tell Sabi Abyad aware of a significant change in their environment? If they were, how did they comprehend these changes in terms of their understanding of the environment and their belief systems? The way in which the landscape was both perceived and exploited would have affected both the ability of the people to adapt to an environmental change and the likelihood that the effects of the change could be mitigated through human agency. The way the 8.2k climate shift was perceived would have a marked effect on the response of the population. Human response is conditioned by the ways individuals as members of a community comprehend variability, and the so-called normal variation of climate that falls

within a tolerable range will of course vary from society to society (McIntosh *et al.*, 2000). Deviations must have enough magnitude to trigger the perception that conditions are beyond the norm (*Ibid*). Was this the case at Tell Sabi Abyad? When variability exceeds that normal range, not only will the response be different, but so will the rate of response, the ability to find innovative ways to adapt, and the ability to tap the society's past experiences with similar extremes will also widely differ (*Ibid*). Within the normal seasonal cycle of resource availability, particular activities would have been tied to particular times of year, with specific places being visited and seasonal abundances or shortages noticed, forming key reference points within a groups recent past (Kansa *et al.*, 2009b). Social memory is of course very important as it can supply an arsenal of responses. It is difficult, if not impossible, to assess to what extent the people at Tell Sabi Abyad were aware of the climate change and to what they would have attributed the arrival of many years of drought conditions. What is clear is that if the society at Tell Sabi Abyad lacked the social memory, technology, the economic or the organisational means to put into motion the best coping strategies and adaptations with sufficient speed to deal with the problems associated with the climate change, then the community would not have survived and there would have been a "collapse". This was not the case.

The presence or absence, the appearance or disappearance of human cultures is often explained away as being a factor of climate (Bottema, 1989: 8) and it is often argued that climate change can lead to cultural collapse (Weiss and Bradley, 2001). "Collapse" is a broad term that can cover many kinds of processes including a rapid, significant loss of an established level of socio-political complexity and common elements of social structure (Tainter, 1988: 4). An understanding of collapse often depends more on the characteristics of the society itself than on the environmental stresses it faces (Tainter, 1988: 59¹⁷). There is certainly no collapse apparent in the Late Neolithic at Tell Sabi Abyad. Dealing with resource uncertainties is a common activity of societies; human societies are problem-solving organisations (Tainter, 1988: 89, 93). If climate change was a factor in the many cultural changes occurring at this time then it clearly fitted into a complex range of culture developments already taking place in the Late Neolithic at Tell Sabi Abyad.

8.8.3 Summary

Palaeoecology provides ecological histories while archaeology provides cultural histories (Roberts, 1998: 4). The difficulty is in tying these two lines of research together. One of the weaknesses of the palaeoenvironmental approach is that it cannot reconstruct attitudes of people in the past to their natural world (*Ibid*). When archaeology and palaeoecology are combined however, long-term developments in the environment can be analysed together with patterns of cultural changes (*Ibid*). The aim here was not to isolate climate change as the ultimate underlying cause of the changes seen the animal exploitation patterns around 6225 BC, but to examine some of the mechanisms that could have been activated by climate change as one of the sources of system stress.

Archaeological and palaeoecological findings can appear confused, with some lines of evidence indicating the potential importance of extreme environmental events as triggers for collapse of systems, while other studies suggest that the perception of land as marginal has more to do with social and socio-economic factors than any inherent quality of environmental marginality (Coles and Mills, 1998). The results from the current research at Tell Sabi Abyad suggest a complex inter-relationship of environmental, economic and social systems. Rather than climate and environment being the only forcing factors involved, environmental conditions should instead be seen as a series of potential constraints upon population growth which may be overcome by the adoption of new technologies or subsistence methods (*Ibid*). Much of human behaviour can be viewed as problem-solving, with people constantly trying to solve the mundane problems of survival, many of which are rooted in the relationships between people and their natural environments, in their own terms (Jochim, 1981: 1). The immediate causes of cultural changes are often seen as being cultural, but humans are not above the effects of changes to the natural environment

¹⁷ Tainter (1988) is strongly systems-processual but much less behavioural ecological and in his systems model, culture and cognition play a large role.

(Jochim, 1981: 3). Although culture can be understood primarily only in terms of cultural factors, it can be argued that it is entirely unintelligible without reference to the environmental factors which condition the culture (Kroeber, 1969). The environment can not only condition culture but may in addition be permissive or prohibitive with respect to technologies (Steward, 1973: 38). Climate, topography, soils, hydrography, vegetation, and fauna are crucial, but some features may be more important than others (Steward, 1973: 40).

The range of conditions which bring about the marginalisation of a human group has very little to do with the inherent qualities of the environment itself and much more to do with the way in which the landscape is both perceived and exploited (Coles and Mills, 1998). The fate of a human population faced with changes in their environment will largely depend on their ability to adapt through the use of novel resources, new technologies and subsistence methods, and changes in settlement pattern. If a population fails to respond adequately then this may result in social fragmentation, famine, death and large scale outward population migration (*Ibid*). It is clear that there was no social fragmentation or large scale outward population migration around 6225 BC at Tell Sabi Abyad. There was however a great deal of cultural change in this period with changes apparent in the settlement structure (Kaneda, in prep.), ceramics (Nieuwenhuyse, in prep.; Nieuwenhuyse, in press), lithics (Astruc and Russell, in press) and small finds (Akkermans *et al.*, 2006; Rooijakkers, 2005: 21, 25). Although it can be argued that the degree to which changes in climate and culture can be correlated with settlement patterns is poor (Coles and Mills, 1998), the broad spectrum of change at Tell Sabi Abyad at the time of the 8.2k event, including major cultural, technological, typological, ritual, and economic changes suggests that there may have been an association. How do we reconcile these changes with the advent of a climate change and if climate change was not a factor, then how do we explain these changes?

In terms of faunal remains, there are a number of possible explanations for the considerable changes seen in animal based subsistence and domestic animal management strategies. Could the move towards domestic herd pastoralism and away from wild animal exploitation be a result of anthropogenic environmental degradation? One huge and very important side effect of the one-sided propagation of a few key plant and animal species is that it comes at the expense of all other indigenous species, with massive ramifications on the local ecosystem. Degradation caused by grazing animals, extensive woodcutting and over farming of sensitive, rain-fed areas leads to depletion of soil nutrients, a loss of fertility and eventually a decrease in productivity of both pastoralism and cultivation (Köhler-Rollefson, 1988; Verhoeven, 1999). As such, the momentum of the Neolithic revolution was precarious, and only sustained as long as the environment could cope with human manipulation. It has been argued, that in the central and southern Levant at least, that it was the sustained seventh millennium strategy of combined farming and herding that led to the widespread abandonment of settlements, because of the severe damage caused to ecological systems around agricultural settlements (Rollefson and Köhler-Rollefson, 1992). With such small populations of humans inhabiting the Balikh Valley in the Neolithic, particularly in comparison to the huge numbers of people present today, it is hard to believe that they could have had such a severe effect on the environment without other factors coming into play.

Could the move to domestic herd pastoralism and away from wild animal exploitation be merely the result of a natural progression and evolution in the subsistence strategies of the people of the Late Neolithic? The adoption of domestic herd animals into subsistence economies of northern Mesopotamia began some 2000 years before the 8.2k event, and it can be argued that the adoption of an agro-pastoral way of life with a dwindling reliance on wild fauna was a natural progression of this earlier development. Climate change was not necessarily a factor in this development.

Whatever the impetus, there can be no denying that this period of history saw a number of considerable socioeconomic and sociocultural changes. Despite clear evidence that many cultural changes were immediately preceded by the climate event, it is still very difficult to demonstrate causality. I do not suggest these cultural changes were fully determined by the environment, in a deterministic manner. Rather, I hypothesise that these social and economic changes significantly increased the local

community's resilience against the effects of the climate change, and made it possible for them to mitigate the environmental effects of the climate shift. The 8.2k event lasted several generations at its height c. 6225 BC and many centuries if the broader climate anomaly dating 8.6 to 8.0k BP is taken into account. The effects of this event would have been felt by many generations of inhabitants at Tell Sabi Abyad and by the end of the event these conditions may have been considered the norm, with elders harking back to a time when their grandparents said the rains came more regularly. The increased resilience against climate change was not the result a conscious decision of the Late Neolithic people to mediate changes in climate, but a side effect of daily cultural decisions taking place over generations. Where possible social responses to climate change could be detected in the animal based subsistence system, these responses seem to be primarily reinforcing changes that had already been set in motion.

Change is not a new phenomenon but is intrinsic to life on Earth and as we look at the past we often see 'tipping points' where the culmination of an accumulation of small changes can effect a rapid and significant change within a short span of time. Change is not always linear and although some change can be gradual and incremental, many systems in nature show periods of turbulence and instability, associated with dramatic changes. Investigations at Tell Sabi Abyad have revealed evidence for both gradual, incremental changes and such a "tipping point". Earlier I asked the following question of the changes seen occurring at 6225 BC: was this the natural result of the centuries of previous developments seen in the animal based subsistence system or was this transition promoted by degradation in the climate due to the 8.2k event? I would argue that the faunal data suggests it was in all likelihood a mixture of these two factors, with both aspects entangled within a complex culture/environment dynamic.

Chapter 9 Conclusions

“It is impossible to envisage a Neolithic world in any detail without thinking about the conditions in which people, day after day, and from season to season, cooked, ate, gathered, talked, resided, looked after their animals, or moved through and attended to the landscapes which they inhabited.”

(Whittle, 2003: 22)

9.1 Introduction

This study deals with the zooarchaeological analysis of the faunal remains recovered from an area known as Operation III at Tell Sabi Abyad. The preceding chapter concentrates on specific aspects of the animal based subsistence strategies implemented through time at the site of Tell Sabi Abyad in the Late Neolithic, c. 6900 to 5900 BC. In this chapter a concise overview of the main results will be presented. Since chapter 8 already summarises the conclusions drawn, they will not be discussed in detail here. Firstly I will address the research questions once more and briefly review the results of the analysis undertaken in this research. To conclude, some recommendations for future research are presented.

9.2 Reassessing the research questions

The main objectives of this research were to gain a better understanding of animal based subsistence in the Late Neolithic and to explore developments in animal exploitation through the seventh millennium BC. To address these objectives a large sample of faunal material was recorded and analysed using traditional zooarchaeological methodologies. A number of research questions were put forward in the introduction:

- What was the local spectrum of wild and domestic fauna, how and to what extent were these animals exploited and how did this change through time?
- What was the domestication status of the animals exploited and what was the role of domestic animals in the subsistence economy in the different phases?
- How did the composition of herds, the strategies of herd management and animal husbandry develop through time?
- What was the relationship between the fauna and its natural environment?
- Is there any evidence of the effects of climate change in the faunal material?

This section addresses these questions and provides a summary of the main results.

The local spectrum of wild and domestic fauna

The spectrum of wild and domestic fauna was reconstructed using the faunal material uncovered in the settlement levels dated c. 6900 to 5900 BC at Tell Sabi Abyad. Over thirty species were identified but there were clear temporal differences in both the species present and the species proportions. Domestic species predominate (85.5 to 96.7 % of the assemblage), with ovicaprids (in particular sheep) making up the vast majority of the faunal remains in all levels. Domestic pigs are the second most common species in levels A12 to A3 but the proportion of these animals in the assemblage gradually decreases through time (from 16.7 % in levels A12-A10 to just 3.3% in level A1), until the husbandry of these animals is apparently abandoned in level A1. Domestic cattle are the second most common species in levels A2 to C with the proportion of cattle in general increasing through time (from 4.0 % in levels A9-A5 to 24.1% in levels B3-B1). Wild species were always secondary (3.3 to 14.4 % of the assemblage), with onager and goitered gazelle being the most common wild species encountered. In levels A9-A3 a wide range of wild resources were exploited including a variety of bird species and hares. The exploitation of these animals tapers out from level A2 onwards (from 6385 BC).

Animals were central to the Late Neolithic way of life; people were bound closely to both wild and domestic animals on a daily basis. Many of the routines of daily life may have revolved around animals.

Not only were animals an integral part of the subsistence system but it is likely that they were an inseparable part of how identities were constructed. The analysis of the faunal data from Tell Sabi Abyad directly informs us about the role of the different wild and domestic species to the subsistence economy. Understanding the social and symbolic meaning of these animals is more difficult to determine using zooarchaeological analyses alone. Kansa *et al.* (2009b) argue that it is inconceivable that animals did not have some social and symbolic meaning, apart from their basic role as a source of food and materials. Animals are among the rare but striking naturalistic and abstract representations on painted pots in the early sixth millennium, the so called 'Halaf' period. These representations of animals suggest that animals had ideological, symbolic and social meanings beyond their role in the subsistence economy (De France, 2009; Nieuwenhuyse, 2007: 219). Social factors also play a decisive role in the choice of animals, which were not merely chosen for their practicality, or the products they offered, but also for the symbolic weight they carried (Kansa *et al.*, 2009a, 2009b).

Domestication status

The sheep and goats at Tell Sabi Abyad were domestic in all levels, with the domestication of these animals presumably occurring much earlier than the period analysed here (in the PPNB period). These animals formed the foundation of the animal based subsistence system in the Late Neolithic at Tell Sabi Abyad providing meat, milk and fibres. Demographic information, together with secondary evidence from ceramics and direct evidence from residue analysis, suggests that milk production became a clear aim of the husbandry of these animals from c. 6225 BC but the occasional use of milk before this period cannot be discounted. Pigs were also apparently domestic in the earliest levels analysed in the sample, based on both morphological and demographic information. These animals were kept for their meat and fat. Domestic pig husbandry falters c. 6225 BC with the proportion of pig remains rapidly decreasing. The husbandry of these animals apparently either failed or was abandoned in favour of other species at this time. The domestication of cattle appears to have been untaken at the site shortly before 6900 BC. The demographics of the cattle at this time suggest not a wild, hunted population but one of culturally controlled animals, reared and exploited for their meat by the inhabitants of Tell Sabi Abyad. By c. 6225 BC the cattle were clearly far smaller than aurochs and were morphologically domestic. In general, the proportion of cattle increases through time, presumably indicating that these animals became more and more important to the subsistence economy. There is no evidence for the exploitation of cattle for milk production and cattle were apparently raised for prime meat production. Domestic dogs and cats were also present in very low numbers, and these animals may have been merely tolerated scavengers rather than pets¹.

The herds

Herding was obviously an integral part of the animal based subsistence system in the Late Neolithic. In particular sheep and goats were pivotal to the Late Neolithic way of life at Tell Sabi Abyad. Based on the vast quantities of ovicaprid faunal remains encountered in all levels it can be assumed that large numbers of these animals were kept at any one time. Using estimates of human population size and ethnographic information about minimum herd size for subsistence purposes, the number of ovicaprids that may have been necessary to keep was considered, bearing in mind off-take, herd security and the harsh environment. It was speculated that perhaps 600 ovicaprids may have been herded in the A sequence. These animals were probably herded fairly locally; there is no evidence for a highly specialised long distance mobile pastoralism, instead it is likely that a village-based form of herding was practiced with mixed herds of sheep and goats herded some distance away from the settlement, out into the steppe, at least for some periods of the year in order to find good grazing and to avoid the animals damaging cultivated fields. Relatively small numbers of cattle were present in levels A12-A3 with herd size perhaps doubling in level A2 and the B levels. These animals were probably herded closer to the village than the ovicaprids because they need frequent watering and move more slowly. Small herds of pigs were kept in levels A12-A2 and these animals were almost certainly kept around the settlement and in the shelter of

¹ There is certainly no evidence that the remains of these animals were treated any differently to any of the other fauna.

the riverine thickets of the Balikh and the Nahr Turkman, a tributary that originally passed right by the settlement.

The strategy of herd management and animal husbandry was continually developing through time with ovicaprids increasingly being exploited for their secondary products, while cattle husbandry was progressively more targeted towards prime meat production. These animals became the focus of animal based subsistence as part of a developed agro-pastoral way of life. This pastoral lifestyle perhaps led to some elements of the community at Tell Sabi Abyad becoming more mobile through time with, at around 6200 BC, the switch to the almost exclusive exploitation of pastoral animals, the appearance of 'communal storage' buildings and the presence of clay sealings to denote personal property (Operation I), all suggesting increased mobility.

Although domestic animals can be considered nutritionally subordinate to grain crops, these animals were obviously important not only as a source of protein but also manure, hides and fibre, and as storage on the hoof (Halstead, 1996). Livestock were not only a prime form of storage but also vehicles of social interaction and they may have enjoyed a cultural significance beyond that of calorific value (*Ibid*).

Fauna and the natural environment

The exploited animals at Tell Sabi Abyad have different management and habitat requirements and, like all sites of the Neolithic, their relative abundance in the assemblage results from human choices regarding the expected seasonal availability of pasturage and other plant resources around the settlement. The faunal species identified clearly represent the presence of certain ecological niches in the vicinity: steppe, riverine forest, and a river. The seasonal use of animal resources was also explored. There were some clear seasonal patterns identified, hunting for example seems to have taken place primarily in the autumn and winter. In levels A9-A3 (c. 6675 to 6375 BC) a wide range of species from all these environments were exploited but from level A2 (from 6385 BC) onwards hunting appears to be a fairly rare activity that focused almost exclusively on the large game of the steppe, the onager and the goitered gazelle. Whether the change in hunting activity was due to environmental degradation, either anthropogenic or due to climate change, or resource depletion due to over exploitation, or simply a cultural choice to no longer hunt certain species is unclear. What is clear is that over time there was a decrease in both the diversity of wild species exploited and in the role of hunting in the subsistence economy.

Climate change

It was hoped at the beginning of this study that the analysis of the faunal data would facilitate the assessment of the possible effects of the 8.2k event on the inhabitants of Tell Sabi Abyad. Several changes in the animal based subsistence system were approximately concurrent with the peak of this event but demonstrating causality was extremely difficult, partly due to the complexity of the event itself. Many of these changes could trace their roots to the centuries before the zenith of the event although still within the timescale of the broad event. The increasing focus on pastoral animals and possible increase in mobility, the abandonment of pig husbandry, and the focus on secondary product production in ovicaprids could all be seen as coping mechanisms implemented in order to mediate the effects of drought brought on by the 8.2k event. They can however also be seen as general cultural adaptations to living in a marginal environment, regardless of any climate change. Disentangling the intricately interwoven cultural and environmental causes of change through time at Tell Sabi Abyad proved impossible without direct proxy evidence of the effects of the 8.2k event in the Balikh Valley.

As McIntosh *et al.* (2000) eloquently put it: by ignoring the great laboratory of millennia of responses to environmental change we condemn ourselves to reinventing a very complex wheel in the face of one of humanity's greatest challenges. Rather than separating our study of the community from that of its environment, we should be viewing all human action in terms of socio-natural relations (van der Leeuw, 2000). Zooarchaeologists must consider the various roles that animals filled and the choices that people made in difficult circumstances (De France, 2009). We should be aware that while social and economic crisis may seem to provide a satisfactory answer for explaining change, the concept of crisis and collapse

should not be handled too strictly and our explanations need to allow space for slower local and indigenous developments (Verhoeven, 2002b).

Isotope Study

In addition to the above research questions, one of the aims of this project was to assess the possibility of using carbon and nitrogen isotope composition in archaeological bone samples from Operation III to deduce animal husbandry and herding practices at the site. The collagen preservation of the bones was very poor and only 34 samples yielded enough collagen to provide reliable carbon and nitrogen isotope values. Although the dataset was very small, the study did provide information about the diet of these animals allowing tentative interpretations about herding practices at the site through time. In general, a form of pastoralism was taking place that involved moving the ovicaprids around the local landscape where they could feed on a wide range of distinct plant biomasses. The isotope analysis also suggested foddering of the animals was undertaken, particularly in the B levels.

Summary

The aim of this research was to reconstruct the roles animals played in the subsistence economy in the Late Neolithic. With so few comprehensively studied Late Neolithic sites in the Balikh Valley, especially if you only include those with detailed faunal analyses, little was known about the animal based subsistence systems employed in at this time. The new data from Tell Sabi Abyad has significantly added to our knowledge about this period. Previous studies on the fauna at Tell Sabi Abyad, notably that of Cavallo (2000, Operation I), informed us about the animal based subsistence strategy in the early sixth millennium at Tell Sabi Abyad. This study can now be supported by faunal data from the preceding millennium. This new data from Operation III, together with the data from Operation I, allows us to trace developments in animal husbandry from c. 6900 to 5800 BC and to compare the animal based subsistence strategy at Operation III to that at Operation I. The long sequence of shifting occupation on the mound was characterised by a continually developing system of animal husbandry and stock rearing. We can now trace the presence of domestic cattle at this site to around 6900 BC, contemporaneous with the appearance of the first domestic cattle at Tell Sabi Abyad II and at Tell Halula. This suggests that aurochs were first domesticated in this area almost 9000 years ago. We can also trace the first targeted secondary product production to the end of the seventh millennium BC with several lines of evidence, including traditional zooarchaeological studies of demography, ceramic studies and residue analysis, all pointing to the use of some domestic animals for milk production in this period. At Tell Sabi Abyad this is apparently limited to sheep and goats, as it appears was also the case at Tell Damishliyya, Tell Halula and Tell Seker el-Aheimar. This is it seems was a period of 'revolutions' in animal husbandry, but these transformations did not occur over night but materialised slowly over the millennium of study. At Tell Sabi Abyad the appearance of morphologically domestic cattle followed the appearance of culturally controlled cattle by about 700 years. Clearly this was a long and continuous process. The use of ovicaprids for milk and fibre production was presumably also a gradual development.

Archaeologists often employ models in order to try and disentangle the complicated patterns of subsistence strategies of past populations. These models often focus on population, environment and technology to try to predict and explain general changes in subsistence through time (Gumerman, 1997 and references within). All archaeologists can ever do is interpret what remains after people have acted on the world as they perceived it (McIntosh *et al.*, 2000). The long term perspective offered by archaeology has prompted us to focus specifically on the relationship between human populations and their environment. In light of recent research into Holocene climate change, a new direction for archaeology is to see what impact these climate changes had on human populations. Tell Sabi Abyad provided the perfect opportunity to do just that with the 8.2k climate event. Although this event's effects in the Northern Hemisphere were dramatic (see chapter 4) the effects on the climate of the Balikh valley remains undetermined. Analysis of the contemporary levels at Tell Sabi Abyad certainly shows that the effects were not catastrophic – there was no collapse. There were however a great deal of socio-economic and socio-cultural changes coeval with the event. There are of course different reasons for change, and we need to tease out the difference processes involved and reasons behind them. Based on

the faunal data, these changes seem to have their roots in gradual developments seen through the levels with some cultural and economic elements apparently being promoted by a degradation in the environment due to the 8.2k climate event. The people Tell Sabi Abyad did not invent new coping mechanisms, but put more emphasis on certain existing adaptations that came about from living in a marginal landscape. In the face of external stimulus, human agency was put into action. With so few sites in the region spanning the event, it is difficult to develop this site based view into a regional one.

9.3 Recommendations for future study

This study provides a wealth of new information about the economic role of animals at Tell Sabi Abyad c. 6900 to 5900 BC, with the aim of gaining a better understanding of animal exploitation in the Late Neolithic of Northern Syria. There is however, still much to learn about developments in animal husbandry in the seventh millennium BC. More faunal studies are needed from this area and period in order to build up a more comprehensive picture of regional developments in animal exploitation strategies at this time. Such studies will help expand the site based view into a more cohesive region wide view. More accurate chronological frameworks, with comprehensive radiocarbon dates, from other sites are also necessary in order to accurately trace developments between and within sites in the Balikh region and beyond.

Further isotope studies into diet (carbon and nitrogen) and mobility (oxygen and strontium) in the herd animals would be beneficial in analyses of pastoralism and mobility in the Late Neolithic. Although collagen preservation was generally poor, the small sample analysed in this study did show the value of such analyses. Bone and tooth apatite could provide a good alternative to bone collagen, and the isotopic analysis of this material would be a good avenue to pursue in the future.

This study has sought to explore the ways in which Late Neolithic societies subsisted in the relatively marginal environment of the Balikh Valley, also in the context of the 8.2k event, in order to understand how cultures in this period interacted with their environments and how changing environmental conditions may have shaped cultural developments. Tell Sabi Abyad is just one site in this region and the next step will be to look more closely at other sites that span the event. Unfortunately such comprehensively excavated and analysed sites seem to be few and far between. In order to build a comprehensive regional picture, more excavations with a reliable stratigraphic sequence and comprehensive post-excavation analyses, including faunal remains, are needed. What this research project has shown is that even with extremely well dated stratigraphic levels and detailed archaeological studies, it is extremely difficult to prove causality without local proxy data. Proxy climate data from the region should be sought out in order to build-up of picture of exactly what the effects of the 8.2k event were in this area.

Cross-discipline collaborations and discussions provide a much more informed picture of resource exploitation at a site and go beyond basic subsistence, and for this reason this was attempted wherever possible in this research project. This should be continued as excavations continue and more data is analysed and published.

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Samenvatting

Het onderhavige onderzoek maakt deel uit van het onderzoeksprogramma ‘Abrupt Climate Change and Cultural Transformation in Syria in Late Prehistory (c. 6900 - 5900 BC)’, een project onder leiding van Prof. Dr. P. M. M. G. Akkermans en Prof. Dr. J. van der Plicht. In mijn promotieonderzoek bestudeer ik de veranderende relaties tussen mens en dier tijdens het Late Neolithicum op Tell Sabi Abyad, en op hoe deze veranderingen zijn in te passen in het bredere kader van de prehistorie van het oude Nabije Oosten. De prehistorische nederzetting Tell Sabi Abyad bevindt zich in de vallei van het riviertje de Balikh in het noorden van Syrië. De vindplaats ligt ongeveer 30 km ten zuiden van de Turkse grens, bij het huidige dorpje Hammam et-Turkman. De vindplaats Tell Sabi Abyad bestaat eigenlijk uit een groep van vier individuele, vlak naast elkaar ruïneheuvels. De dorpelingen kennen ze als ‘Khirbet Sabi Abyad’. De menselijke bewoning op deze plek gaat terug tot het zevende millennium voor onze jaartelling. Het dierlijke botmateriaal dat de aanleiding was tot mijn studie is afkomstig van de omvangrijke opgravingen op de grootste van de heuvels, Tell Sabi Abyad I.

Het boek bestaat uit negen hoofdstukken, inclusief deze korte introductie (hoofdstuk 1). In hoofdstuk 2 begin ik met een samenvatting van het chronologische en stratigrafische raamwerk. Ik geef een kort overzicht van de bewoningsgeschiedenis in de Balikh vallei, de nederzettingsgeschiedenis van Tell Sabi Abyad en van de op die site opgegraven Neolithische architectuur. Ook komen hier het kenmerkende aardewerk, vuursteen en overige materiele cultuur van deze Laat Neolithische nederzetting kort aan bod. Hoofdstuk 3 behandelt vervolgens de geografische, ecologische, paleobotanische en zooarcheologische achtergrond van de regio en van dit specifieke onderzoeksveld. Hoofdstuk 4 verkent het complexe thema van klimaatsverandering als verklaringsmodel binnen de archeologie. In dit hoofdstuk ga ik uitgebreid in op de specifieke klimaatsverandering die de aanleiding vormde tot het onderzoeksproject, namelijk de ‘8.2 ka climate event’. Wat zouden de mogelijke gevolgen zijn geweest van deze abrupte klimaatsverandering op menselijke samenlevingen en hun leefomgeving in de Balikh vallei? In hoofdstuk 5 vat ik mijn zooarcheologische onderzoeksmethoden samen, en behandel ik enkele methodologische aspecten die tamelijk relevant zijn voor een betrouwbare interpretatie van het botmateriaal, waaronder de taphonomische eigenschappen van het materiaal. Hoofdstuk 6 bevat dan de zooarcheologische analyse zelf. Hoofdstuk 7 bevat een proefonderzoek naar de potentie van isotopenanalyse voor een reconstructie van het dieet van schapen en geiten op prehistorisch Tell Sabi Abyad.

In hoofdstuk 8 kom ik vervolgens tot de interpretatie van de reusachtige hoeveelheid zoologische data samengevat in hoofdstuk 6. In dit hoofdstuk bekijk ik de gegevens wederom in detail, maar nu vanuit verschillende interpretatieve invalshoeken. Aan bod komen achtereenvolgens de veranderingen in diergebruik door de tijd, ruimtelijk verschillen in diergebruik binnen de nederzetting, de domesticatie van diersoorten, strategieën voor het omgaan met en beheren van de kuddes, het gebruik door de mens van de natuurlijke omgeving, de relatie tussen dieren en hun natuurlijke omgeving, verschillende manieren van voedselbereiding, en de “secondary product revolution”. Ik breng deze nieuwe inzichten samen en bespreek hun relevantie voor het bestaande beeld van Tell Sabi Abyad en andere, gelijktijdige site in de regio. Tot besluit bekijk ik de nieuwe inzichten specifiek vanuit het perspectief van de abrupte klimaatsverandering omstreeks 6200 v. Chr.. Was deze klimaatsverandering de drijvende kracht achter culturele verandering? Zowel de argumenten vóór alsook de argumenten tégen komen in dit hoofdstuk uitgebreid aan de orde. In hoofdstuk 9 kom ik tot besluit terug op de onderzoeksvragen zoals deze in dit eerste hoofdstuk zijn verwoord, op basis van mijn resultaten samengevat in de eerdere hoofdstukken. Ik kom tot samenvattende conclusies, en ik geef aan waar interessante nieuwe mogelijkheden liggen voor vervolgonderzoek.

Binnen deze studie is ruim 170 kg aan botmateriaal bestudeerd, in totaal maar liefst 48,802 botfragmenten. Ik heb deze grote hoeveelheid materiaal geanalyseerd met behulp van gangbare methoden in het vakgebied van de zooarcheologie, om daarmee de volgende onderzoeksvragen te kunnen beantwoorden:

- Uit welke soorten bestond het repertoire aan wilde en gedomesticeerde dieren op Tell Sabi Abyad? Hoe, en in welke mate, werden deze dieren door de mens geëxploiteerd, en hoe veranderde dit in de loop van de tijd?
- In welke mate waren de diersoorten aangetroffen op Tell Sabi Abyad gedomesticeerd? Wat was de rol van gedomesticeerde dieren in de bestaanseconomie van de nederzetting in haar verschillende bewoningsfasen?
- Welke ontwikkelingen kunnen we waarnemen in de samenstelling van de kuddes en in de wijze waarop specifieke dieren gehouden werden?
- Hoe verhieldden de dieren die we in deze nederzetting aantreffen zich tot hun natuurlijke omgeving?
- Welke aantoonbare gevolgen had klimaatsverandering rond 6200 v. Chr. op het diergebruik in de prehistorische nederzetting Tell Sabi Abyad?

Het primaire doel van het onderzoek was een reconstructie van de rol van verschillende diersoorten in de bestaanseconomie tijdens het Late Neolithicum. In de Balikh vallei zijn nog maar weinig prehistorische nederzettingen in enig detail archeologisch onderzocht. Goede studies van het dierlijke botmateriaal uit het Late Neolithicum zijn nog buitengewoon schaars. Ons beeld van de economische en culturele betekenis van specifieke dieren in deze periode is dan ook uiterst beperkt. De opgravingen op Tell Sabi Abyad zijn in dit opzicht een buitengewoon belangrijke stap vooruit. Eerdere faunanalyses, in het bijzonder die van Cavallo (2000, Operation I), hadden al tot baanbrekende nieuwe inzichten geleid met betrekking tot het vroege zesde millennium op Tell Sabi Abyad. Dit werk kan nu worden aangevuld met deze studie, die het voorafgaande millennium bestrijkt. Door de resultaten van Operation III samen te voegen met die van Operation I kunnen we deze onderling zo verschillende nederzettingen met elkaar vergelijken. We krijgen zodoende zicht op veranderingen in diergebruik vanaf omstreeks 6900 tot 5800 v. Chr.

De lange, dynamische bewoningsgeschiedenis op de ruïneheuvel van Tell Sabi Abyad laat een geleidelijke ontwikkeling zien in de richting van steeds toenemende controle over het gedrag van dieren. De allervroegste aanwijzingen voor het optreden van het gedomesticeerde rund kunnen we momenteel traceren tot omstreeks 6900 v. Chr. Dat is gelijktijdig met het verschijnen van het gedomesticeerde rund op andere nederzettingen, waaronder Tell Sabi Abyad II en Tell Halula. Klaarblijkelijk werd de oeros in deze regio omstreeks 9000 jaar geleden voor het eerst gedomesticeerd. Aan het einde van het 7^e millennium v. Chr. zien we eveneens de eerste sporen van een doelbewust gebruik maken van de “secondary products”. Aanwijzingen hiervoor vinden we in de leeftijdscurven van dieren, in residuensporen op aardewerk en in de aardewerktypologie. Alles wijst erop dat in elk geval een deel van de dieren in deze tijd werd gehouden vanwege de productie van melk en daarvan afgeleide producten. Het lijkt erop dat op Tell Sabi Abyad de melkproductie zich beperkte tot schaap en geit, net als op Tell Damishliyya, Tell Halula en Tell Seker el-Aheimar.

Hoewel we hier weliswaar te maken hebben met een ware “revolutie” in de rol van bepaalde dieren, is het belangrijk dat we ons realiseren dat deze transformatie zeker niet van de ene dag op de andere tot stand kwam. Zij ontwikkelde zich zeer geleidelijk, over een tijdspanne van ongeveer een millennium. Op Tell Sabi Abyad is het morfologisch gedomesticeerde rund duidelijk aanwezig pas ongeveer 700 jaar ná de vroegste aanwijzingen voor menselijke controle over zijn wilde voorganger, de Oeros. Het moge duidelijk zijn dat we hier te maken hebben met een langdurig en gradueel proces. We mogen aannemen dat het aanwenden van schapen en geiten voor hun melk en wol op soortgelijke wijze eveneens een zeer graduele ontwikkeling was.

Archeologen maken graag gebruik van modellen om orde te scheppen in de chaos van ruwe gegevens met betrekking tot de bestaans economie van samenlevingen in het verre verleden. Deze modellen benadrukken dikwijls thema's als populatie, omgeving en technologie, om met behulp van deze factoren brede economische veranderingen te voorspellen, en zelfs te verklaren (Gumerman, 1997 en verwijzingen). Archeologen zijn in hun interpretaties doorgaans helaas gedwongen genoeg te nemen met het vaak zeer povere dat mensen ons nalieten, lang nadat zij in het verre verleden leefden in de wereld zoals zij die zelf waarnamen (McIntosh *et al.*, 2000). Het lange-termijn perspectief van de archeologie leidt daarmee dikwijls tot een sterke thematische nadruk op de samenhang tussen menselijke culturen en hun natuurlijke omgeving. Het recente onderzoek naar klimaatsverandering tijdens het Holoceen heeft geleid tot de opkomst van een nieuwe onderzoeksrichting in de archeologie, een stroming die zich nadrukkelijk richt op de mogelijke effecten van zulke klimaatsveranderingen op menselijke samenlevingen. De opgravingen op Tell Sabi Abyad bieden de perfecte gelegenheid dit thema te benaderen met betrekking tot de '8.2 ka climate event'.

Ofschoon de effecten van deze klimaatschommeling in de noordelijke hemisfeer aanzienlijk waren (hoofdstuk 4), hebben we tot op heden geen duidelijk beeld van de mogelijke effecten in de Balikh vallei. De bestudering van de relevante bewoningsniveaus op Tell Sabi Abyad laat echter zien dat deze effecten in elk geval verre van catastrofaal waren: er was allerm minst sprake van een complete sociale en economische "ondergang". Zeker, uit de studie blijkt dat aanzienlijke sociaal-economische en culturele veranderingen samenvielen met de '8.2 ka climate event'. Maar aangezien meerdere, onderling zeer verschillende factoren bij de verklaring van deze veranderingen een rol spelen, zullen we uiterst zorgvuldig, stap voor stap het complexe proces van oorzaak en gevolg moeten ontrafelen. Wanneer we nu de resultaten van het archeozoologische onderzoek in aanmerking nemen, lijken deze veranderingen hun wortels te hebben in tamelijk geleidelijke economische en culturele aanpassingen, die al lang voor de klimaatsverandering een aanvang namen. De periode omstreeks 6200 v. Chr. was gekenmerkt door een versnelde intensivering van deze processen, en het is goed denkbaar dat ecologische degradatie van de omgeving veroorzaakt door van de '8.2 ka climate event' dit proces stimuleerde. De bewoners van Tell Sabi Abyad ontwikkelden echter niet plotseling volstrekt nieuwe overlevingsstrategieën om de klimaatsveranderingen het hoofd te bieden. Zij maakten intensiever gebruik van lang bestaande culturele en economische praktijken, strategieën die het hen in het daaraan voorafgaande millennium mogelijk hadden gemaakt in een marginaal steppe landschap een succesvol bestaan op te bouwen. Geconfronteerd met een externe bedreiging – klimaatsverandering – gaf strategisch menselijk handelen – agency – de doorslag: de Laat-Neolithische bewoners van Tell Sabi Abyad overleefde, floreerden zelfs. Of zij daarmee uniek waren laat zich momenteel moeilijk vaststellen. Het zeer geringe aantal opgravingen in het Midden Oosten waar deze cruciale tijdsperiode wordt gedocumenteerd maakt het lastig om de inzichten van Tell Sabi Abyad te vertalen naar een breder, regio overkoepelend kader.