Scourge or Sustenance: Using microfauna to explore the palaeoenvironment and palaeoeconomics of Epipalaeolithic and early Neolithic communities in Anatolia

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Abstract

Microfaunal assemblages from three important sites in Central Anatolia which straddle the end of the Pleistocene and the beginning of the Holocene were analysed. The sites studied were: Çatalhöyük, a large proto-urban settlement (c7100-5950 cal. BCE); Boncuklu Höyük, a small early Neolithic village (c8300-7800 cal. BCE), and Pınarbaşı, a transitory rock-shelter site (14150-11000 cal. BCE), with a settled early Neolithic settlement (9800-7800 cal. BCE), and a transitory late Neolithic phase (6500-6000 cal. BCE).

The assemblages were analysed in order to: reconstruct the palaeoenvironment; identify whether microfauna were used as part of a broad-spectrum economy; determine if anthrodependent species such as the house mouse were present at either Boncuklu or Pınarbaşı indicating sedentism, and to establish if any of the species recovered were utilised in ritual practices, as has been previously noted at Çatalhöyük.

The assemblages from Çatalhöyük and Boncuklu were not suitable for palaeoenvironmental reconstruction because of the impact of humans on the assemblage accumulation. At Çatalhöyük, the proto-urban nature of the settlement created an anthrodependent niche which was exploited by the house mouse, almost to the exclusion of all other species. At Boncuklu, the assemblage was dominated by frogs, with taphonomic evidence showing they were part of the human diet. As such, neither of these assemblages was necessarily indicative of the local ecology. The seasonally occupied, Epipalaeolithic levels at Pınarbaşı were more reflective of the species present in the ecotonal rock-shelter site, however the early Neolithic settlement also showed evidence of frog consumption.

The microfaunal assemblages from Boncuklu and the early Neolithic phase of occupation at Pınarbaşı provided conclusive evidence that frogs were being eaten. At Boncuklu, anura remains were also recovered from human coprolite samples, providing direct evidence of consumption. Taphonomic signatures on water voles at Boncuklu, and snakes at Epipalaeolithic Pınarbaşı also suggest that these animals were being eaten by people.

Further ritual incorporation of scats into burials was not found during this round of research, however curation of the scats of small carnivores by people is evidenced by

anthropogenic contexts with high numbers of microfauna, such as niche infill. Whether the small carnivore scats were collected for a ritual purpose, or a mundane one remains unknown, however the practice was not widespread and appears to be spatially restricted.

At Boncuklu, mice were recovered in small numbers from building contexts, and geometric morphometric analysis showed these to be house mice, making them the earliest house mice specimens in Anatolia, pre-dating those at Çatalhöyük by over 1000 years. Evidence for human impact on house mouse populations at Çatalhöyük were also discovered, with specimens from a single building exhibiting molar shape change consistent with that of an isolated island population.

The analysis of these assemblages has shown that microfauna can provide a significant level of information, not only on the palaeoenvironment, but on how people utilised these animals as food resources, the effects settlements had on the wider landscape with habitat partitioning taking effect, and the impact these small animals had on settlements as pest species.

Table of Contents

List of Figures

List of Tables

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Due to restrictions caused by the global Covid-19 pandemic, Geometric Morphometric analysis (GMM) was carried out by Dr Katerina Papayiannis, University of Athens, based on photographs and measurements supplied by myself.

1. Introduction

Microfaunal assemblages are a valuable resource under-utilised in archaeology due to the need for a sound sampling strategy, a lack of specialist knowledge, and access to comparative material. Microfauna are a diverse group of small animals under 5kg in weight (Andrews 1990), and can provide a whole suite of information about the local ecology, how humans utilise settlements and exploit the wider landscape, past diets and human movement and trade exchange.

Small mammals, amphibians, and squamates can represent a high proportion of species richness within an ecosystem (Denys *et al*. 2017, Fernandez-Jalvo *et al*. 2016) and due to their small body size, tend to have low tolerances to environmental stress (Avery 1982). Their presence can therefore be used to estimate vegetation coverage, precipitation levels, and temperature of the local habitats (Avery 1982).

Microfauna also forms part of the human diet, both in the past and in present day, with frogs, amongst other species, still being widely eaten as a delicacy around the world. Their inclusion and depiction in religious practices shows microfauna can be viewed with both positive and negative attitudes. However, most modern communities consider them serious pests, as exemplified by the devastating mouse plagues that occur on agricultural sites in Australia (Joosse 2021). However, to understand the importance of microfauna on archaeological sites the method of deposition of the assemblage must be understood in order to remove any bias (Andrews 1990).

Predation is often stated as the main cause of microfaunal accumulations on archaeological sites (Denys et al 2017), and so to use microfauna as palaeoenvironmental proxies, an understanding of the predator is required in order to strip away any bias and ensure the assemblage is indicative of the surrounding habitat (Avery 1982: Andrews 1990). Much work has been done on recognising the taphonomic signatures of predation on small mammals (Mellet 1974; Mayhew 1977; Andrews 1990; Fernandez- Jalvo and Andrews 1992; 2003; Terry 2007), however other microvertebrate species, for example herpetofauna, have not received the same amount of study (Denys et al 2017; Lev et al 2020). As well as predation, other taphonomic processes must be taken into account as accumulators of microfaunal bones, for

example fluvial transport (Korth 1979), as well as the effect of assemblage recovery (Andrews 1990).

In addition to reconstructing past environments, microvertebrate assemblages can be used to examine human impact on the environment, for example large scale deforestation (Vigne and Vallidas 1996), or to establish phases of increasing urbanisation or abandonment of sites (O'Connor 2013). Human settlements can provide protection from predators, access to stored food, as well as reduced competition with other species (Tchernov 1991a). Certain species of microfauna, such as small commensals, like house mice, can also be used to examine sedentism in early communities, due to habitat partitioning and the niches created by human occupation of the landscape that allow these animals to out-compete other species (Weissbrod et al. 2017). These creatures have also been spread around the world by people, and so by examining their aDNA, we can use certain small mammals to explore human dispersal patterns in the past (Cucchi et al. 2020). Unfortunately, commensals, such as mice, carry diseases, and can be responsible for damage to property, and can destroy crops and food stores (Meyer 1994), so there may also be the potential for indications of whether the inhabitants of a site undertook pest control, for example in traps, or the eventual domestication of certain species like cats or ferrets.

The microfaunal assemblages that are the focus of this thesis come from three important and well-excavated archaeological sites in Central Anatolia, Turkey. A more extensive examination of the archaeology of these sites can be found in Chapter 2.

Çatalhöyük is a UNESCO World Heritage site and large proto-urban settlement dating to 7100-5700 cal. BCE (with Çatalhöyük East dating to 7100-5950 cal. BCE). It comprises two tells that rise 21 metres above the Konya plain, and which so far has revealed 18 levels of Neolithic occupation (Hodder 2021). It provides unique evidence of large scale sedentism and cultural practices of early agricultural Neolithic life, and is seen as a key site for understanding human prehistory.

Boncuklu is held as being one of the earliest villages in Central Anatolia, dating to 8300-7800 cal. BCE. It lies approximately 9.5km north of Çatalhöyük and contains some of the earliest houses showing decoration, in the form of painted clay and plaster relief, including plastered cattle skulls (Baird 2016; Spataro *et al*. 2017).

Pınarbaşı is a multi-phase settlement dating from the Epipalaeolithic (14150-11000 cal. BCE); to the Early Neolithic (9800-7800 cal. BCE) and the late Neolithic (6500-6000 cal. BCE). It lies approximately 32 km to the southeast of Çatalhöyük.

By comparing the microfaunal assemblages from these three important central Anatolian sites, this research will contribute new information about the palaeoenvironment of each site. It also has the potential to provide new insights on indicators of sedentism, the use of space within the sites, ritual practices within the locale, and whether small vertebrates formed part of any subsistence economies.

1.1. Aims and Objectives

Aim 1: Reconstruct the palaeoenvironments of each site to determine under what environmental conditions the occupants were living.

Aim 2: Establish whether microfauna were part of a broad-spectrum subsistence economy at any of the three sites.

Aim 3: Identify any ritual behaviour across the sites, such as the previously discovered deliberate deposition of predator scats in human burials at Çatalhöyük, and whether further analysis can help to identify the motivations for the ritual practices.

Aim 4: Determine if human commensals can be found at Pınarbaşı and/or Boncuklu, and whether they can therefore be used as identifiers of sedentism.

Objective 1: Undertake taxonomic and taphonomic assessment of the three microvertebrate assemblages in order to analyse the microfauna by context, feature type, and phase, for each of the sites.

Objective 2: Analyse data to determine how the assemblage was derived.

Objective 3: Compare the microfaunal assemblages from the three sites in order to determine any similarities or differences that could aid environmental reconstruction.

Objective 4: Undertake geometric morphometrics of the *Mus* sp. teeth from Boncuklu and/or Pınarbaşı to determine whether the commensal species (*Mus musculus domesticus*) is present.

1.2. Thesis Structure

This chapter introduces the research aims and objectives of this study. Chapter 2 provides background information on the archaeological sites of Çatalhöyük, Boncuklu, and Pınarbaşı, including a brief background on the architectural, economic, and social organisation, highlighting the similarities and differences of each site. This chapter also provides a reconstruction of the palaeoenvironment of the Konya Plain, Central Anatolia, in which all three sites are located.

Chapter 3 examines the role of taphonomy in microfaunal analysis and the ways it can be used to strip away the biases introduced into assemblages by human and/or predator agency, to determine the depositional pathway of the microfauna under study.

Chapter 4 focuses on how microfauna can be used by the archaeologist to examine how people utilised the landscape around them, as well as how individual species have been perceived and utilised by people around the world through time. This includes using microfauna to reconstruct past ecologies; their use in past and current human diets around the world; their incorporation into religious practices, both past and present, and the use of microfauna in ritual; as well as how certain species, such as the house mouse, can be used to explore human settlement and dispersal around the globe.

In Chapter 5 the methodology for the study of the three microfaunal assemblages is outlined, including methodologies for a full taxonomic and taphonomic approach. The Results (Chapter 6) are presented for each site, followed by a discussion (Chapter 7) that brings together the key results in order to explore the sites in greater detail (Part 1), as well as the aims of this thesis (Part 2). The main conclusions of this study, as well as scope for further work can be found in Chapter 8.

2. Sites and Study Area

2.1. Introduction

Çatalhöyük, Boncuklu, and Pınarbaşı, the three sites examined for this thesis, are located close to each other on the Konya Plain in Central Anatolia (Figure 2.1), with Boncuklu 9.5 km northeast of Çatalhöyük, and 33.4 km northwest of Pınarbaşı (Yak 2021).

The Konya Plain is a large, marl-filled, closed karstic lake bed approximately 1000 metres above sea level, located to the south of the Central Anatolian Plateau (Figure 2.1) (Reed *et al*. 1999; Ayala *et al*. 2017). The current climate of the region is semi-arid, with an average of 300mm of rainfall annually, with the summer months drier than the winter months (Kuzucuoglu *et al*. 1999; Rosen and Roberts 2005).

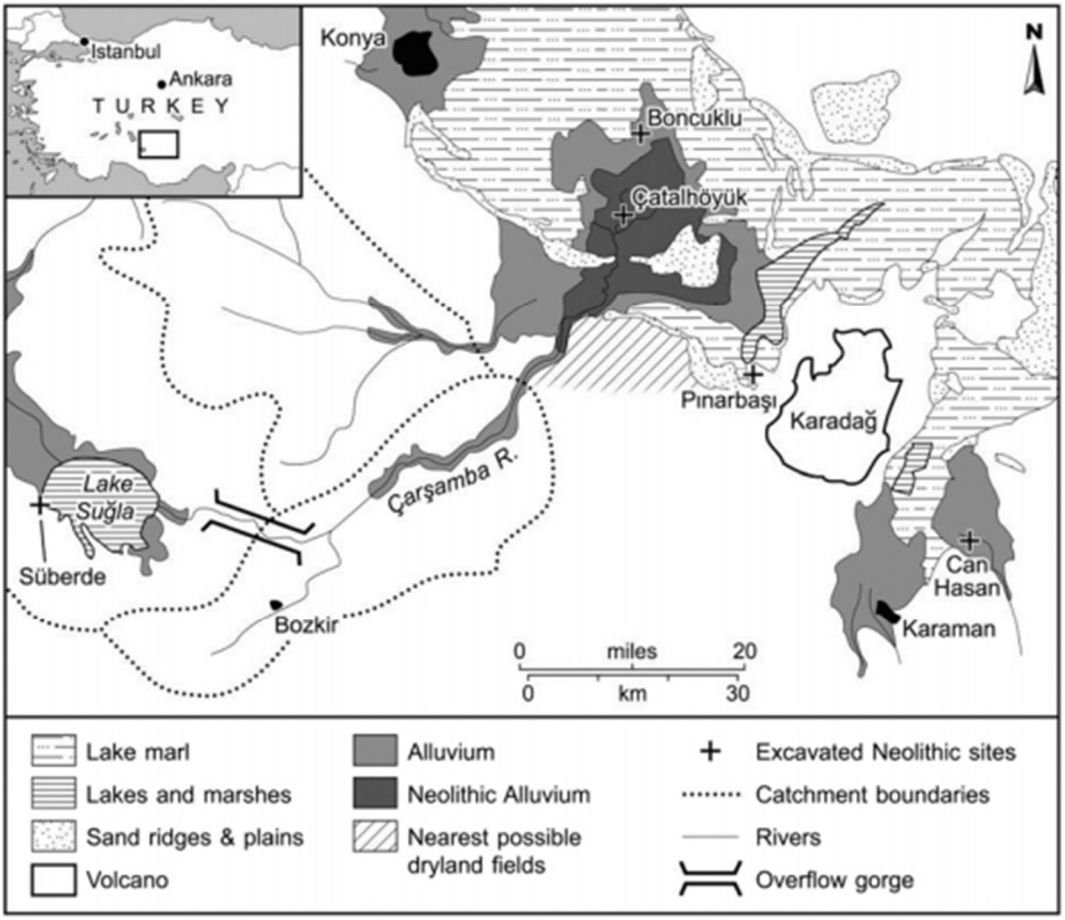

Figure 2.1 Map of central Anatolia showing the Neolithic sites of Pınarbaşı, Boncuklu, and Catalhoyuk (taken from Baird et al. 2018:3)

2.2. Palaeoenvironmental Reconstruction of the Konya Plain

Palaeoenvironmental reconstruction of the Konya Plain has been studied extensively, with many strands of evidence, or proxies, being employed in order to understand the regional climatic and ecological changes from the Pleistocene to the Holocene. Palaeoenvironmental proxies and the method for palaeoenvironmental reconstruction in general can be found in sub-chapter 4.1.

The lake that once dominated this landscape was fed by rivers whose catchment areas were predominantly over the Taurus Mountains that lie to the south of the region, as well as melt waters coming from the range (Fontugne *et al*. 1999). As the palaeo-lake was a non-outlet system, changes in ground water, surface run-off, and precipitation can be identified in the sedimentology, and allow for the reconstruction of palaeoclimatic variations over time. Radiometric dating of sediment cores taken from Suleymanhaci gölü, Pınarbaşı, and Akgöl, has aided in dating the stratigraphy of the Konya Basin, which in turn has helped to identify and date the life span of the palaeo-lake to ca. 23-17 ka (Fontugne *et al*. 1999; Roberts *et al*. 1999). Sedimentary, diatom, and ostracod analyses of these cores also revealed that while the Suleymanhaci gölü site may have been more brackish, Pınarbaşı was a fresh water site, with Akgöl varying between fresh to slightly brackish. All three showed evidence that the palaeo-lake was shallow, with a maximum depth of approximately 25 m (Fontugne *et al*. 1999). Diatom, and associated oxygen isotope analysis indicated that prior to ca. 23 ka there was an arid phase of low lake levels with high evaporation rates. This analysis also evidenced a higher lake level indicative of increased humidity levels at the end of the Pleistocene. This was then followed by an increase in salinity with a reduction in lake levels which may have been caused by human activity in association with high rates of evaporation during the Holocene (Reed *et al*. 1999).

The Late Pleistocene-early Holocene transition, globally, was characterised by large-scale shifts in climate and vegetation that framed anthropogenic socio-economic shifts (Asouti and Kabukcu 2014). Widespread cooling during the 8.2 ka cold event in the Northern Hemisphere, first recorded in the Greenland ice core records (Thomas *et al*. 2007; Matero *et al*. 2017), may have caused long-term climate stress and could therefore have influenced cultural changes for people inhabiting the Konya Plain that may be visible in the archaeological record (Lewis *et al*. 2017). Analysis of sediment

cores from the alluvial landscape near Çatalhöyük, has suggested that lake deposition ended in the later Pleistocene and that local variations in the depth of the marl may indicate periods of erosion (Ayala *et al*. 2017). There was also evidence of pits dug for extraction of the Pleistocene clay beneath the marl in order to produce mud bricks for Çatalhöyük. This in itself informed on the seasonality of the site, as the lack of flood deposits in the extraction pits indicated the absence of seasonal floods in the local area (Ayala *et al*. 2017).

The analysis of charcoal to determine long-term vegetation change has also recently been used to reconstruct the palaeoclimate of the Konya Basin (Kabukcu 2017). Samples were taken from well-dated contexts on archaeological sites that spanned the period from the Late Pleistocene through to the mid-Holocene. Samples of charcoal were taken from Epipalaeolithic Pınarbaşı (14^{th}-12^{th} millennium cal. BCE) through to chalcolithic Çatalhöyük (7^{th}-6^{th} millennium cal. BCE) (Kabukcu 2017). The anthracological samples provided evidence for the development of woodlands following the end of the Late Glacial Maximum (LGM), at the end of the Pleistocene, when the climate became warmer and wetter. The charcoal analysis showed the spread of *Juniperus, Pistacia*, and *Amygdalus* into the area, which was not evident in the off-site pollen record (Eski Acıgöl, Akgöl and Nar lake) for this area (Kabukcu, 2017). Anthracology also allows for the analysis of anthropogenic woodland exploitation and human impact on the environment (Kabukcu, 2017; Asouti and Hather, 2001).

Isotopic analysis of *Unio* shells, recovered from archaeological contexts at Çatalhöyük showed that between 7150-600 cal. BCE there were seasonal cycles of wet winters and dry, evaporative summers (Lewis *et al*. 2017). This was calculated by measuring differing levels of $\delta^{13}C$ and $\delta^{18}O$ isotopes in the shells, that were most likely collected from the wetlands close to the site. Low $\delta^{18}O_{shell}$ values suggest high precipitation levels in winter, with high $\delta^{18}O_{shell}$ values reflecting higher rates of evaporation in summer (Lewis *et al*. 2017). As such, isotopic analysis of the freshwater molluscs that would have lived in close proximity to the site, have also been used to draw conclusions regarding the seasonality of the broader palaeoenvironment of the Konya Basin (Lewis *et al*. 2017). The shells also provided evidence of a significant seasonal climate shift in the early Holocene, by way of a reduction in the contrast between the summer and winter months at the same time as the 8.2 KA event.

2.3. Çatalhöyük

2.3.1. Introduction and Dating

Çatalhöyük is a UNESCO World Heritage site, known for its density of buildings and rich art and symbolism. The site is large, covering 13.5 hectares, rising 21m above the Konya Plain, with 18 levels of occupation identified, and was inhabited for 1,500 years (Figure 2.2). The site has been radiocarbon dated to 7100 – 5950 cal. BCE (Bayliss *et al.* 2015; Der and Issavi 2017). At its peak, it had a dense population of over 1000 people (Hodder 2021).

Figure 2.2 Site plan of Catalhoyuk showing the areas of excavation on the east and west mound (Taken from Hodder 2013:7)

The site was discovered in 1958 by James Mellaart, David French, and Alan Hall and was initially excavated in the early 1960's by Mellaart (Mellaart 1962; 1963; 1964; 1965; 1966; 1967). Excavation began again at the site in 1995 under Ian Hodder, and is still ongoing following a change in leadership in 2018.

Mellaart's excavations focussed on the South Area of the East Mound, with the stratigraphy separated in levels from 0 to XII. However, during the early excavations by Hodder it became clear that these sequences were insufficient, and so new systems of levels were introduced based on the stratigraphy within the distinct areas of excavation, e.g., South, North, IST, and TP Areas (Hodder 2021). These levels were not stratigraphically linked between areas, and so temporal groupings were used in order to understand relationships across the site. Radiocarbon dating and Bayesian analysis was used to date these groupings (Table 2.1).

Table 2.1 Chronology for the levels at Çatalhöyük East for North and South Areas (Hodder 2021: 11)

Temporal grouplings of levels	***South***	***North***	***Cal BC***
Final	TP.O-R and TPC Trenches 1 & 2 (B.109 and 115)		6300-5950 BCE
Late	GDN	North.H, I, J and IST	6500-6300 BCE
	South.T, TP.N, TPC B110 and B150		
	South.S, TP.M, TPC B150 and B122		
	South.R		
	South.Q		
	South.P		
Middle	South.O	North.F, G	6700-6500 BCE
	South.N		
	South.M		
Early	South.L		7100-6700 BCE
	South.K		
	South.J		
	South.I		
	South.H		
	South.G		

The material examined for this thesis came from the 2008-2017 fieldwork seasons, under Ian Hodder and focuses on the Çatalhöyük East mound only (Feider and Jenkins 2021).

2.3.2. Architectural Organisation

The buildings at Çatalhöyük were rectilinear and made of mudbrick. Unlike the structures at Boncuklu and Pınarbaşı, the buildings were not semi-subterranean.

Instead, they were densely packed with access via a ladder from the roof (Figure 2.3). Like the houses at Boncuklu they had a delineated internal use of space, with 'dirty' areas, that included the spaces with the ovens and hearths, and 'clean' spaces on raised platforms. Many of the houses have side rooms which contain built-in storage bins, containing food items such as cereal grains and peas (Twiss *et al*. 2009). Walls were generally not shared between houses, but abutted each other, occasionally with a small space, that might have been used as a midden or yard area (Der and Issavi 2017). A continuity of location, or ancestral space, is also seen at Çatalhöyük. Following abandonment and demolition, buildings were often built over the footprint of the previous houses. Throughout the occupation of the house, it was continually being replastered and repainted, with internal features, such as platforms, benches, ovens etc., being remodelled, added, or removed (Russell *et al*. 2014).

All of the buildings at Çatalhöyük have been interpreted by Hodder as houses, and there is no evidence so far for social hierarchy, for example the presence of high-status individuals, or those whose burials appear more favoured (Hodder 2021).

Figure 2.3 Representation of a house at Çatalhöyük, showing the internal delineations of space, sub-platform burials, location of the oven, and entry via the roof (taken from http://www.catalhoyuk.com)

2.3.3. Economic Organisation

The faunal assemblage at Çatalhöyük is dominated by domesticated sheep/goats, at a ratio of five sheep to one goat (Wolfhagen *et al* 2021). However, as cattle provide much more meat than sheep/goat the numbers represented by NISP may not accurately reflect

the dietary contribution of each animal (Russell *et al*. 2013). It has been suggested that ovicaprines and cattle were utilised differently, and that ovicaprines were used as a daily food item, whereas cattle were consumed during feasting (Russell *et al*. 2013). Oxygen stable isotopes and microwear analysis on the teeth of ovicaprines, suggest that herding remained on the Konya Plain rather than moving further afield (Wolfhagen *et al*. 2021).

There has always been a question as to whether the cattle at Çatalhöyük were wild or domestic, and if domestic, when this domestication event took place? Measurements of bones have now shown that the large size of the bovids in the early phases of occupation at the site were consistent in size with aurochs, the wild cattle, and remain so through the majority of the occupation of the site. In the later levels at Çatalhöyük, the size of the cattle remains are reduced, suggesting that domestication of cattle did not take place until the final period of occupation of the east mound (Arbuckle and Makarewicz 2009; Twiss *et al*. 2021).

Dogs were also present on site, only occasionally as a food item, and the low incidence of gnawing suggests dogs were low in number at any one time. Wolf remains were identified, but were rare and restricted to foot bones, suggesting skins rather than actual animals were represented (Twiss *et al.* 2021). Other animals recovered include wild equids, foxes, badgers, and a very limited number of hares and cats, including a burial of a kitten in Building 160 (Twiss *et al*.2021). Bear remains were also recovered but were limited to a single set of front and hind paws, suggesting they were from the same skin (Twiss *et al.* 2021) as well as single leopard claw that had been used as part of a pendant (Hodder 2006).

Wild boar remains were recovered in very low numbers, despite the close proximity to the wetlands and presence of crops, and appeared to serve a more symbolic purpose than a dietary one. Tusks have been recovered showing they were worn as collars, or beads, and boar remains were also used in installations, despite not featuring highly in the diet, if at all (Twiss *et al.* 2021).

Cereal grain and chaff are evident even in the earliest levels at Çatalhöyük, and include wild einkorn, emmer wheat, and barley. Whilst cereals dominate the assemblage, pea, lentil, bitter vetch, grass pea, chick pea and mustard were also identified, as well as pistachio, acorn, hackberry fruits, and almond, which although wild were most likely

managed (Bogaard *et al.* 2017). Glume (hulled) wheat grains dominated the assemblage in the early levels, transitioning to a mix of glume wheat, free-threshing wheat, and naked barley in the mid-levels, (Table 2.1). Naked barley then becomes the dominant taxon in the later levels, with the final levels also seeing the presence of hulled barley grains (Bogaard *et al*. 2021).

Plants were also used to make mats and baskets, identified through phytolith evidence, some of which were also incorporated into burials (Santiago-Marrero *et al*. 2021).

2.3.4. Social Organisation

Over 800 individual burials have been recovered during the 1995-2017 excavation seasons, providing a wealth of data to examine Neolithic mortuary practices at the site. The vast majority of the burials took place within the buildings, beneath the platforms, although there was slightly more variation in burials for the very young (Haddow *et al*. 2021). There is evidence at Çatalhöyük, that the bodies were bound and wrapped, and placed on mats or in baskets before burial (Hamilton 2005; Vasić *et al*. 2021). Grave goods included beads, jewellery, worked bones, chipped stone, pouches, and *Unio* shells, as well as red, blue, and green pigments (Vasić *et al*. 2021).

During abandonment and closure of the houses, some were intentionally burnt, which led to extraordinary levels of preservation of the sub-platform burials. Organic remains were preserved *in-situ*, and included textiles, wooden bowls, cord, animal hide, basketry, reed matting, and even carbonised human soft tissue (Haddow *et al*. 2021). In other, unburnt burials, basketry, matting, and cord has been identified via phytolith evidence (Rosen 2005; Boz and Hager 2013; Ryan 2013).

Skull removal was also practised at this site, with evidence of crania removed from primary burials following partial or full decomposition, as well as additional skulls placed into other burials (Andrews *et al.* 2005; Haddow *et al*. 2021).

Elaborate wall paintings, plaster installations, and bucrania also occur within the 'clean' areas of the buildings, above the raised platforms (Czeszewska *et al*. 2014). Many of the painted wall decorations are geometric motifs. Some also include prints of human hands, and zoomorphic images (Figure 2.4), although these are less frequent than the geometric designs (Czeszewska *et al*. 2014). Bucrania have been uncovered at

Çatalhöyük ever since the early excavations by Mellaart, and have been set into walls, and structural installations such as platforms and benches (Russell and Martin 2005). Chipped stone at Catalhoyuk is primarily made from obsidian (90% of the assemblage), with the nearest obsidian sources being approximately 190km away in southern Cappadocia (Düring 2007), with an estimated return journey time of 10-13 days (Cessford and Carter 2005).

Figure 2.4 Reproduction of a building at Çatalhöyük, showing a replica of the wall art from Building V.1 uncovered during Mellaart's excavations. The image depicts the hunting of an aurochs. To the far left of the picture, an opening into a storage area can be seen (Photo: M. Feider 2018).

2.4. Boncuklu

2.4.1. Introduction and Dating

Boncuklu was originally discovered in 2001 as part of the Konya Plain Survey, with surface finds suggesting the presence of a 9th-8th millennium BCE settlement (Figure 2.5). Boncuklu was deemed a site at risk due to the ploughing and bulldozing that was taking place on the mound at the time. The mound now stands 2 m above the plain (Figure 2.6), and is approximately 1 ha in size (Baird *et al*. 2012).

Figure 2.5 View from the live site across to Boncuklu Höyük. The tents visible are covering the open trenches (Photo: M. Feider 2018)

A field Season began in 2006 with site surveying, surface scraping, and two preliminary trench excavations, the beginning of a 10-year excavation project (Baird *et al*. 2012). Based on the similarity of the lithics assemblages from Boncuklu with those from Musular (7600-700 cal. BCE), Canhasan III (7400-7100 cal. BCE), and early levels at Çatalhöyük (7100-7000 cal. BCE) it is likely that the settlement was occupied after 7600 cal. BCE. However, it is not possible to date the end of occupation because the later levels have been eroded (Baird *et al*. 2018).

Figure 2.6 Site plan of Boncuklu showing the location of trenches (Taken from Baird et al. 2018 Supplemental Information Appendix Figure S4). The Visitor Centre and the building reproductions are off to the right of the excavated area.

Table 2.2 Calibrated radiocarbon dates for Area H at Boncuklu (Baird et al. 2018)

Area H	
	cal. BCE
Late	7952-7711
Early	8462-8271

Samples from the site have been radiocarbon dated to 8300-7800 cal. BCE (Table 2.2), however, erosion and ploughing removed Bronze Age and later Neolithic levels. Final dates for the Neolithic occupations are therefore unknown.

2.4.2. Architectural Organisation

The buildings at Boncuklu were sub-oval and semi-subterranean, and the walls were made of mudbrick (Baird *et al*. 2012). The houses were oriented north-west to south-east, and were small, with internal dimensions ranging up to approximately 5x4m

(Baird *et al*. 2017). The individual buildings were also low in density; clustered together, but with more space between buildings than those at Çatalhöyük (Figure 2.7). Later houses were constructed in exactly the same location as previous structures, suggesting a continuity with ancestral houses; a feature also noted at Çatalhöyük (Baird *et al*. 2017).

Figure 2.7 Reproduced Boncuklu houses as well as an open area to the front used as a general midden space and containing hearths. The building behind is the Visitor Centre on site (Photo: M. Feider 2018)

As at Çatalhöyük, the internal layout of these houses is characterised by 'dirty' areas in the north-west which had slightly lower floor surfaces than the 'clean' areas in the south-east. The 'dirty' area included the hearth and had a different floor plaster make-up to that of the raised 'clean' area (Baird *et al*. 2012), and the boundary between these areas was marked by a ridge (Figure 2.8). On several floors in Building 6 this raised lip was painted to further emphasise the internal demarcations of the house (Baird *et al*. 2017). Finds from the 'dirty' area suggest that this was the occupational zone as it contained higher levels of organic material and small bone fragments, as well as evidence of hearth rake-out material (Baird *et al*. 2017).

Figure 2.8 Photograph of a typical Boncuklu building, showing the separation of the 'dirty' and 'clean' areas (Taken from Baird et al. 2017:757)

In contrast, the ‘clean’ areas only show very thin layers of silt build up between the replastering episodes, and also contain evidence of reed matting, as indicated both by the presence of reed phytoliths as well as impressions left when the mats were placed on floors before the new plaster was dry (Baird *et al*. 2012; 2017). ‘Clean’ areas also hold more in the way of symbolism within the house, being the locations where the dead were buried, as well as being adjacent to painted walls, and plaster reliefs (Baird *et al*. 2012). The internal walls and floors of the houses were re-plastered regularly, with the Bayesian analysis of the floor sequences in Area K supporting an annual or 1.5-year replastering schedule (Baird *et al*. 2017).

There is no evidence of in-built storage vessels or bins within the houses, so any storage vessels would have been baskets or hide bags, which did not survive. Building 6 did, however, have a mudbrick bin attached to the outside of the house, although whether it was used for food storage or another function is unclear.

While the buildings at Boncuklu show similarities in structural layout and design, the symbolic use of painting and art in each building is distinct, lending an air of individuality to the occupants of each building (Baird *et al*. 2017).

2.4.3. Economic Organisation

In the faunal assemblage at Boncuklu, wild boar (48% by NISP) and aurochs (31% by NISP) were the most common taxa on site. However, a single aurochs would have provided approximately six times the amount of meat than a wild boar (Baird *et al*. 2018). Ovicaprine elements were also present in the assemblage and the Carbon (C) and Nitrogen (N) stable isotope values for them are more variable than those found at the neighbouring site of Pınarbaşı. Whilst several specimens showed values similar to those at Pınarbaşı, several others showed values more similar to those from Çatalhöyük. This most likely reflects a diet based on grazing on the plain, rather than in the hills (Baird *et al*. 2018). This change in diet for some of the ovicaprines, as well as herbivore dung found on site, may suggest small-scale ovicaprine herding, although the %NISP for ovicaprines remains low, at 4%.

Evidence for plants at Boncuklu are dominated by wetland species, but also include terebinth nuts, hackberry fruit, and almonds (Baird *et al*. 2018). Cereals and legumes are also found in the seed and phytolith assemblage, along with their weeds. Crop seeds and chaff form a very low percentage of the Boncuklu archaeobotanical assemblage, at only 1.1%. However, they do include emmer and einkorn, with phytoliths of wheat trapped *in-situ* beneath reed matting on a building floor. The presence of emmer and einkorn on site has been confirmed with AMS dating. However, all barley recovered has proven to be contaminants (Baird *et al*. 2018). Emmer wheat, pea, lentil, and einkorn wheat, all found on this site, lie outside their wild distribution range in central Anatolia, so must have been brought to the area. This suggests that crops were introduced, cultivated, and processed at low densities at Boncuklu, and consumed alongside foraged food (Baird *et al.* 2018).

C and N stable isotopes of the human remains at Boncuklu show a diet similar to those living at Çatalhöyük which suggests the inhabitants at Boncuklu were more reliant on cereals, legumes, and low-protein tubers than the protein-rich almonds of their contemporaries at Pınarbaşı (Baird *et al.* 2018).

2.4.4. Social Organisation

Human burials at Boncuklu received much more varied mortuary practices than at Pınarbaşı or Çatalhöyük. Primary inhumations took place under the 'clean' floor areas within buildings (Baird *et al*. 2017), averaging one to three burials per building, with one house containing five inhumations (Yaka *et al.* 2021). The number of burials recorded inside the houses are insufficient to account for the longevity of the buildings (Baird *et al*. 2017). Recent research by Yaka *et al*. (2021) on the genetic relatedness of the people buried beneath houses has shown that whilst some of the people buried in the same house may have been related, not all were. For example, a perinatal child was placed within the same grave cut as an adult female, who was genetically unrelated.

There were also a significant number of burials in the outside midden spaces at Boncuklu. These included both primary inhumations and disarticulated remains, including a cluster of skulls (Baird *et al*. 2017; Yaka *et al*. 2021). All sub-building burials had their skulls in place, so the disarticulated skull clusters in the midden areas were not from these burials. However, they could have been from sub-building inhumations where all the bones were collected, as there were also disarticulated post-cranial remains in the outside area (Baird *et al*. 2017). These two groups appear to have had different diets, revealed by stable isotope analysis, with the group buried in outside spaces showing signatures of a more lacustrine and riverine-based diet of fish and frogs, and also possibly wild boar, whereas the people buried beneath buildings showed evidence of more herbivore protein, such as aurochs, in their diet (Baird Pers Comm 2021). The burials in the outside spaces also had more grave goods than the burials within the buildings, suggesting that this was not necessarily a deviant burial practice, and may account for the insufficient numbers of inhumations beneath the floors of buildings (Baird *et al*. 2017). This could also suggest that the burials outside were not secondary burial; or those that had been moved.

As well as plaster reliefs, animal bones were also incorporated into the walls, and included aurochs bucrania installations, as well as pig mandibles (Baird *et al*. 2017). The bin outside building 6 also contained the remnants of what may once have been a bucranium, with the larger part of the cranium removed at the end of the life of the bin, with only the lower part of the skull remaining *in-situ*. Whether this was simply decorative or symbolically significant, a way of watching over the contents of the bin, is unclear (Baird *et al.* 2017).

2.5. Pınarbaşı

2.5.1. Introduction and Dating

Pınarbaşı is located towards the end of the Bozdağ, a range of limestone hills that project north-west of the Karadağ mountain range, on the eastern edge of the southwest Konya Basin (Baird *et al*. 2018). The site is made up of several phases of occupation, from the 14th-12th millennium cal. BCE Epipalaeolithic rock shelter site, to the 10th-9th millennium cal. BCE early Neolithic settlement mound to the west, and a 7th millennium cal. BCE late Neolithic seasonal site above the Epipalaeolithic levels, all within several hundred meters of each other (Baird *et al*. 2018). The Epipalaeolithic and late Neolithic settlements were identified in Trench B, at the base of the cliff, with the early Neolithic mound identified in Trenches A and D on a small promontory to the west of the cliff face (Figure 2.9). The site was adjacent to the Hotamiş lake and marshes to the north, which were present until recently at the site, and dried up over the last several decades due to water infrastructure work lowering the water table (Russell 2020). The Karadağ foothills south of the site were covered with terebinth-almond woodlands, with steppic landscapes to the west. As such, Pınarbaşı sits at a junction between the steppe, the lake and marsh, and the hills, increasing the local ecological niches that could be exploited by humans (Russell 2020).

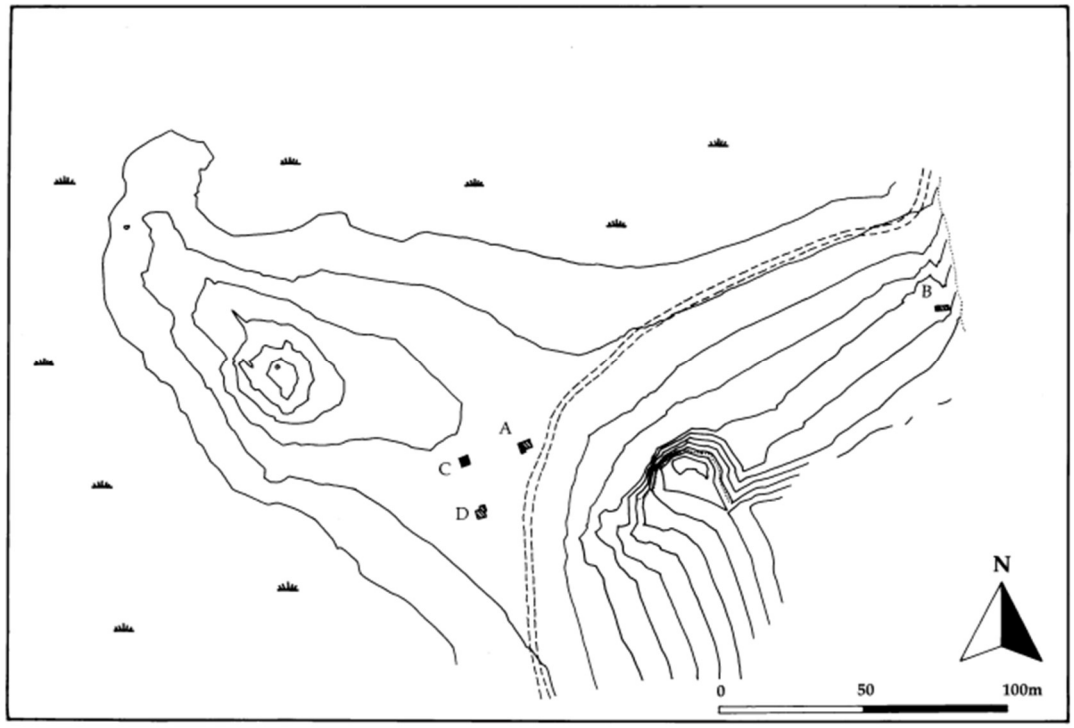

Figure 2.9 Site plan of Pınarbaşı showing the location of the trenches (taken from Baird et al. 2018 Supplemental Information Appendix Figure S1)

The site was identified as a potential prehistoric site in the 1970's by David French, based on the artefacts he discovered there. As part of the Konya Plain Survey in 1993, Professors Douglas Baird and Trevor Watkins revisited the site and found that looting of Byzantine burials had disturbed quantities of microliths, indicative of the presence of an early Holocene or even Epipalaeolithic site. Works beginning in the mid 1990's identified two settlement areas, a rock shelter site and a Neolithic mound. The archaeology also included Roman-Byzantine, and Bronze Age settlements that overlay 9th millennium artefacts (Baird 2012).

Radiocarbon dates for the site include those obtained from burials and floor contexts in Trenches A and D, as well as burials and fills from the Epipalaeolithic levels in Trench B (Table 2.3). Occupation in Area D began at, or just after, the Pleistocene/Holocene transition approximately 9800-9400 cal. BCE (Baird *et al.* 2018). In Area A the occupation levels began approximately 9000 cal. BCE, although the dates of the earliest phases have yet to be confirmed, and could potentially be earlier. Occupation in the area of both trenches continued to approximately 8200-7800 cal. BCE.

Grave 13, an *in-situ* human inhumation from the Epipalaeolithic levels of Trench B was radiocarbon dated to approximately 14,159-13,071 cal. BCE. Grave 14, also an *in-situ* burial of a male was radiocarbon dated to 13,180-12,246 cal. BCE (Baird *et al*. 2013). The dates for the Epipalaeolithic layers from these *in-situ* inhumations, suggest that the settlement was occupied prior to, as well as during, the Early Natufian sequences in the Levant.

Table 2.3 Radiocarbon dates for Trenches A, D, and B at Pınarbaşı (Baird et al. 2013;2018)

	10th-9th Millennium cal. BCE		Epipalaeolithic cal. BCE
	Trench A	Trench D	Trench B
Late	8164-7395	8300-7800	11247-10897
Early	9380-8801	9799-9406	14159-13071

2.5.2. Architectural Organisation

During the 14th-12th Millennium BCE levels at Pınarbaşı (Figure 2.10) the presence of both reed and sedge phytoliths suggest possible light structures were constructed, as both of these plants would have to have been brought to this locale. However, they could also have been utilised as wind breaks, or as functional and utilitarian items like basketry or bedding, or even as food. There is no conclusive evidence of any buildings or structures during this period of occupation. The thin layers of occupational debris suggest that this site was only occupied intermittently or seasonally, for short periods (Baird 2012; Baird *et al*. 2013).

Figure 2.10 The Epipalaeolithic site at Pınarbaşı. Trench B was excavated just to the right of the crag that runs down the middle of the promontory (Photo: M. Feider 2018)

The 10th-9th Millennium BCE settlement mound (Figure 2.11) covers an area of approximately 0.5 ha, and excavations revealed semi-subterranean, curvilinear structures with plastered walls and floors, that showed evidence of replastering as well as flecks of red ochre. The buildings were similar to those found at Boncuklu, however, where building at Boncuklu were made from mud brick, those at Pınarbaşı had a wattle and daub superstructure. The buildings contained central hearths, as well as other structural elements that included a possible storage bin, stone seats, and quern stones. The external areas of the site were comprised of trodden areas, with scatters of stones and animal bones (Baird 2012).

The clear differences between the Epipalaeolithic and the early Neolithic settlements suggests a change in lifeways at the site, with the appearance of more substantial structures in the early Neolithic that suggest a longer term use potentially indicating a sedentary or sedentarising community (Baird 2012).

Figure 2.11 Looking from the rock shelter at Pınarbaşı across to the early Neolithic site in front of the rocky mound. Until very recently the flat land to the right of the mound was the Hotamiş marshes (Photo: M. Feider 2018)

The 7th Millennium BCE, late Neolithic occupation of the site, overlaying the Epipalaeolithic levels in Trench B, shows successive use comprising irregular oval cuts serving as fire pits, which were then back filled with stone and burnt material. These features were then cut by a low curvilinear stone walled enclosure, adjoining the rockface, which was utilised as a dwelling. Evidence of reed phytoliths suggests the superstructure of this building would have been made of a more temporary material, that was then easily reconstructed following disuse of the site. There is evidence to suggest fills accumulating within the structure, which lends weight to the theory of successive abandonment, as the site was in seasonal use only (Baird 2012).

2.5.3. Economic Organisation

The 14th – 12th Millennium BCE macrofaunal assemblage at Pınarbaşı was highly fragmented due to human processing, including burning, with nearly 68% unidentifiable fragments and only 13.7% identifiable to species (Baird *et al*. 2013). The remainder were identified using broader, size categories and included large wild game, such as aurochs and equids, as well as smaller animals such as hares and tortoises. The most abundant animals were wild sheep and goats, with slightly more of the diagnostic fragments being sheep. Sheep/goat made up 35% of the total NISP, with the next highest NISP being that of tortoise, at 21.6%, excluding several clusters of canid bones.

All the canid bones belonged to young individuals. Their presence, along with taphonomic evidence, suggests they were not present via human agency and may instead represent a wolf nursery den used during periods of human absence. Other canid remains were made up predominantly of head and foot bones suggestive of skins being brought on to site (Baird *et al*. 2013).

The lack of gnawing, only 0.1% of the total assemblage, as well as a lack of acid attack, or digestion on discarded bones, suggests that dogs were not present on site during its occupation, and therefore any canid remains were not likely to belong to the sites inhabitants. Additionally, the taphonomic analysis of the human-derived animal bone assemblages suggested a quick burial of the specimens, due to the lack of evidence of trampling or weathering (Baird *et al.* 2013).

Fowling in the Epipalaeolithic period concentrated on wetland species. However, a very small percentage of the taxa (2%) was made up of steppe and mixed-habitat species with single elements also coming from mountain and forest taxa (Russell 2020). Ducks were the predominant species of wetland birds hunted, with a quarter of these being mallards (Russell 2020).

Plant remains were scarce in the Epipalaeolithic levels, with nutshells almost completely absent. A single nutshell of terebinth was recovered, but it is more likely that this tree was being exploited for its wood, rather than as food, as it has been identified in the charcoal fragments (Baird *et al*. 2013). As such, it is likely that plant foods made up only a small part of the Epipalaeolithic diet.

The 10^{th} – 9^{th} millennium faunal assemblage was dominated by aurochs, at 34% and sheep/goat, at 27%, although sheep/goat were not as well represented compared with the Epipalaeolithic levels. C and N stable isotopes for the ovicaprines at Pınarbaşı, indicate the 10^{th}-9^{th} millennium population had a similar diet to the ovicaprines in the Epipalaeolithic levels. This is in contrast to the isotopic evidence for the Çatalhöyük ovicaprines, and suggests the ovicaprines in the 10^{th}-9^{th} millennium deposits at Pınarbaşı were most likely hunted rather than managed (Baird *et al.* 2018). Wild boar were not well represented at only 6%, which is in contrast to the contemporary Boncuklu assemblage (Baird *et al*. 2018). Evidence of fowling was also present, and was again predominantly made up of wetland species. However, there were more

steppe taxa present, including bustard. Birds, however, made up an even smaller percentage of the macrofauna than in the Epipalaeolithic levels, suggesting they were not as important a part of the diet during the Holocene (Russell 2020).

Plant remains were found in much higher quantities during the early Neolithic occupation and are dominated by taxa indicative of semi-arid and steppe woodland. This is probably due to the site's location allowing its inhabitants to exploit the hill zone for food and fuel (Fairbairn *et al*. 2014). Plants collected included almonds, terebinth nuts, and hackberry fruit. However, there is still no evidence for the gathering or cultivation of cereals or legumes (Baird *et al*. 2018: Table 1:4).

C and N stable isotopes obtained from the human remains at Pınarbaşı show differences between the Epipalaeolithic and Neolithic inhabitants, suggesting that plant consumption was higher during the Neolithic. This is supported by the archaeobotanical assemblage, in which protein-rich almonds dominate the 10^{th}-9^{th} millennium assemblage (Baird *et al*. 2018).

Domestic sheep remains were recovered from the 7^{th} millennium occupation at Pınarbaşı, including a number of foetuses, neonates, and young animals, highly suggestive of seasonal use in spring (Baird 2012). As well as hunted aurochs and equids, consumption of migratory birds also suggests an autumn/early winter period of occupations in addition to that of spring. Wetland birds still dominate the bird assemblage; however, duck use drops dramatically in this period, with geese being the preferred prey. This is in contrast to the two preceding periods of occupation, where duck, in particular the mallard, was the preferred species (Russell 2020).

Plant remains from the 7^{th} millennium occupation however, showed little evidence of cultivated cereals or legumes, with most of the phytolith and carbonised wood evidence relating to structural or other uses, such as bedding and animal fodder (Baird 2012). Exploitation for food of the terebinth-almond woodland in the hills near the site is also conspicuously uncommon, despite the wood from the trees being used as fuel for the fires. This all lends support to the theory that the occupation was discontinuous during this phase in the life history of the site, rather than one that was permanently occupied.

An extensive number of chipped stone tools were recovered from the Epipalaeolithic levels at Pınarbaşı, mostly manufactured from obsidian, with flint and chert making up a small proportion of the assemblage (Baird *et al*. 2013; 2018). The obsidian derives from Cappadocia, 160 km to the east and this was also the source for the obsidian found at Boncuklu and Çatalhöyük. The 14th-12th millennium lithic assemblage is characterised by the small size of the artefacts, with nearly 90% of the blades and bladelets being less than 10 mm in width (Baird *et al*. 2013). Microliths dominated the assemblage, with chipped stone used for butchery purposes, as well as skinning with ochre, or possibly red ochre working. The small size of the blades and bladelets, the continuous retouching, and the curation of tools made elsewhere, suggests individual toolkits, which fits with the mobile nature of the community, as well as conservation of the raw material due to its restricted availability. Other worked stone recovered from the Epipalaeolithic levels included incised shaft straighteners made of local basalt (Baird *et al*. 2013).

The 10th-9th millennium chipped stone assemblage is very similar to the Epipalaeolithic assemblage, with the continuity of a mainly obsidian toolkit made up of microliths. However, the introduction of additional bladelet and microlith production strategies suggests incoming knowledge and an adoption of new lithic technologies (Baird 2012).

The 7th millennium chipped stone assemblage is very similar to the assemblage from Catalhoyuk, with 90% being obsidian. Levels of knapping at Pınarbaşı during this phase of occupation were low. However micro-debitage and flakes were recovered. This, again, suggests occasional knapping activity as needed, rather than tool production at the site (Baird 2012).

2.5.4. Social Organisation

Excavation of several early graves in the 14th-12th millennium levels at Pınarbaşı showed that elaborate mortuary practices were being performed during the Epipalaeolithic, even though there is no evidence for long-term occupation of the site. Grave 14, contained an artefact cluster that had been placed beneath the head of the deceased and covered with red ochre. Reed and sedge phytolith evidence suggested that the body was either wrapped in, or laid on, a reed mat or was associated with basketry. The burial contained beads of *Nassarius* (marine sea snail shells) which would have come from the Mediterranean to the south, as well as those made of bone, and a large

cache of *Dentalium,* marine mollusc tusk shells. The *Dentalium* shells were arranged in rows and had been placed within a tortoise shell container and covered with red ochre (Baird *et al*. 2013). This arrangement of *Dentalium* was also seen in burials from el-Wad (Bar-Yosef 2008) and was interpreted to be part of an elaborate early Natufian head dress.

Grave 13 also contained an inhumation identified as an adult male whose cranium had been removed post-burial. The presence of maxillary teeth in the grave suggest that the head was included in the initial burial and that the cranium was retrieved at a later date following at least partial decomposition (Baird *et al*. 2013). With no evidence of later disturbance this appears to be the first instance of cranial removal from graves in southwest Asia, connecting it to later sites in the area and suggesting that potential ancestor worship was not linked to sedentary behaviour (Baird *et al*. 2013). The skeletal pathology of this individual indicate asymmetry in the arm muscles which is similar to that found in some Natufian male skeletons (Petersen 2002). It has been suggested that this could be due to the hunting techniques involved in spear throwing, and that the use of this technique also suggests the sharing of knowledge between Anatolia and the Levant (Baird *et al.* 2013). Enamel hypoplasia on the teeth suggests both the adults buried at the site suffered nutritional stress during childhood (Baird *et al.* 2013).

In the Neolithic levels, an outside cemetery was uncovered that included articulated individuals, including an adult male, an 18–20-year-old female, and a child aged 10. Several of these burials had grave goods, including obsidian points and red ochre. There was no evidence for inhumations beneath the floors of houses (Baird 2012).

2.6. Summary

The three sites of Pınarbaşı, Boncuklu, and Çatalhöyük span the Epipalaeolithic in Central Anatolia, all the way through to the Chalcolithic period, and as such show how human lifeways changed over time, and how sedentary and farming practices were established in this area, in comparison to the contemporary Levantine sequences. Despite periods of contemporaneity, Boncuklu and Pınarbaşı adopted different lifeways, with Boncuklu showing evidence for small-scale cultivation while Pınarbaşı remained a hunter-gatherer community.

The differences in wild boar exploitation at Boncuklu and Pınarbaşı cannot be explained by local ecological differences but may be due to the boars being attracted to crops, prompting a change in hunting strategy at Boncuklu, in order to protect them (Baird *et al*. 2018). However, this pattern is not seen at Çatalhöyük, where farming was at much higher levels, but with wild boar not being well represented in the faunal assemblage. These three sites share significant similarities, whilst also maintaining separate identities, details of which are shown in Table 2.4.

Table 2.4 Comparison of a number of features across the different sites, highlighting the similarities and differences between them.

	14th-12th millennium Pınarbaşı	10th-9th millennium Pınarbaşı	Boncuklu	Çatalhöyük
Seasonal occupation	X			
Permanent occupation		X	X	X
Wattle and daub superstructure		X		
Buildings curvilinear in shape		X	X	
Semi-subterranean		X	X	
Mudbrick superstructure			X	X
Buildings rectilineal in shape				X
Repeated construction over the footprint of older dwellings			X	X
Replastering of walls and floors		X	X	X
Internal delineation of space within dwelling			X	X
Presence of structural storage bins within the dwellings		X?		X
Primary inhumations in cemeteries or outside spaces	X	X	X	
Primary inhumations under house floors			X	X
Post-burial cranial retrieval	X	X	X	X
Animal bone, such as auroch horn cores incorporated in architecture			X	X
Painted walls and floors		X?	X	X
Herding of caprines			X	X
Presence of cultivated cereals			X	X

Differences between the sites show that 10th-9th millennium BCE Pınarbaşı and Boncuklu shared elements of continuity between settlements, being contemporary settlements for 300-500 years. However, it is unlikely that they were part of the same

community. Evidence of similarities and continuity between Boncuklu and the much larger site of Çatalhöyük, however, lend weight to the theory that Boncuklu is a direct antecedent of Çatalhöyük, showing many of the same structural, economic, and symbolic practices, despite no evidence that they were contemporary sites (Baird *et al*. 2018).

This chapter has given a brief background on the architectural, economic, and social organisation of each of the three archaeological sites included in this thesis, showing the similarities and differences between them, as well as further information about the area of Central Anatolia in which they are located. The next chapter will focus on microfaunal analysis which has long been traditionally used to explore palaeoecological reconstructions, but also to further understanding of ritual practices, broad spectrum economics, and sedentism. As these three sites straddle the transition from mobile hunter-gatherers to settled farmers, examining the microfauna will allow us to look at these aspects of human lifeways at this important period in human history.

3. Microfaunal Taphonomy

3.1. Introduction

In order to understand how microfauna can be used to interpret past human lifeways as part of an archaeological assemblage, the nature of deposition must be understood. In order to do this a taphonomic analysis is undertaken, and the evidence used to determine how those bones became incorporated into contexts within a human site.

Microfauna in archaeology are usually described as animals that weigh less than 5 kgs when alive (Andrews 1990; Denys *et al.* 2017), and generally encompass small mammals such as mice and rats, gerbils, hamsters, voles, shrews, and bats, as well as herpetofauna, which include amphibians, lizards, and snakes. Although birds and fish can fall within this weight range, they are not included within the scope of this thesis.

Microfaunal assemblages are, more often than not, considered non-cultural, and are used to interpret the local palaeoecology of the site, without relating their presence back to the settlement, or their potential effect or reflection on settlement practices (Edwards and Martin 2007). It is important, therefore, to understand the nature of deposition for microfaunal assemblages in order to be sure of the significance these assemblages have for archaeological interpretations. If the circumstances of deposition cannot be determined then the contextual information of the assemblage becomes ambiguous and the interpretations open to questioning (Smoke and Stahl 2004).

It is often assumed that the majority of microfaunal assemblages recovered from archaeological sites are predatory in origin, and therefore do not actively play a role in settlement archaeology (Smoke and Stahl 2004; Terry 2007). In order to interpret the method of deposition, taxonomic identification is accompanied by a taphonomic analysis in order to strip away any potential bias to interpretation. Taphonomy, from the Greek *taphos* meaning burial, and *nomos* meaning law (Lyman 1994), is essentially the study of processes that affects species as they go from the living community to being analysed (Andrews 1990). These pathways, and the effects they may have on a microfaunal assemblage, are discussed below.

3.2. Pre-depositional taphonomy

3.2.1. Causes of death

It is unusual for archaeological microfauna to be recovered in their original place of death, as natural deaths due to old age or disease are unlikely. These bones would be represented in an assemblage with no taphonomic markers related to cause of death and so a contextual analysis would be required in order to understand the method of deposition. For most microfauna, however, an 'unnatural' death is more likely.

Pitfall traps

Steep sided pits, not an uncommon feature on many archaeological sites, might trap certain species of microfauna, creating a specific death assemblage. The local vegetation surrounding pits, or lack thereof, will create a biased pitfall assemblage, as certain species may not venture out from beneath vegetation cover or require more open ground. For example, the bank vole (*Myodes glareolus*) is unlikely to get caught in pits that had cleared edges due to its requirement for cover (Rackham 1982; Armitage and West 1987). As such, pitfall assemblages would not be indicative of the local environment, as not all species present in the immediate environment would be represented. Species also adapted to climbing and jumping would also potentially be able to escape the pit, and would also not be represented in a pitfall death assemblage (Andrews 1990).

In order to further understand the likelihood of pits to act as a trap, Whyte and Compton (2020) undertook an experimental excavation of three window wells on a rural property in Howard County, Maryland, USA. Window wells are spaces between the subterranean basement windows and the ground outside, and the wells at this property had not been excavated or cleaned out since the building's construction in 1952. The window wells are a good analogue for archaeological pit features, such as food storage or rubbish pits, as they are steep sided and in immediate proximity to domestic dwellings. After the initial leaf litter was removed, in which a live toad was discovered, the soil was excavated in 5cm spits, and then wet-sieved through 6.4mm, 3.2mm, and 1.6mm sieves. Microfaunal remains recovered from the window wells contained several species of frogs and toads, of all sizes, as well as salamanders, pine voles, tree squirrels, short-tailed shrews, and deer mice (Whyte and Compton 2020), with an

assemblage NISP of 4897, of which 4129 were anura. This indicated that pits could accumulate a large number of microfaunal remains. It would be unlikely, however, that any one species would be there exclusively, and that victims of pitfall traps would be found in association with a range of other species. An exception to this could be amphibians attracted to water-filled pits for potential breeding; in this instance the remains would be more likely to be limited to those of larger, adult specimens.

As well as being taxonomically mixed, pitfall traps, as receptors of specimens without human or predatory intervention, would also contain complete animals, and an analysis of the proportion of skeletal elements represented in the assemblage would provide evidence of this (Rackham 1982; Smoke and Stahl 2004; Whyte and Compton 2020). The varied taxonomy would be important in distinguishing a pitfall trap assemblage from one that had been cached by a predator. Although a prey cache may not show any direct evidence of predatory intervention, such as puncture marks it is more likely to be taxonomically restricted to a single species, for example, a weasel decimating a nest of voles and then caching the uneaten prey (Andrews and Evans 1983; King and Powell 2007).

Catastrophic death

Catastrophic death assemblages, such as those caused by flash flooding or volcanic activity, would potentially be dominated by a single species, and include individuals of all ages. A catastrophic death assemblage would represent the full demographics of a population, rather than one which is attritional and which would be dominated by the very young and the very old (Korth and Evander 1986; Silcox and Rose 2001). In the instance of flooding, there may also be sorting of elements seen in fluvial transport.

Predation

Predation of small vertebrates is often cited as the main accumulating factor for microfauna on archaeological sites (Andrews 1990; Denys *et a*l. 2017; Fernandez *et al*. 2017; Fernandez-Jalvo and Andrews 1992; Fernandez-Jalvo *et al*. 2016). The taphonomic signatures of predation, specifically on small mammals have been extensively studied (Raczynski and Ruprect 1974; Andrews and Evans 1983; Holt *et al*. 1987; Andrews 1990; Bochenski 1998; Saavedra and Simonetti 1998; Bux *et al*. 2000; Laroulandie 2002; Laudet *et al*. 2002; Mahan *et al*. 2002; Terry 2004; Bontozorlos *et al*. 2005; Reed 2005; Matthews 2006; Seckin and Coskum 2006; Bulut *et al.* 2012;

Dziemian *et al.* 2012; Dauphin et al. 2015; Selçuk *et al*. 2017), but are limited for other small vertebrate taxa, for example anura (Denys *et al.* 2017).

It has long been thought that a predatory derived assemblage is biased by the predators feeding strategies (Mellett 1974; Andrews and Evan 1983), and therefore holds little value for palaeoenvironmental reconstruction. Biases in the microfaunal assemblage from predation are based more on the hunting strategy of the predator, rather than prey selectivity, as certain species are more likely to be predated upon if they share the same home range and lifestyle (e.g., nocturnal) as the predator and are the correct size for consumption, although weasels are known for taking down prey of much greater size (King and Powell 2007). Furthermore, while predators may have a preferred prey item they will take others when available (Andrews and Evans 1983; Denys *et al*. 2017), as evidenced by the same species of owl consuming predominately different prey species based on geographical location (Saavedra and Simonetti 1998). However, with the identification of the predator these biases could be recognised and the microfaunal assemblage still hold value (Mayhew 1977; Andrews and Evans 1983).

Taphonomic markers of predation include bone breakage, evidence of digestion on bones, and gnaw marks which can then be used to deduce the category of the predator, as demonstrated by Andrews (1990).

Breakage

Many predators of small mammals and amphibians have different methods of eating their prey and this can affect levels of bone breakage. For example, owls tend to swallow their prey whole, whilst diurnal raptors tear their prey into sections before consumption. Mammalian carnivores chew their food before swallowing and unlike owls or raptors they do not regurgitate indigestible elements such as bones and fur (Andrews and Evans 1983; Fernandez-Jalvo *et al*. 2016; Fernandez *et al.* 2017). Additional factors that affect levels of bone breakage by predators include the size of the prey. The bodies of smaller prey are less likely to be fragmented than those of larger prey. Breakage levels between different groups of mammalian carnivores were examined by Andrews and Evans (1983). They determined that analysis of breakage and digestion levels was fundamental in distinguishing between assemblages created by different groups of predators such as canids and mustelids, and that examining the relative proportion of elements (RPE) alone was insufficient as results could be biased by differential survival and other taphonomic processes such as transport. These could

replicate RPE patterns. This was also borne out by Terry (2007), who used principal component and discriminant function analysis to conclude that bone breakage levels could be used to distinguish between higher taxonomic categories of avian predators, for example nocturnal owls and diurnal raptors.

Digestion

The severity of digestion can be different depending on the species of predator (Andrews 1990). For example, the pH of gastric acids of nocturnal birds of prey, such as owls, ranges from 3.1 to 1.3, whereas for diurnal raptors the pH can range from 1.8 to 1.3, with dogs being 4.5, cats 3.6, ferrets 1.5, and humans 1.5 (Duke *et al*. 1975 cited by Beasley *et al.* 2015; Fernandez *et al.* 2017). The lower the pH the more acidic the stomach, and therefore the greater the damage to bones.

Andrews (1990) looked at the effect of digestion and breakage on small mammal cranial and post-cranial elements, and assigned different predators to categories based on the severity of their effect on bones and teeth recovered from pellets or scats. Five categories of predator were established and included owls, diurnal birds of prey, as well as a limited number of mammalian carnivores. It was found that most species of owl fell into the categories that produced low levels of modification, most likely due to prey items being swallowed whole. Diurnal birds of prey such as the raptors caused moderate levels of modification, as they tear their prey before swallowing. Mammalian carnivores produced extreme levels of modification, again, most likely because prey were masticated before being swallowed. Modification categories defined by Andrews (1990) were;

Category 1: Digestion absent or low, 0-3% molars affected, 8-13% incisors affected. Breakage levels low, with complete elements recovered.

Category 2: Digestion moderate, 4-6% molars affected, 20-30% incisors affected (tips only). Breakage low, fewer complete elements.

Category 3: Digestion heavy, 18-22% molars affected, 50-70% incisors affected. Moderate levels of breakage.

Category 4: Digestion extreme, 50-70% molars affected, 60-80% incisors affected. Breakage moderate to heavy.

Category 5: Digestion extreme, 50-100% molars affected, 100% incisors affected with dentine corroded. Breakage heavy with few to no complete elements recovered.

Levels of digestion on microfaunal bones can be affected both by time spent in the digestive tract of the predator, as well as by the species of predator itself. Different species produce different levels of modification due to digestion, ranging from none to light, through to extreme. These are seen on both the teeth of the predated prey animal as well as on the long bones (Andrews 1990). The age of the predator can also change the levels of modification. For example, juvenile barn owls produce moderate to heavy digestion on bones, whereas an adult barn owl is more likely to produce light modification or none at all (Andrews 1990; Williams 2001). If food is scarce, and the predator is hungry, then food may remain in the digestive tract for longer to extract as many nutrients as possible before the indigestible elements are excreted or regurgitated, thus increasing levels of digestion (Raczynski and Ruprecht 1974; Fernandez-Jalvo *et al*. 2016). This also works in reverse, so if the prey is plentiful then the prey item may swiftly traverse the digestive system before being excreted or regurgitated, and so levels of digestion may be lower than expected for that category of predator (Andrews 1990; Fernandez-Jalvo *et al*. 2016). The modification levels can also vary between different types of teeth as well. For example, microtine molars are much more easily modified by gastric acids than murid molars, due to the shape of the teeth. Microtine molars have sharp salient angles, as well as exposed dentine on the occlusal surface (Figure 3.1). In contrast, the dentine in murid molars is not exposed until wear has taken effect, and their teeth are generally more rounded. As such, light digestion on a microtine molar would suggest a category 1 predator (Figure 3.2), whereas light digestion on a murid molar would suggest a category 3 predator (Andrews and Fernandez-Jalvo 2012: 45). The digestive effects on incisors, however, are very similar, as microtine and murid incisors are almost identical in structure. This makes identification of digestion on incisors very important, as a category 1 predator that has consumed *Mus* sp., for example, may show evidence on the incisors, but not on the molars (Andrews 1990; Fernandez-Jalvo *et al*. 2016).

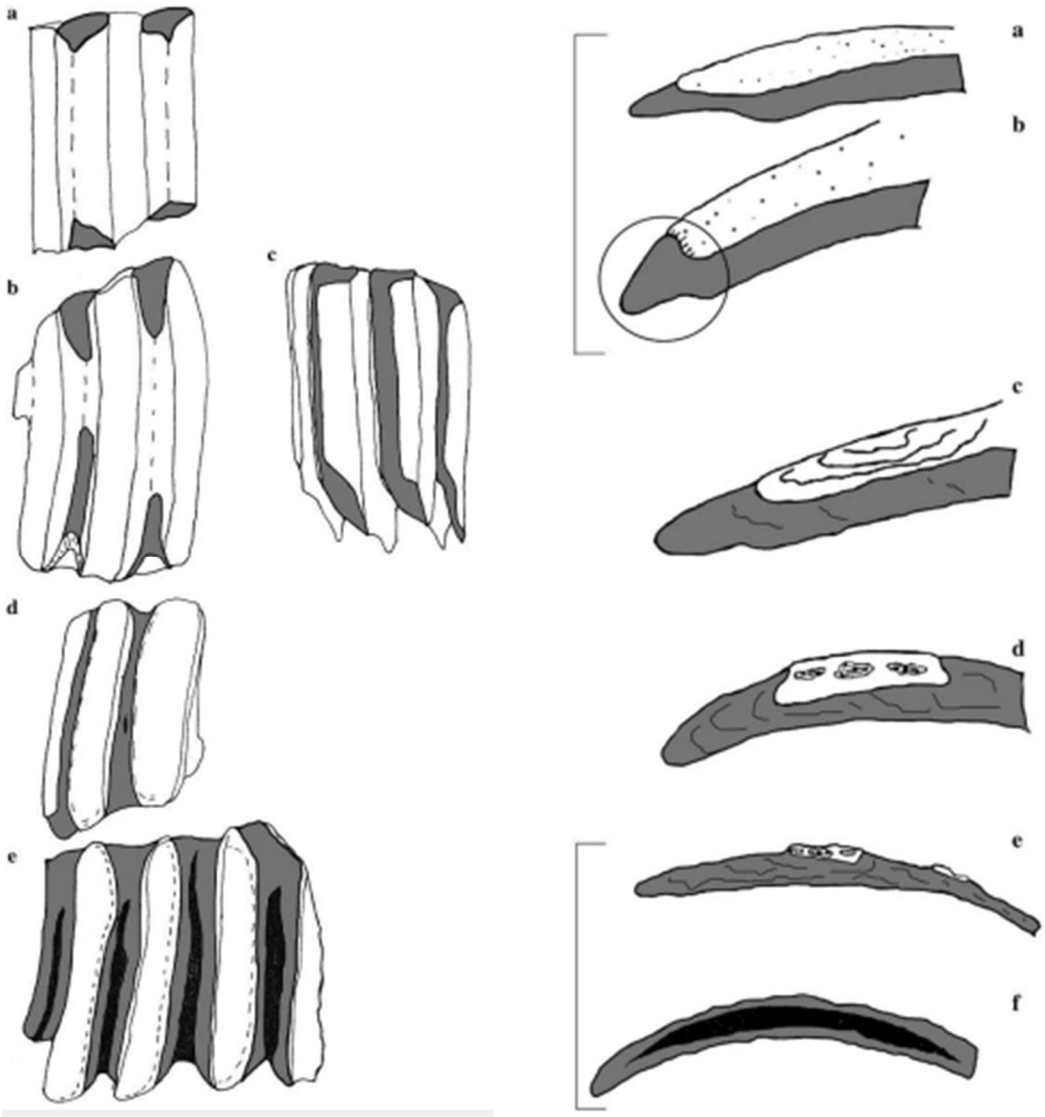

Figure 3.1 Drawing of the different levels of digestive modification to microtine molars and incisors. White represents the enamel, grey the dentine, and black is empty spaced cause by dentine collapse. MICROTINE MOLARS: a=light, b and c=moderate, d=heavy, and e=extreme digestion. INCISORS: a and b=light, c= moderate, d=heavy, and e and f= extreme digestion. (From Fernandez-Jalvo and Andrews 1992: 412 & 413)

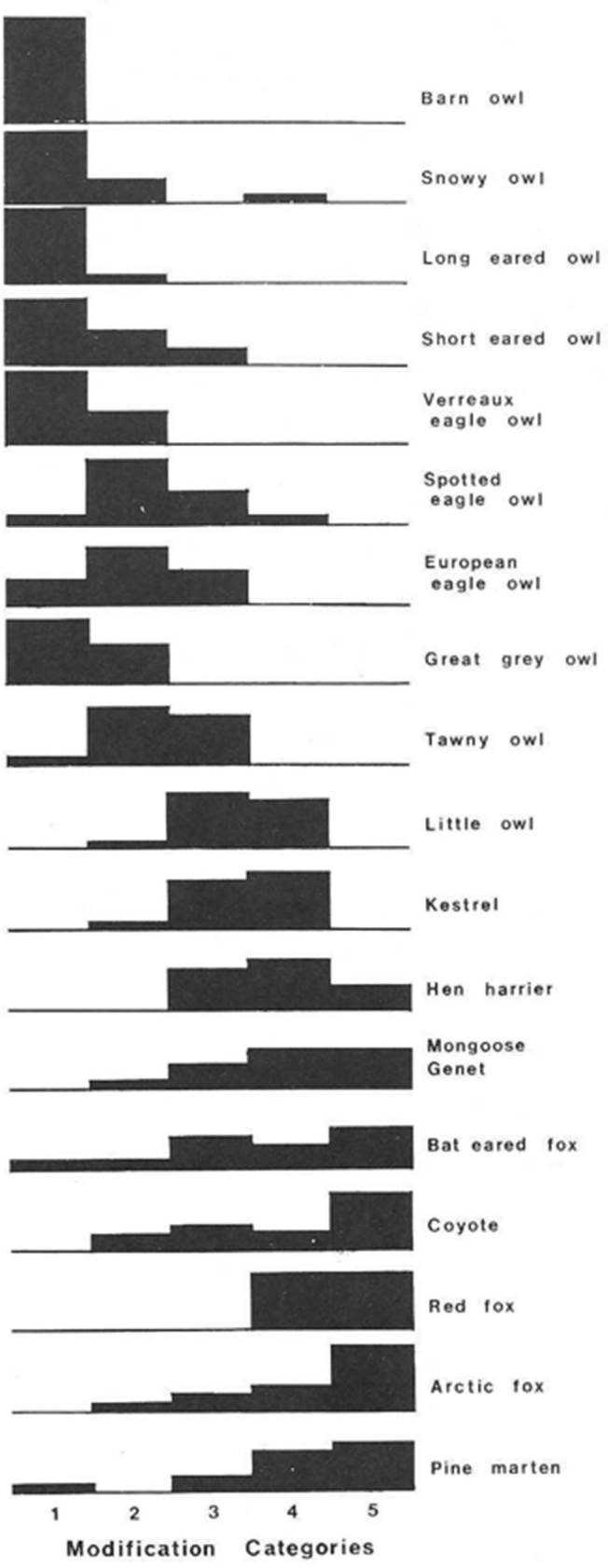

Figure 3.2 Summary of predators belonging to each category (From Andrews 1990:89)

As well as considering possible avian and mammalian carnivores as responsible for the accumulation of microfaunal assemblages, we must also consider the possibility that humans have eaten microfauna and were the agents of accumulation. In an effort to understand the effect of the human digestive system on small mammal remains, Crandall and Stahl (1995) conducted an experiment involving consumption and eventual collection of a shrew by an adult human male. The shrew was skinned, eviscerated, and segmented prior to the swallowing whole of the head, forelimb, hindlimb, trunk, and tail segments. As the segments were swallowed without mastication the experiment did not attempt to understand fragmentation patterns caused by humans, although one would usually expect food to be chewed before being swallowed (Crandall and Stahl 1995). As such all the major limb bones remained complete, with the exception of a tibia.

Andrews (1990) suggested that the limited number of cranial elements recovered from the assemblages created by some predators may reflect their hunting strategy which involves removal of the head before ingestion. However, the Crandall and Stahl (1995) experiment showed high levels of fragmentation of the skull, despite being swallowed whole. As well as extreme levels of fragmentation of the skull, no maxillary teeth were left *in-situ*, although the palatine fragments were recovered (Crandall and Stahl 1995). This is comparable with what is found following ingestion by mammalian carnivores (Andrews 1990). The mandibles of the shrew, were recovered, but breakage was extreme, affecting the ascending ramus and inferior border, as well as the teeth. Few teeth were left *in-situ*, and those that were showed evidence of moderate to extreme levels of digestion along with the loose teeth.

Post-cranial digestion levels varied with some elements exhibiting different levels of digestion along the same element. This may be attributed to the way the animal was segmented prior to ingestion, with some elements being more 'protected' by soft tissue than others, which could potentially affect the way postcranial elements are digested following mastication. This is because more bone may be open to direct digestive acid attack.

Consumption by humans leads to high levels of bone breakage and digestion on skulls and teeth, making the positive identification of small mammals recovered from human faecal deposits unlikely, or likely to be classed as an Andrews (1990) Category 5

predator. The results of Crandall and Stahl's (1995) experiment cannot accurately reflect either breakage or digestion levels of small mammals actively eaten by a human, as this reflects a best-case scenario with the animal being carefully segmented and swallowed whole. This is something that is unlikely in a human subsistence scenario, but it can be used as a baseline. Without mastication breakage was high for the skull, meaning the lack of cranial elements may not be due to a hunting strategy, but to the category of predator. However, breakage of the post-cranial remains without mastication was comparable with a Category 2 or Category 4 predator (Crandall and Stahl 1995).

In addition to the experimental work conducted by Crandall and Stahl (1995), a human burial, excavated at the Groen River North site, Namqualand, South Africa, revealed micromammalian remains in the abdominal region of the skeleton, representing the person's last meal (Dewar and Jeradino 2007). The micromammal remains from the stomach and intestinal area were retrieved separately and this revealed much higher levels of digestion in the intestines with 62% of bones exhibiting evidence of digestive attack, than the stomach, at 38% most likely due to longer exposure to gastric acids (Dewar and Jeradino 2007). This discovery also offers direct evidence of the consumption of micromammals by humans, who should be considered as a possible accumulator of microfauna on archaeological sites.

Gnawing

Evidence of gnaw marks caused by mammalian carnivores or, potentially humans have not been extensively studied on microfaunal remains, as they are rare (Andrews 1990; Fernandez-Jalvo *et al*. 2016) and the experiments undertaken to date have been more concerned with levels of breakage caused by predation (as noted above). However, isolated and multiple puncture marks caused by small predators have been noted in archaeological assemblages (Domínguez-Rodrigo and Piqueras 2003; Jenkins 2009; 2012a). The size of the tooth mark is not always indicative of the size of the predator. For example, the tip of a canine tooth may produce a small puncture mark, but the puncture would get larger the further the tooth penetrated the bone. Small predators, however would not be able to produce large punctures as the size of the puncture would be in proportion to the size of the tooth. Therefore, the size range of tooth marks are more informative than mean sizes (Fernandez-Jalvo and Andrews 2016), as well as the distance between any that may appear to be a pair.

Gnawing can also be produced by scavengers, including species that may not be considered as predators, for example some insectivores. Microfaunal remains have been identified with bite marks relating to other microfaunal species. At the site of Sima del Elefante (Sierra de Atapuerca, Burgos), a bitemark on a mole (*Talpa europaea*) humerus has been attributed to a fossil soricid, *Beremendia fissidens* (Bennasar *et al*. 2009), as the bitemark was too small to be that of a mustelid. This hypothesis was later supported by the recovery of that species at the site, and with measurements of the upper dentition matching the measurements of the punctures on the humerus (Bennasar *et al.* 2014).

3.2.2. Death to burial

Transport

Due to their lifeways, microfauna are more likely to be moved from their place of death, either by predators, scavengers, or through weathering mechanisms such as water transport. They may also be moved on an inhabited site, disposed of as rubbish from place of death, or as redeposited midden fill used to fill a pit, for example.

The effect of fluvial transport on a microfaunal assemblage includes both breakage and a degree of sorting (Korth 1979; Fernandez-Jalvo and Andrews 2003). Hydrodynamic sorting of microfaunal carcasses, or dispersed pellets or scats, is caused by the energy levels of the fluvial environment, as well as the shape and density of the bones (Stahl 1996). As such, certain bone groups are moved further than others based on morphology, and these can be separated into different groups (Voorhies 1969 cited by Fernandez-Jalvo and Andrews 2003:148). In small mammals, experiments have shown that vertebrae are the first elements to be transported by water flowing at as little as 6 cm per second, with the mandible being the last to move, requiring 35cm/s (Korth 1979). Hydrodynamically sorted assemblages, therefore, will be made up of different groups of elements due to the flow rate of the water (Stahl 1996; Fernandez-Jalvo and Andrews 2003). Additional taphonomic markers caused by fluvial transport could include abrasion by sediments in the water (Fernandez-Jalvo and Andrews 2003). Damage to small mammal bones transported by fluvial action along coarse sands and gravels, includes the breaking up of skulls, and the rounding of the tips of incisors, although this is morphologically different to digestion (Fernandez-Jalvo and Andrews 2003). Therefore, water transport may mask evidence of digestion on rodent incisors,

but is unlikely to be mistaken for digestion. Abrasion by water transport does, however, produce rounded salient edges on microtine molars, and low levels of damage to several other elements. Damage is significantly less with finer sediments, and whilst elements transported with coarser grains appear more polished, this is not to case for the finer-grained sediments (Fernandez-Jalvo and Andrews 2003).

Although on a much smaller scale to fluvial transport, and most likely occurring over shorter distances, another consideration is transport linked to scavenging of a carcass by invertebrates. Harvester ants (*Messor barbarus*), observed in Kenya, were considered to be important agents of accumulation of microfaunal remains. Surface debris collected from an ant hill, produced a large microfaunal assemblage consisting of several rodent species, a shrew, and even a small lizard. All animals would have weighed less than 120g when alive, and all skeletal elements were represented, although mandibles and humeri were the most frequent (Shipman and Walker 1980). This suggests that harvester ants, species of which are found throughout Eurasia, Africa, and the Americas, can accumulate microfaunal assemblages. However, the scavenged prey item would have been small in size (Shipman and Walker 1980).

Butchery

Although cut marks could be considered as taphonomic signatures of a human predator, they have been separated out from predatory derived taphonomy in this chapter due to the difficulties of identifying these signatures on small vertebrates. Cut marks are rare on small vertebrates, and are difficult to distinguish from abrasion caused by trampling (Fernandez-Jalvo *et al*. 1999). On the rare occasions that cut marks on rodent remains are obvious, the species are usually larger than the microfauna considered here, such as coypu (*Myocastor coypus*) or the capybara (*Hydrochaeris hydrochaeris*), both of which weigh over 10 kg (Aulagnier *et al.* 2009), with the capybara weighing up to 65 kg (Mones and Ojasti 1986). Neither of these species, despite being rodents, would be classed as micromammals. Cut marks have, however been found on the remains of fossil hedgehogs (*Erinaceous broomei*) at Olduvai, but suggest skinning rather than butchery for consumption (Fernandez-Jalvo *et al*. 1999). Ethnographic evidence of the consumption of small mammals suggests they are cooked and mostly eaten whole with only tails and legs removed (Meyer-Rochow *et al*. 2015), so butchery would be limited and therefore cut marks are unlikely.

Burning

Burning, or thermal alteration of the bone structure is not uncommon in microfaunal assemblages, but the degree to which the alteration occurs does differ. Thermal alteration can be either intentional or incidental. When it comes to recognising assemblages derived through human diet, one of the taphonomic markers most often required alongside contextual detail is that of cooking (Simonetti and Cornejo 1991; Chiquet 2005; Romaniuk *et al.* 2016).

Much experimental work has been conducted on burnt bones, although this has almost exclusively been done on macrofauna (Bennett 1999; Cáceres *et al*. 2002), and in a forensic context, to examine burned human remains (Ubelaker 2009; Gonçalves *et al*. 2011; Ellingham *et al*. 2015). The colour of thermally altered bone corresponds to the temperature to which it was heated, going from brown/dark grey/black to milky white (Ellingham *et al.* 2015). These colours can be used to explore the taphonomic pathway of the assemblage formation, for example partial burning or charring associated with cooking versus the unintentional burning of refuse, or the dumping of hot coals into middens into which scats have been disposed (Stahl 1996; Lev *et al*. 2020).

Some experimental work on cooking of small mammals has been undertaken on the carcasses of guinea pigs and cavies, known to still be eaten around the world today (Medina *et al*. 2012). The experimental data showed that burning on small mammal carcasses being cooked, rather than discarded into the fire, was limited to the extremities, and long bone areas with less meat, such as the distal tibiae, radii and ulnae, along with the anterior portions of the mandibles and premaxilla. The flesh of the carcass protected the rest of the bones from burning during the cooking process, leading to partial burning and a recognisable cooking signature. (Medina *et al*. 2012). A similar pattern of charring was also seen when the Cape dune mole rat was cooked during ethnographic observations (Henshilwood 1997). The cooking of the small mammal for food produced charring on the mandibular and maxillary incisors, as well as the premaxilla. The rest of the animal was protected from burning by the pelt that was then removed prior to eating. In both these cases, the archaeological microfaunal assemblages recovered showed similarities to the cooking patterns, and it was established that these assemblages had been accumulated by humans, rather than other predators (Henshilwood 1997; Medina *et al.* 2012).

Microfauna can be burnt for incidental reasons as well, as shown by the recovery of charred mouse bones and pellets from a storage bin in Building 52 at Çatalhöyük. Despite being recovered from a food storage area, these animals are more likely to be the victims of deliberate arson or accidental burning of the house, rather than being a stored food item themselves (Bogaard *et al*. 2009; Twiss *et al.* 2009) due to the complete burning of the bones, as well as the presence of the mouse pellets, suggesting an infestation.

Weathering

Weathering has been defined in various ways by different people. Behrensmeyer (1978), for example, defines weathering as the processes by which the organic component of the bone is destroyed and separated from the inorganic component, and the nutrients are recycled within the soil. Miller (1975:217 cited by Lyman 1994:516) defined weathering as the "effects on the bone of saturation, desiccation, and temperature changes". So put simply, it is the physical effect of the environment on the bones (Andrews 1990). The effects of weathering are seen on the bone surfaces themselves as cracking, flaking, and splintering, and the degree to which these affect bones denotes the severity of the weathering, or the length of time they have been exposed (Behrensmeyer 1978; Andrews 1990; Lyman 1994). Weathering in terms of understanding microfaunal deposition can therefore help to explain whether remains have been left exposed on site or buried rapidly.

Taphonomic markers of weathering, however, may be masked if the remains are in a sheltered place or otherwise protected from the environment, such as those contained within regurgitated pellets. Experiments on how fast pellets break down have shown that location is important for pellet survival. For example, a dry place will preserve them longer than damp conditions (Andrews 1990). In addition, the species of the owl or raptor that deposited them is also relevant. Marti (1974) found that great horned owl pellets disintegrated more quickly (< 2 months) than those of barn owls (< 10 months), and that long-eared owl pellets remain whole for longer still (> 10 months). It was noted that these longer lasting pellets did display evidence of weathering. However, it was unclear if this was with regards to the pellet as a whole, or the bones within them (Marti 1974). It is important to note that although weathering patterns for microfauna are similar to that of macrofauna, the Behrensmeyer weathering stages are different for microfauna, as is the time frame surrounding them (Andrews 1990:11).

3.3. Post-depositional taphonomy

3.3.1. Burial to analysis

Burial of microvertebrates can come about by the natural process of sediments being laid down on top of the carcass, but microfaunal remains can also be buried by other mechanisms. Sexton beetles (*Microphorus sp.*) are an invertebrate species known for burying carcasses of small mammals. These beetles lay their eggs in the newly buried corpse, which remains hidden and protects the eggs, and is then consumed later by the larvae (Milne and Milne 1976; Andrews 1990). This process actually transports the small carcass over short distances and can disturb stratigraphy (Andrews 1990).

Bioturbation can also disperse bones throughout the sediment, moving bones up and down in the stratigraphic sequence, and also horizontally (Armour-Chelu and Andrews 1994). Earthworms (Oligochaeta), move soil upwards, whilst dragging leaf litter down into their burrows, and have been observed to be effective movers of small bones and other small objects and artefacts (Armour-Chelu and Andrews 1994). The common worm (*Lumbricus terrestris*) can burrow up to three metres deep but surfaces to feed on detritus. Worms have been known to move bones up to 20 cm through the soil. This dispersal through stratigraphic sequences could have implications for contextual archaeological interpretations, although it would primarily only affect deposition of microfauna or artefacts on palaeosols (Armour-Chelu and Andrews 1994), rather than those included in archaeological features, for example pits or middens.

Acidity in the soil can mimic corrosion caused by digestion. However, the distribution of corrosion over the bone is different. Digestive corrosion is initially restricted to the ends of long bones and the teeth, due to flesh protecting the rest of the element. Soil corrosion, however, affects the whole bone once all the flesh has decayed (Andrews 1990). The differences between digestion and soil corrosion is that the former is an enzymatic process that also involves the pH of stomach acids, whilst the latter is simply due to the pH of the soil and its effects on the organic and inorganic components of the bone.

Buried bones can also be affected by algal attack in moist environments, as well as bacterial and fungal attack. Experiments on macrofauna have shown that moss and

lichen can produce superficial corrosion in localised areas. However, these will be randomly spaced over the surface of the bone in areas exposed to light (Fernandez-Jalvo and Andrews 2016). How this affects microfauna is unknown, but it is more likely to affect the whole surface due to the small size of most elements. Root marking may also be seen on the bones. This can usually be distinguished by the u-shaped profile of the marks which rarely run in straight lines (Fernandez-Jalvo and Andrews 2016).

Fragmentation

As well as fragmentation caused by predation, fragmentation may also occur from soil compaction following burial. Experiments of post-depositional breakage were conducted by Smoke and Stahl (2004) in order to determine whether pre- and post-depositional fragmentation could be distinguished. Pellets were collected from a captive Eastern screech owl (*Otus asio*) that had been fed pre-trapped white-footed mice (*Peromyscus leucopus*). The species of owl was specifically chosen for the experiment due to the high levels of modification it produces, including bone loss. Nearly all elements recovered from the pellets showed evidence of digestion. In addition, two other mice were macerated to collect skeletal specimens without predatory taphonomic markers. The digested and 'uneaten' specimens were then buried and compacted in a controlled environment under known pressures, and the levels of fragmentation this produced were analysed. These experiments showed that skeletal elements that had been previously modified by digestive attack were more easily broken by compaction than those that had not been eaten. The taphonomic markers associated with digestion were still evident on the broken specimens and had not been masked by further fragmentation. The coarseness of the burial substrate also had an effect on fragmentation, with finer sediments producing increased levels of fragmentation than coarser material (Smoke and Stahl 2004; Fernandez-Jalvo and Andrews 2016).

Breakage can also occur during recovery of the assemblage, due to the need for sieving for thorough recovery of microfaunal remains (Fernandez-Jalvo and Andrews 2016) and it can also be caused during transport if the bones are improperly packed. Modern breaks are usually easy to spot because of the colour of a fresh break.

Although post-depositional breakage may cause increased levels of fragmentation within an assemblage, it does still allow us to use breakage as a predatory indicator. Skeletal elements will only become more fragmentary, not less, so if fragmentation

levels are low, and the specimens show evidence of digestion, then an assessment on the category of the predator is still achievable.

Recovery

A large bias in any microfaunal assemblage can be caused by the means of recovery of the remains. Recovery of microfauna requires the sieving of soil samples or deposits as hand recovery is inefficient, and elements like loose molars will require a 0.5mm sieve for retrieval (Rackham 1982, Andrews 1990). Wet sieving of samples is likely to cause more damage to the remains, although this will be minimal. It may, however, separate elements that were either in articulation *in-situ*, or that were extremely fragmented or fragile (Andrews 1990). In a sieving experiment by Clason and Prummel (1977), deposits were sieved through 10, 5, and 1 mm sieves, and the results compared to what had been collected by hand. The vast majority of macrofauna was hand collected, with another large percentage being retained by the 10 mm sieve. In contrast, a small number of microfaunal bones were hand-collected, with none recovered in the 10 mm sieve, and the vast majority collected in the 1 mm sieve.

In a separate experiment to the window well/ pitfall trap experiment conducted by Whyte and Compton (2020), discussed above, the role of sieve size on cranial versus post-cranial recovery was examined. The complete remains of known specimens of microfauna were sieved through various sieve sizes and this determined that cranial remains became more common in the assemblage as the sieve size decreased. The skeleton of an adult American toad (*Anaxyrus americanus*) approximately 84mm in length, was sieved through 6.4 mm, 3.2 mm, and 1.6 mm sieves. Other than small foot bones, all elements were caught by the 1.6 mm sieve, and at 3.2 mm 100% of the post-cranial remains were recovered. However, only 75% of the cranial elements were retained, and at 6.4 mm, less than 50% of either cranial or post-cranial elements were recovered (Whyte and Compton 2020). Therefore, sieve size in recovery of microfaunal remains has the potential to skew the sample toward larger species, as well as larger elements if the strategy for recovery is not targeted at the small species and elements.

Rackham (1982) suggested that sampling should be targeted at features that provided a 'concentrating mechanism' for microfauna, or ones that may have acted as traps, such as wells, pits, and drains. This, however, assumes that the majority of microfauna died *in-situ*, and neglects other accumulation mechanisms, such as predatory-derived

deposits, which could include humans as consumers of small mammals or amphibians, which may be concentrated in deposits elsewhere.

3.4. Amphibian and Squamate taphonomy

Amphibians, due to the nature of the skeletal remains, have a much more complex taphonomic process than mammals (Andrews and Fernandez-Jalvo 2012; Pinto Llona and Andrews 1999), which has not been sufficiently studied (Lyman 1994; Denys *et al.* 2017). The open-ended nature of many of the amphibian limb bones, and the unfused nature of their skull, means that patterns of digestion that would traditionally be looked for on micromammal remains are not possible. An alternative system for examining amphibian taphonomy is required to the methods outlined above. An analysis of the different effects of predation on amphibian bones was conducted by Pinto Llona and Andrews (1999). The analysis focused on six major limb bones including the scapula, humerus, radio-ulna, ilia, femur, and tibio-fibula, all of which are readily identifiable and frequently found in archaeological assemblages. Modifications due to digestion were observed on the surfaces and ends of the bones, and included thinning, rounding, flaking, splitting, and inward curving or collapse to various degrees depending on the predator. The digestion categories were then compared with a breakage category (Table 3.1) to estimate the predator responsible (Table 3.2) for the assemblage formation (Pinto Llona and Andrews 1999).

Table 3.1 Digestion and breakage categories for modification on amphibian bone (Pinto-Llona and Andrews 1999: 418)

	Digestion	Breakage
Category 1	Little effect	Most bone unbroken
Category 2	Light alteration	Little breakage, most complete
Category 3	At leas 50% bones show alteration	Less than 50% bones complete
Category 4	Well over 50% altered	Most bones heavily broken
Category 5	Almost all bones heavily digested	Only harder parts of bone survives

Table 3.2 Predators associated with the digestion and breakage categories on amphibians (Pinto-Llona and Andrews 1999).

Category	Digestion	Breakage
1	*Tyto alba*	*Tyto alba*
2		*Strix aluco*
3	*Lutra lutra* *Putorius putorius* *Genetta* sp. *Mustela lutreola*	*Asio flammeus* *Bubo bubo*
4	*Strix aluco* *Asio flammeus* *Meles meles*	*Genetta sp.* *Meles meles*
5	*Bubo bubo*	*Lutra lutra* *Putorius putorius* *Mustela lutreola*

Abrasion by water transport was also examined and amphibian bones appear to be more robust with rounding occurring in fine sediments and coarse gravel, with little additional breakage recorded (Pinto Llona and Andrews 1999).

An experiment on weathering also showed that amphibian bones were resistant to environmental modification, as they were still in articulation after 18 months of exposure. However, the long bones exposed on a south-facing wall did exhibit splitting and surface erosion, whereas those exposed on a north-facing wall only exhibited surface micro-flaking (Pinto Llona and Andrews 1999). A weathering experiment lasting 16 years showed that although bone survived, there was evidence of extensive splitting of the ends of the elements, as well as surface erosion (Pinto Llona and Andrews 1999).

Squamate (lizards and snakes) skeletal morphology is different again to those of mammal and amphibians, so traditional taphonomic markers no longer apply, resulting in limited archaeological analysis to date (Lev *et al*. 2020). Due to the lack of taphonomic experimental data on squamate remains, specifically vertebrae which are the most commonly recovered element from archaeological sites, Lev *et al.* (2020) undertook experiments using the European glass lizard (*Pseudopods apodus*), common viper (*Vipera palaestinae*), and the digested remains of lizards and snakes recovered from the pellets of eagle owls (*Bubo bubo*), to further examine taphonomic markers associated with weathering, burning, sediment erosion, and trampling.

The weathering experiment consisted of leaving the glass lizard carcass outside for 12 months. Very little modification occurred during the first five months and the carcass remained articulated. At nine months the carcass was mostly disarticulated and slight cracking appeared on the vertebrae. During this same period, the digested elements showed no modification at all. At one year, the carcass exhibited only slight cracks to the vertebra and the digested remains were still unaffected; the experiment continues following publication of the preliminary data.

The burning experiments showed that squamate vertebra turn black more readily than macrofaunal bones, most likely due to the small size of the specimens, and that the effect of burning on both fresh and previously digested remains is the same. Vertebrae showed evidence of cracking, which increased with longer burning time (Lev *et al*. 2020).

Erosion of the bone surface was observed as slight abrasion to large perforations on different aspects of the vertebrae, depending on the length of time the elements were tumbled with soil (Lev *et al*. 2020).

The digested elements in the same study showed additional breakage and rounding to the abrasion to those seen on the undigested elements. Trampling experiments also produced abrasion, perforation, and breakage of the protruding parts of the vertebrae. Burnt bones were included in the trampling experiment and were affected to a greater degree than the untreated or digested elements. The digestion evident on the vertebrae from the eagle owl pellets consisted of perforations to the bone surface, with 81% being digested. Half of these showed light digestion, and 22% exhibited moderate digestion. Breakage on digested vertebrae was low with 74% of the vertebrae complete (Lev *et al*. 2020)

These experiments have led to a typology of bone surface modification in squamates that can now be used to identify taphonomic processes on elements that are frequently recovered on archaeological sites, and can help to identify if humans were eating these animals (Lev *et al.* 2020).

3.5. Summary

Microfauna are a good indicator of local ecologies as they have specific vegetational habitats, limited geographical home ranges (often to just a few square metres), and are highly susceptible to environmental change (Denys *et al.* 2017; Fernandez-Jalvo 2016). However, due to high levels of predation on microfauna, the methods of deposition and therefore the identity of the predator need to be assessed in order to identify any biases that may have been introduced to the assemblage, including those by humans. This is analysed by looking at taxonomic composition and taphonomic markers, that can be used to identify categories of predators or other depositional pathways. A summary of what taphonomic markers may be expected depending on depositional pathways can be found below. However, it is important to take into account the contextual evidence of the deposit, and what the remains were in association with, in order to fully understand the depositional pathways;

Natural death:	Contextual evidence of burrowing; taxa known for fossorial or hibernating behaviour; skeletal frequency showing complete individuals; articulation *in-situ* (if known); lack of other taphonomic marks such as digestion (Smoke and Stahl 2004).
Catastrophic death:	Single taxa; possible sorting of elements via fluvial transport; possible burning (as per bones found in burned buildings) (Korth 1979; Korth and Evander 1986; Silcox and Rose 2001).
Pitfall traps:	Mixed taxa; skeletal frequency showing complete individuals; lack of breakage; lack of other taphonomic marks such as digestion (Whyte and Compton 2020).
Predator cache:	Single taxa; skeletal frequency showing complete individuals; possible breakage due to hunting strategy; lack of other taphonomic marks such as digestion, with possible exception of gnaw marks (King and Powell 2007).
Predation:	Evidence of digestion on teeth and at ends of long bones; fragmentation; relative proportion of elements relating to category of predator; gnaw marks; evidence of partial burning (Andrews 1990; Romaniuk *et al.* 2016; Simonetti and Cornejo 1991; Chiquet 2005).

Fluvial transport: Skeletal element frequency limited - of being sorted by size/shape; Similar bone orientation *in-situ* (if known); bone surface modification; sediment context (Korth 1979; Stahl 1996).

The next chapter will focus on how microfauna can be used to examine how people affected the landscape around them and utilised microfauna, specifically looking at palaeoenvironmental reconstruction, the inclusion of small vertebrates in a broad spectrum economy, their use in ritual practice, and how they can be used to better understand anthrodependancy and its relationship with sedentary practices.

4. Microfaunal Study

The vast majority of published microfaunal analysis concentrates on taphonomy and palaeoenvironmental reconstruction only, with considerations for other ways in which microfauna were utilised on archaeological sites left largely unexplored. This chapter seeks to explore the different ways microfauna could have been used by the inhabitants of archaeological sites, as well as how they are currently analysed.

4.1. Palaeoenvironmental Reconstruction

4.1.1. Introduction

Palaeoenvironmental reconstruction is the reconstruction of local or regional environments based on proxies or indicators, excavated from securely dated contexts on archaeological sites, or recovered by other means such as coring. A proxy is an indirect measurement of past climates preserved in sediments, ice cores, shells, pollen etc (Gornitz 2009). The vast majority of palaeoenvironmental proxies depend on good preservation and recovery, and a taxonomic identification of the specimens. Once the taxonomy is understood, a picture can be created of the environment at the time the deposit was formed. Nearly every method of palaeoenvironmental reconstruction has its biases, whether they be anthropogenic influences, such as selections of resources, or predator preference selection of small mammals. As such, it is better to use a range of proxies for palaeoenvironmental reconstruction.

4.1.2. Methods for palaeoenvironmental reconstruction

Many techniques, in addition to microfaunal analysis, can be used to reconstruct palaeoenvironmental conditions, including the analysis of other biological indicators, such as plant remains, insects, molluscs and macrofauna, as well as isotopic, geomorphological, and sedimentological analysis. The remains that rely on biological indicators generally use modern day proxies as indicators of past behaviours and habitat requirements. This is problematic, especially when used on extinct species when we have to attribute the behaviours and characteristics of their closest living relative, but generally when used alongside other indicators they can create a full picture of past ecologies.

Sedimentology

Sedimentology is the study of changes to sedimentary deposits by natural or anthropogenic processes (Perry and Taylor 2009). The make-up of sediments and how they change over time, often sampled by coring, can explore differences in the chemical, biological, and physical events that modify them, and therefore can be used to examine the environments they were formed in (Jenkins 2009, Perry and Taylor 2009).

Plants

Phytoliths and other microscopic plant remains

Phytoliths are opaline silica structures formed in and around plant cells following the uptake of silicon dioxide in the ground water during transpiration. Following taxonomic identification, or morphological classifications, phytolith indices can be used to examine environmental change, such as tree density, drought, and water stress (Jenkins 2009, Jenkins *et al.* 2016; 2020; Coe *et al*. 2014).

Pollen grains are the male reproductive cells of seed plants (Cappers and Neef 2012), and can be used to reconstruct local and regional palaeoclimates. Pollen dispersal methods must be taken into account during reconstruction, as species of plants that are self-pollinated, or pollinated by insects may be absent or under-represented in the pollen record for that area when compared with plants that are pollinated by wind (Cappers and Neef 2012). Pollen requires specific conditions for preservation, and is often not recovered from archaeological sites, however in hypoxic environments that are not subject to fluctuating groundwater levels, pollen grains can last for millennia.

Diatoms are colonial, single celled microalgae that are found in abundance in nearly all aquatic environments. Their cell walls, also known as valves or frustules, are made of silica and preserve well in sediments. Different species have specific ecological niches and tolerances (Reid *et al.* 1995; Battarbee *et al*. 2001; Serieyssol *et al.* 2011), and can therefore be used to assess water quality, salinity, and pH.

Starch is a semi-crystalline, insoluble carbohydrate, which acts as a plant's main food storage substance, and can be found in roots, seeds, rhizomes, and tubers (Farley *et al*. 2018). Preservation of starch grains is best in tropically derived sediments (Farley *et al*. 2018).

Seeds and other macroscopic plant remains

The remains of macro-botanical specimens, as well as charcoal, are usually recovered via flotation and heavy residue sorting, and may contain seeds, fruit stones, nutshell fragments, as well as other identifiable plant remains such as chaff or spikelets from cereals (Ergun *et al*. 2018). In order to be preserved in the archaeological record, most macro-botanical specimens need to be charred, waterlogged, or desiccated (García-Granero *et al*. 2015, Jenkins *et al*. 2020).

Charcoal is any blackened plant-derived material which has been thermally altered, and is biologically and chemically inert which makes it less susceptible to degradation over time (Hall *et al*. 2008). Charcoal is introduced into archaeological sites via a variety of methods, including the burning of wood as fuel, as well as the accidental or deliberate burning of objects or structures made of wood, such as pyres or buildings.

Animal remains

Both land and water molluscs can become incorporated into archaeological deposits through a number of pathways. Some molluscs are routinely eaten by people, and their incorporation will be indicative of gathering and human consumption. Some non-dietary molluscs, however, may also be accidentally incorporated into archaeological deposits, for example, attached to other resources, such as harvested seaweed or algae. Molluscs inhabit different environments, and are sensitive to fluctuations in the local environment, including temperature and salinity (Evans 1972 cited by Reitz and Wing 1999:308).

Beetle parts, specifically the head, thorax, and wing cases preserve well in archaeological deposits and can be used to suggest local habitats, such as bogs and marshes, grassland, or dry areas, based on ecological preferences for the different species or genera recovered. They can be used to assess levels of vegetation, and different species can also be temperature dependant, and suggest temperature range (Zhang and Elias 2019).

Chironomid (non-biting midges) larvae develop in freshwater ecosystems and therefore preserve well in lake sediments (Eggermont and Heiri 2011). As they are highly sensitive to temperature fluctuations in the lake surface water, they are an excellent tool for identifying past temperature ranges (Eggermont and Heiri 2011).

Both macrofauna and fish can be used for palaeoenvironmental reconstruction, however their inclusion in archaeological assemblages is usually due to their use by the inhabitants on the site, and therefore are rarely indicative of the local ecology.

4.1.3. Microfauna in palaeoenvironmental reconstruction

Microvertebrate species, including small mammals, amphibians, lizards, and snakes can represent up to 80% of species richness within an ecosystem (Fernandez-Jalvo *et al*. 2016; Denys *et al*. 2017). Due to their abundance and small size, they often have low tolerances for environmental change and particular requirements for their ecological niches, such as vegetation cover, levels of precipitation, and temperature (Jenkins 2009; Fernandez-Jalvo *et al.* 2016). A summary of selected species of microfauna from Turkey, their habitat preferences, and diet etc. can be found in Table 4.1 (Andrews 1990; Harrison and Bates 1991; Hofmann 1995; Kryštufek and Vohralik 2001; 2005; 2009; Sterry 2005; Aulagnier *et al*. 2009; Dufresnes 2019).

Microfauna have been used as palaeoenvironmental indicators for over 60 years, with one of the first studies being that of De Graaff (1960), who examined microfaunal assemblages recovered from Australopithecus-bearing breccias from Taung, Sterkfontein, and Makapansgat in the Transvaal System, South Africa. This early study used fossil micromammal species as bio-proxies to suggest that species composition between the sites differed, indicating that the earlier sites were drier than the later ones. However, although De Graaff recognised that the microfaunal assemblages under study were produced by an owl, no mention was made as to the species of the accumulator, nor any mention of how this could affect the assemblage under analysis.

Brain (1974) took this further still with a microfaunal assemblage from Mirabib, Namibia, and suggested that species composition and habitat preferences of small mammal assemblages could provide information about changing habitats over time, such as the movement of sand dunes due to the presence and/or absence of soft-sand dwelling small mammals such as the golden mole. Again, although predators are mentioned as the accumulating agent, no attempt was made in the paper to identify the species responsible, and the differential effect on microfaunal accumulation by different predators was not discussed.

Avery (1982) used archaeological microfaunal assemblages and the behaviour of their modern-day proxies, to create detailed information about the palaeoenvironmental conditions under which early humans lived during the last 80 000 years in the Southern Cape Province (now the Western Cape), South Africa. Avery, unlike her forebears, also looked at the accumulating agent of the micromammalian assemblages, and how it could bias the interpretation. However, this was determined based on the fact that most of the prey species recovered were not naturally found in cave habitats, and therefore that they must have been accumulated by predatory action. The process for identification of the predator was predicated on the prey species, and whether their activity patterns e.g., nocturnal versus diurnal behaviour, matched. The means of identifying the predators responsible was therefore, not based on a taphonomic assessment of the bones themselves, save for a notation that levels of fragmentation were low, but a process of elimination, and a comparison with modern owl pellets.

Andrews (1990) seminal work on the effects predation has on microfaunal bone, looked at over 40 predator species and the subsequent taphonomic effects on bones recovered from known pellets and scats. This evidence was then used to analyse archaeological assemblages, and identify the predator or predators responsible for accumulation (as outlined in Chapter 3). This methodology has allowed researchers to strip away the biases caused by potential prey selection and allows for a more thorough examination of local ecologies than before.

The advantage of this methodology can be seen in the subsequent analyses of microfauna from Olduvai Gorge, a Pleistocene hominid site in Tanzania. Andrews *et al*. (1979) initially examined this site using taxonomy, body size, and ecological diversity indices in order to reconstruct past ecologies. This study found that the Olduvai fauna was one that suggested a woodland-grassland community, similar to the modern-day ecology of the area (Andrews *et al*. 1979). However, a reanalysis of the microfauna which incorporated a body part and breakage analysis, determined that the assemblage had been accumulated by a mammalian carnivore (Andrews 1983). Taking into account the biases introduced by the predator, Andrews (1983) reassessed the local ecology to be much denser woodland than previous considered, and that it would have been much wetter than the current climate.

Further analysis of the Olduvai Bed-I microfauna, taking into account a full taphonomic analysis, has subsequently identified several predator species in the different units within Bed-I (Fernandez-Jalvo *et al*. 1998). The identification of several predators has explained some of the variability in rodent faunas throughout the different units, however this analysis also highlighted a change in the dense woodland environment in the middle of the series, changing to more open woodland at the top of the series (Fernandez-Jalvo *et al*. 1998). This series of papers exploring the palaeoenvironmental reconstruction of a single site over time, has shown the importance of a full taphonomic analysis, and an understanding of the biasing factors involved in assemblage formation, prior to the reconstruction of past climates.

Much work has since been done on recognising the taphonomic signatures left by different predators on small mammal bone (Andrews 1990; Fernandez- Jalvo and Andrews 1992; 2003; Terry 2007; Dauphin et al. 2015; Fernandez-Jalvo et al. 2014; 2016; Denys et al. 2017). However, other microvertebrate species, for example amphibians and squamates, have not received the same degree of study (Lyman 1994; Stoetzel et al. 2012; Denys et al. 2017; Lev et al. 2020).

Amphibian bone in particular is morphologically different to those of small mammals, as many of the articular joints in amphibians are cartilaginous rather than bony. As such, the post-cranial digestion methodology devised by Andrews (1990) no longer applies. This is also true of the cranial methods used for small mammals, as these rely on the digestive affect on teeth, which differ greatly in amphibians and squamates, if they have teeth at all. As such, modifications by predators to herpetofaunal bones is distinctly different (Pinto Llona and Andrews 1996).

Pinto Llona and Andrews (1999) conducted a study similar to Andrews (1990) with a specific emphasis on the predator taphonomy on amphibians. In the analysis, taphomonic markers linked with method of predation, such as breakage was analysed, as well as the specific effects of digestion on amphibian bone. Categories were then devised that could be used to identify specific predators. Other taphonomic agents were also examined, including fluvial transport and weathering.

Lev et al. (2020) extended this taphonomic study to include vertebrae of squamates, due to their high abundance on archaeological sites, and the lack of taphonomic data. They

experimentally tested weathering, burning, erosion, and trampling on lizard and snake bones, and use the data to discern non-cultural and cultural deposits in Natufian squamate assemblages.

There is still more experimental work needed in order to fully understand herpetofaunal taphonomy and its place in palaeoenvironmental reconstruction, as this area of study is still lagging behind that of the small mammals.

Table 4.1 Summary of small mammals and herpetofauna which may be prey species for predators currently found in Turkey

Species name	Common name	Size	Activity period	Diet	Habitat preferences
Erinacidae					
Erinaceus concolor	White-breasted hedgehog	197-297 mm	Nocturnal, occasionally diurnal	Omnivore	Steppe, semi-arid areas, farmland, gardens, and forests. Found up to 1400 m a.s.l.
Hemiechinus auritus	Long-eared hedgehog	140-270 mm	Crepuscular and nocturnal	Omnivore	Sandy, semi-arid areas, salt-marsh, steppe. Found up to 900 m a.s.l.
Soricidae					
Sorex minutus	Pygmy shrew	42-72 mm	Active both night and day	Insectivore	Plains, riparian forest, marshland, swamps, and other wet habitats. Found up to 2300 m a.s.l.
Sorex araneus	Common shrew	59-88 mm	Active both night and day	Omnivore	Grasslands, moorlands, hedges, forests, and riparian zones. Found up to 2850 m a.s.l.
Neomys anomalus	Miller's water shrew	56-94 mm	Active both night and day?	Omnivore	Wet habitat including marshland, streams, small rivers and wet grassland. Found up to 2100 m a.s.l.
Neomys teres	Transcaucasian water shrew	85-101 mm	Active both night and day?	Omnivore	Streams and small rivers, coniferous forests. Found up to 2500 m a.s.l.
Suncus etruscus	Pygmy white-toothed shrew	34-54 mm	Crepuscular and nocturnal	Insectivore	Disturbed ground, shrubland, stony grassland. Found up to 1300 m a.s.l.
Crocidura leucodon	Bi-coloured white-toothed shrew	50-90 mm	Nocturnal	Insectivore	Rocky areas, grassland, forests, hedges. Found up to 2150 m a.s.l.
Crocidura suaveolens	Lesser white-toothed shrew	50-92 mm	Diurnal	Insectivore	Dense bushlands, reedbeds, hedgerows, marshland, rocky areas. Found up to 2500 m a.s.l.
Vespertilionidae					
Myotis myotis	Great mouse-eared bat	55-67 mm	Nocturnal	Insectivore	Cave dweller. Lowland and low mountain habitat, open woodland. Found up to 1700 m a.s.l.
Pipistrellus kuhlii	Kuhl's Pipistrelle	30-36 mm	Nocturnal	Insectivore	Crevices in cliffs. Lowlands, and lower mountain slopes. Found up to 1450 m a.s.l.
Cricetidae					
Mesocricetus auratus	Golden hamster	120-165 mm	Crepuscular and nocturnal	Omnivorous, although mainly grain	Steppic habitats, irrigated fields, edges of arable land. Found up to 650m.
Mesocricetus brandti	Turkish hamster	135-166 mm	Nocturnal	Omnivore	Dry, rocky, Steppe habitats, occasionally near cultivated fields. Found up to 3000 m a.s.l.
Cricetulus migratorius	Grey dwarf hamster	80-147 mm	Crepuscular and nocturnal	Omnivorous, although mainly herbivorous	Cultivated areas, including human dwellings. Open woodland, steppes, rocky ground. Found up to 4000 m a.s.l.
Cricetus cricetus	Common hamster	222-300 mm	Crepuscular and nocturnal	Omnivore	Steppe, rough grassland
Arvicola amphibius	Water vole	130-240 mm	Crepuscular and nocturnal, possibly diurnal	Omnivore	Associates with bodies of water; streams, rivers, irrigation ditches. Found up to 3210 m a.s.l.
Myodes glareolus	Bank vole	80-120 mm	Predominantly nocturnal	Predominantly herbivorous, occasionally include insects	Deciduous, mixed, and coniferous woodland, forest margins, dense shrubs. Found up to 2400 m a.s.l.
Microtus guentheri	Günthers vole	97-138 mm	Active both night and day	Herbivore	Well drained meadows, pasture, areas with sparse vegetation. Found up to 2000 m a.s.l.
Microtus levis	Southern vole/ Sibling vole	90-165 mm	Crepuscular and nocturnal	Herbivore	Tall, dense shrubs and herbaceous vegetation. Wet, marshy locations preferred. Found up to 2500 m a.s.l.
Microtus socialis	Social vole	80-120 mm	Diurnal and crepuscular	Herbivore	Pasture, grassland, steppe, and semi-desert. Also found in fields, and clearings in forests, Found between 650 m to 2500 m a.s.l.
Microtus anatolicus	Anatolian vole	105-125 mm	Active all day	Herbivore?	Lives in colonies in dry, alkaline soil with sparse halophytic vegetation. Known from a very localised population in Aksaray Ovasi
Muridae					
Apodemus sylvaticus	Wood mouse/ Long-tailed field mouse	80-110 mm	Predominantly nocturnal	Omnivore	Mixed habitat incuding forests, garden, hedgerows, and woodland with sparse vegetation. Found up to 2000 m a.s.l.
Apodemus flavicolis	Yellow-necked mouse	88-130 mm	Nocturnal	Omnivore	Forests, particulary mature deciduoud forest edges, and bushy habitats such as hedgerows, and thickets. Found up to 2120 m a.s.l.
Apodemus mystacinus	Eastern rock mouse/ Eastern broad-toothed field mouse	98-128 mm	Nocturnal	Omnivore	Rocky scrubland and forests, rocky outcrops, pastures with scattered bushes. Found up to 2700 m a.s.l.
Apodemus agrarius	Striped field mouse	75-120 mm	Predominantly nocturnal	Omnivore	Scrub, pasture, woodland egde, marsh, and reedbeds. Found up to 1750 m a.s.l.
Mus macedonicus	Macedonian mouse/ Balkan short-tailed mouse	69-98 mm	Nocturnal	Not known. Possibly omnivorous	Dense vegetation, in association with arable land and water e.g. irrigation ditches. Human settlement avoidant. Found at 1600 m a.s.l.
Mus musculus domesticus	House mouse	70-103 mm	Crepuscular and nocturnal	Omnivore	Commensal; human dwellings as well as isolated outbuildings. Feral populations can exist in areas where *M. macedonicus* is absent in scrubland, agricultural land, and desert oases. Found up to 3800 m a.s.l.
Meriones tristrami	Tristrams jird	105-155 mm	Crepuscular and nocturnal in summer and diurnal in winter	Herbivore	Dry steppe, semi-desert. Shory and tall grass, open hillside, field margins
Spalacidae					
Nannospalax ehrenbergi	Palastine mole rat	130-220 mm	Diurnal and polyphasic during rainy season	Omnivore - mainly tubers, but some small insects also eaten	Open country, steppe. Found up to 2200 m a.s.l.
Chiroptera					
Myotis myotis	Greater mouse-eared bat	65-80 mm	Nocturnal	Insectivore	Woodlands, field systems, meadows, rivers
Pipistrellus pipistrellus	Common pipistrelle	33-50 mm	Crepuscular and nocturnal	Insectivore	Open woodland, gardens and parks, open areas with isolated trees, agricultural land. Found up to 2000 m a.s.l.
Anura					
Pelophylax ridibundus	Marsh frog	110-130 mm		Carnivore - known to eat whatever will fit in its mouth	Aquatic habitat in desert, forest, and steppe- tollerant of brackish conditions. Drainage ditches, pools.
Pelophylax lessonae	Pool frog	50-65 mm		Carnivore	Aquatic habitat, including ponds. Found up to 1500 m a.s.l.
Pelophylax esculenta	Edible frog (hybrid of the marsh and pool frog)	70-90 mm		Carnivore	Aquatic habitat, including ponds.
Bufotes viridis	European green toad	48-120 mm		Insectivore	Dry, open areas, meadow, steppe. Water needed for reproduction, usually shallow. Know for living close to human settlements. Found up to 2400 m a.s.l.
Pelobates sp.	Spadefoot toad	65-80 mm		Insectivore	Lowland, steppic habitat, marsh, with areas of sandy soils or soft clay soils for burrowing
Serpentes					
Natrix natrix	Grass snake	600-900 mm	Diurnal	Carnivore - mostly amphibians	Wetlands, ponds, lakes, marshes.

Table 4.2 provides further information of predator species, found in Turkey, that prey on microfauna and could therefore contribute to the microfaunal assemblages being studied for this thesis, whilst Table 4.3 shows the different species of prey collected in predator pellets or scats (Korpimäki 1986; Veiga 1986; Weber 1989; Högström and Wiss 1992; Van Zyl 1994; Gil-Delgado *et al.* 1995; Graham *et al*. 1995; Al-Melhim *et al.* 1997; Sulkava *et al.* 1998; Zawadzka 1999; Kok et al. 2000; Watson and Clarke 2000; Pedrini and Sergio 2001; Redpath *et al.* 2001; Zawadzka and Zawadzki 2001; Bonvicino and Bezerra 2003; Rizzolli *et al*. 2005; Seçkin and Coşkun 2005; Dell'Arte *et al.* 2007; Posłuszny *et al*. 2007; Remonti *et al.* 2007; Drewitt and Dixon 2008; Palazón *et al.* 2008; Bujoczek and Ciach 2009; De Cupere et al. 2009; Geng *et al*. 2009; Obuch and Benda 2009; Resano-Mayor et al 2010; Rodríguez *et al*. 2010; Latková *et al*.2012; Jankowiak and Tryjanowski 2013; Malecha and Antczak 2013; Demerdzhiev *et al.* 2014; Paspali *et al.* 2015; Ambarli *et al.* 2016; Hussain *et al*. 2016; Nedyalkov and Boev 2016; Bounas and Sotiropoulos 2017; Grano and Catteraneo 2017; Selçuk *et al*. 2017; Per *et al.* 2018; Selçuk *et al*. 2018; Chavko *et al.* 2019; Di Vittorio *et al.* 2019; Alivizatos and Goutner 2021; Güngör *et al*. 2021; Demerdzhiev *et al*. 2022).

This shows that many species of avian and mammalian predators take a wide variety of prey species, and that only a few are specialised. Where the information was available, pellets and scats collected in Turkey were included in the summary table. However, not every species of predator has had their diet examined in detail. As such, there will be more information relating to Turkish prey species for some predators, whereas others will be limited to higher taxonomic classifications. Further information on the taphonomic changes by different avian and mammalian predators, as well as how they are classified into categories based on skeletal changes, can be found in Chapter 3.

Table 4.2 Summary of predator species in Turkey, including their habitat preferences and hunting strategy

Species name	Common name	Size	Activity period	Habitat preferences and hunting strategy	Prey items per pellet
Bubo bubo	European Eagle owl	1-4 kg	Nocturnal	Wooded habitats, nests on the ground, in caves, ledges or fissures in rocks, rarely in trees. Hunt over 10 km diameter area, mostly open area	6-7
Tyto alba	Barn owl	350g	Mainly nocturnal but potentially diurnal in winter	Open habitats, heaths, moors, pasture, grassland, parkland etc. Will nest in human made structures, as well as caves, trees, and crevices. Hunting range from 300 m to 4.5 km, with an average of 1 km	
Athene noctua	Little owl	170g	Crepuscular and nocturnal to diurnal	Open area, meadows, rural settlements	Mean 0.6
Strix aluco	Tawny owl	Up to 800 g	Nocturnal	Woodland habitats, nesting in holes in trees, but also known to nest in buildings, caves, and even rabbit burrows. Very small hunting range - up to 700 m from nest	
Asio flammeus	Short-eared owl	380g	Diurnal	Grassland, tundra, marshes with territory up to 15 to 20 ha, but mainly hunts with 1 km of the nest. More selective hunter of voles, showing prey preference	
Asio otus	Long-eared owl	280g	Nocturnal	Wooded habitat, cultivated steppe parks and gardens. Open grassy habitat, forest edge, More selective hunter of voles, showing prey preference. Can hunt up to 7 km from the nest	1-2
Otus scops	Eurasian scops owl	90g	Nocturnal	Woodland, open habitat including parks, and orchards. May also be associated with human settlements. Scops owls in the northern most part of their range are migratory.	
Circus cyaneus	Hen harrier	300g to 550g	Diurnal	Hunting area of a single male may be up to 2-3 km2, open ground, moorland, heavy vegetation. May roost up to 8 km away from hunting areas in winter	
Buteo buteo	Common buzzard	600 g to 1.3 kg	Diurnal	Wooded habitats for nesting, open areas for hunting including meadow, and grassland. Territory up to 225-253 ha expanding over open country.	
Milvus migrans	Black kite	700g to 1 kg	Diurnal	Wet habitats, forest edge, lakes, farmland. Territory up to 225-253 ha expanding over open country. Hunts up to 4 km away from nest	1-4, mean 1.10
Milvus milvus	Red kite	900g to 1.2 kg	Diurnal	Open areas, including anthropogenic habitats, and lakes. H as been known to hunt up to 10 km away from nest, however this was to take advantage of anthropogenic waste so may have been different in antiquity	
Haliaeetus albicilla	White-tailed eagle			Wetland habitats, lakes, river settings. Can hunt up to 15 km away from nest, but usually within a 5 km radius	
Clanga pomarina	Lesser spotted eagle	1.1 to 1.2 kg	Diurnal	Open areas and forests. Hunts up to 4 km away from nest in trees, but usually within 1 km.	
Clanga clanga	Greater spotted eagle	1.6 to 2.3 kg	Diurnal	Woodlands, heath, meadows, and lakes. Nests in trees	
Aquila heliaca	Imperial eagle	2.5 to 4 kg	Diurnal	Scattered copses on open plain, wooded steppe. Nests in trees	
Aquila chrysaetos	Golden eagle	3 to 6.6 kg	Diurnal	Wooded habitats, mountainous. Nests in trees or on cliffs	
Aquila fasciata	Bonelli's eagle	1.5 to 2.1 kg	Diurnal	Scattered woodland, dry, mountainous areas. Nests in trees or on cliffs	
Hieraaetus pennatus	Booted eagle	600g to 1.1 kg	Diurnal	Wooded habitats. Nests in trees or on cliffs	
Accipiter nisus	Eurasian sparrowhawk	130g to 320g	Diurnal	Wooded habitats for nesting, open areas for hunting	1-6
Falco tinnunculus	Eurasian kestrel	150g to 280g	Diurnal	Open habitats	1-2
Falco naumanni	Lesser kestrel	130g to 180g	Diurnal	Open habitats	
Falco cherrug	Saker falcon	700g to 1.3 kg	Diurnal	Wooded habitat, dry steppe, semi-desert	
Mustela erminea	Stoat	150-300g	Cathemeral	Woodland, scrub hedgerows. Prey killed by bite to the back of the neck	
Mustela nivalis	Weasel	40-170g	Cathemeral	Woodland, hedgerows, gardens. Territory between 5-8 ha, and can travel approx, 2 km a night. Specialises in voles and mice but will eat amphibians and birds	
Mustela lutreola	European mink	550-800g	Crepuscular and nocturnal	Near slow-moving fresh water, lowland wet habitat, banks of rivers and lakes	
Mustela putorius	Western polecat	600g to 1.5 kg	Predominantly nocturnal	River valleys, meadows, fields, scattered woodland. Can hunt over serveral square kms	
Martes martes	Pine marten	900g to 2kg	Crepuscular and nocturnal	Wooded habitat. Exceptionally good at hunting in trees, avoids human settlements, but may be found close to humans in rural areas. Home range of up to 80 km2	
Martes foina	Stone marten		Nocturnal	Woodland, rocky outcrops, human settlements	
Vulpes vulpes	Red fox	4-10 kg	Cathemeral	Commensal of humans and found in most habitats from the coast to mountains, steppe, woodland and human settlements. Excepionally good hearing and can detect a mouse at 100 m.	
Canis aureus	Golden Jackal	7-13 kg	Crepuscular and nocturnal	Steppe, lowland scrub, woodland, anthropogenic habitats	

Table 4.3 Summary of prey species collected from predator pellets or scats showing little prey preference for most species

Species name	Common name	**Insectivores**	*Crocidura suaveolens*	*Crocidura leucodon*	*Arvicola amphibius*	*Myodes glareolus*	***Microtus* sp.**	*Microtus guentheri*	*Microtus socialis*	*Microtus guentheri*	*Microtus levis*	*Mesocricetus auratus*	*Mesocricetus brandti*	*Cricetus cricetus*	*Cricetulus migratorius*	**Murids**	*Meriones tristrami*	*Apodemus sylvaticus*	*Apodemus flavicolis*	*Apodemus mystacinus*	***Mus* sp.**	*Mus macedonicus*	*Mus musculus domesticus*	*Spalax xanthodon*	*Nannospalax ehrenbergi*	***Rattus* sp.**	**Anura**	**Birds**	**Fish**	**Chiroptera**	Notes
Bubo bubo	European Eagle owl	X			X		X		X				X		X		X	X	X				X				X				Opportunistic hunter with prey size ranging from insects to juvenile roe deer
Tyto alba	Barn owl	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X		X	Primarily small mammals
Athene noctua	Little owl	X	X	X		X	X		X		X				X	X	X	X	X		X	X				X		X		X	Primarily small mammals
Strix aluco	Tawny owl	X			X	X	X			X	X		X		X	X	X	X	X	X	X		X	X			X	X	X	X	
Asio flammeus	Short-eared owl	X			X	X	X				X		X		X	X	X		X		X	X				X	X	X	X		Primarily small mammals
Asio otus	Long-eared owl	X	X		X	X	X			X			X	X	X	X	X		X		X		X			X	X	X	X	X	Primarily small mammals
Otus scops	Eurasian scops owl						X									X												X			Primarily insects (up to 98%)
Circus cyaneus	Hen harrier	X					X									X					X		X			X	X	X			Seasonal variation in the quantity of small mammals vs birds taken
Buteo buteo	Common buzzard	X			X		X				X					X		X			X		X				X	X			
Milvus migrans	Black kite	X			X											X							X			X	X	X	X		Primarily birds and fish
Milvus milvus	Red kite	X			X		X									X							X			X	X	X	X		Primarily birds and small mammals
Haliaeetus albicilla	White-tailed eagle	X					X																					X	X		Primarily feeds on birds and fish
Clanga pomarina	Lesser spotted eagle	X			X	X	X									X		X	X								X	X			Mainly mammals and birds
Clanga clanga	Greater spotted eagle	X			X		X				X					X												X			
Aquila heliaca	Imperial eagle	X					X								X	X												X			Larger mammals, such as white-breasted hedgehog, most common prey
Aquila chrysaetos	Golden eagle	X			X																					X		X			Larger species taken, up to the size of reindeer fawns. Mountain hare, grouse common prey
Aquila fasciata	Bonelli's eagle																									X		X			Larger mammal species such as hares/rabbits and squirrels more commonly taken with birds
Hieraaetus pennatus	Booted eagle	X			X																							X			Predominantlly preys on rabbits and birds
Accipiter nisus	Eurasian sparrowhawk						X																X			X	X	X	X	X	Primarily birds with some small mammals
Falco tinnunculus	Eurasian kestrel	X			X	X	X									X		X			X		X			X	X	X			
Falco naumanni	Lesser kestrel						X									X															Mainly insects (up to 97%) with some small mammals
Falco cherrug	Saker falcon	X					X							X		X		X	X				X			X		X			
Vulpes vulpes	Red fox	X			X	X	X								X	X										X		X			
Canis aureus	Golden Jackal						X								X	X			X									X			Mainly feed on fruits, and larger prey like hare, partridges, and young goats
Coluber nummifer	Coined snake																			X											
Mustela erminea	Stoat	X			X		X									X										X	X	X			Mainly small mammals or lagomorphs, but will seasonally eat fruit when abundant
Mustela nivalis	Weasel	X				X	X									X					X						X	X			
Mustela lutreola	European mink						X									X											X	X	X		
Mustela putorius	Western polecat	X			X	X	X									X		X	X				X			X	X	X	X	X	Anurans make up a large proportion of the diet
Martes martes	Pine marten	X				X	X									X											X	X			
Martes foina	Stone marten	X				X	X									X												X			Also feeds on fruit

4.1.4. Summary

This sub-chapter has provided a brief review of several methods used to reconstruct palaeoenvironmental data, using sedimentological and biological proxies to infer vegetational, and climatic histories. Many of these methods rely on the taxonomic identification of flora or fauna, and uses modern habitat requirements as bio-proxies for past species. This may become problematic when inferring the behaviour of extinct species, based on their closest morphological relation. The need for thorough taphonomic analysis along with many bio-proxies is also needed, in order to strip away biases introduced into the assemblage by human selection processes or predator hunting strategies. The short comings of several methods for palaeoenvironmental reconstruction can be mitigated by using an interdisciplinary approach, with several strands of evidence being used for the same location. Using microfauna to reconstruct past local ecologies can become problematic on archaeological sites where the method of assemblage formation is not fully understood. Human selection bias, or even human impact on local environments can mean that on-site microfaunal assemblages do not accurately reflect the surrounding habitats. Palaeontological microfaunal assemblages, with minimal introduction of human biases, most often found in cave sites etc., are much more reflective of local palaeoenvironments.

The next sub-chapter will examine how human subsistence practices can bias microfauna recovered on archaeological sites, as it explores microfaunal use in past human diets.

4.2. Broad Spectrum Economy

4.2.1. Introduction

Microfauna are generally seen as non-cultural additions to the archaeological assemblage, and as such, are often only used to reconstruct past environments, as addressed above. However, as rodents and herpetofauna are still used to supplement the human diet globally today (Fiedler 1990), we would be remiss not to consider this as a possible reason for their accumulation.

The suggestion that smaller animals played a part in diet was popularised by Binford (1968) who suggested that a change of diet in terminal Pleistocene hunter-gatherers required a force that disrupted the balance between the carrying capacity of the environment and human populations levels. This change led to a reduced reliance on big game hunting and an increase in the uptake of small game animals, such as hares. Binford (1968) suggested that this driver may have been linked to global environmental change at the end of the last ice age which led to sea level rises, trapping human populations within restricted geographical areas and reducing the carrying capacity of their environment. This reduction had to be mitigated by diversification of resources.

Flannery (1969), with his 'Broad Spectrum Revolution' hypothesis, expanded on Binford's work by suggesting that subsistence change was not necessarily driven by sea level rises which caused population circumspection, but by environmental mosaics of optimal environments. He suggested that when populations moved from an optimal mosaic to more marginal environments, perhaps driven by greater population density, an increase in the number of animals and plants eaten would be required in order to stretch the carrying capacity of that marginal environment (Flannery 1969). For example, an increase in the uptake of small game animals such as fish, shellfish, wild birds, hare, and tortoises in the faunal assemblages of late Pleistocene hunter-gatherers (Binford 1968; Flannery 1969; Zeder 2011). An increase in the number of plant species used is also found, such as nuts, wild cereals, and legumes (Zeder 2011).

These theories are also supported by an increase of small game found on early Natufian sites in the Levant around 15ka (Stutz *et al*. 2009). Analysis by Stutz (2009) also

indicated that large game within the same assemblages decreases over time and tallies with the increase in small game collection.

Few studies look at animals smaller than the hare or tortoise when considering species that made up past human diet. As both small mammals and amphibians are routinely eaten around the world today, these should be included in the analysis in order to be sure that our conclusions regarding broad spectrum theory is not being biased by modern, western culture.

4.2.2. Amphibians and Squamates as a food source

4.2.2.1. Ethnographic examples

Frogs are still routinely eaten all around the world. The largest demand coming from Europe and the USA (Warkentin et al. 2009) in the form of frog legs, or cuisses de grenouille (Figure 4.1). In France, eating frog legs is seen as part of the national identity and there are still annual fayres in which frog legs are eaten in huge numbers (Letcher 2003). A decade ago, it was estimated that people were eating as many as a billion frogs a year, or the equivalent of between 11.2 and 39 thousand tonnes a year, based on exports and domestic markets in Indonesia (Warkentin et al. 2009), with the industry now being worth $40 million annually (Smithsonian 2009).

Figure 4.1 Uncooked frogs legs showing distribution of meat around the hind limbs (Photo: M Feider 2019).

In France, commercial frog hunting and frog farming was made illegal in 1980 due to the severe decline in numbers and the ecological impact of removing animals from the wild. Several species were protected by law, and although this has slowed the decline in wild populations, many are still poached each year to be sold to restaurants, with people willing to risk fines of up to €15,000 and even a gaol sentence, as illustrated by the arrest of three men in Cantal, France, in 2014, who were caught with 1100 illegally poached frogs from a single night's work (The Local 2014).

Many of the frogs that are now eaten around the world are shipped from Indonesia, with the majority of them collected from the wild, as farming in most instances is unproductive (Warkentin et al. 2009).

4.2.2.2. Historical and Archaeological examples

Amphibian and squamate remains are routinely ignored from archaeological sites, due to the absence of a sound sampling and flotation/sieving strategy and a general assumption ahead of time that they may be intrusive or of little cultural value (Ranworthy *et al.* 1990; Beisaw 2006; Kysleý 2007; Whyte and Compton 2020). This, however, is limiting the consideration of palaeoenvironmental data as well as potential information on human subsistence.

At a site in Engelbert, New York, radiocarbon dated to 1030-1180 and 1430-1460 CE, previous faunal studies had dismissed the anura as intrusive or victims of pitfall traps, but a more in-depth study showed their NISP to be second only to deer remains, and the MNI of Bufonidae was more than double that of deer (Beisaw 2006). However, there were few other species in the contexts that would also be susceptible to pitfall traps, and the other faunal remains in the assemblage were those of deer, known for being subsistence animals at this site. The remains exhibited low levels of taphonomy associated with human subsistence, such as thermal alteration, at only 1%, and there was no evidence of a limb bias. However, along with the context of their deposition, another feature of the site that indicated the collection and consumption of amphibia were the incorporation of green frogs (*Rana calamitans*) in two pots that were then interred within a human burial (Beisaw 2006). One of the pots contained two green frogs and fish remains, and the other pot contained seven green frogs. All specimens showed evidence of thermal alteration, which meant they had been cooked and placed into the burial as a food item or offering. This site shows that contextual information needs to be taken into account without a sole reliance on evidence of cooking or a hind limb bias as, at this site, the high NISP count and the context of deposition is the only real evidence of frogs in human subsistence practices on the site.

In the Levant, a Bronze Age burial on the Manahat Spur, Jerusalem, was excavated in which a storage jar was recovered that contained the remains of several amphibians (Figure 4.2) (Kisilevitz *et al.* 2017). The jar had been split longitudinally with the 'lid' placed back on top, and therefore was not sealed at the time of recovery.

Figure 4.2 Amphibian remains in the base of storage jar B2039 recovered from Tomb 7 at the Manahat Spur, Jerusalem (Kisilevitz et al. 2017:52)

Analysis of the contents revealed that the jar contained at least nine specimens of *Bufo viridis*, the common green toad and that cranial elements appeared to be under-represented in the assemblage, suggesting the heads were removed before being placed in the jar. Although the bones were in a poor state of preservation, there was no thermal alteration evident, and samples from the floor of the tomb showed no trace of other microfauna, strengthening the case that the toads were deliberate offerings to accompany the human burial rather than intrusive. Whether the toads were incorporated into the burial to be used as food in the afterlife, or for another purpose, for example, in relation to spiritual or ritual purposes, remains unclear, however the incorporation of mainly hind limbs strongly suggests consumption.

Evidence for the consumption of frogs has also been found at the site of Kutná Hora-Denemark, in the Czech Republic, dating to the Eneolithic Řivnáč Culture, 3000-2800 BCE (Kysleý 2007). Nearly 400 specimens of the common frog, *Rana temporaria*, were recovered from the site and showed a large hind limb bias and thermal alteration of the bones. In one context 10% of the bones had been burned. The almost complete lack of cranial remains suggested that this was not a death assemblage that had occurred

due to death in hibernation or even flash flooding, but that human agency played a part in its accumulation (Kysleý 2007).

Evidence for the inclusion of frogs in human diet has also been been found in Europe dating back to the Mesolithic. At the site of Baume d'Ogens in Switzerland, over 390 specimens of anura were recorded with approximately 85% of these comprising elements from the hind limbs (urostyle, ilia, femur and tibio-fibula). 58.5 percent of all specimens were thermally altered, 90% of which were hind limbs, which is a comparable rate to those found for the larger fauna which are assumed to have been used as a source of food (Chiquet 2005).

Discussion around what constitutes an anura assemblage accumulated by human agency for subsistence practices has been hard to identify. Does the assemblage have to show a high level of hind limb bias, lack of cranial elements, evidence of thermal alteration or all three? If the assemblage was recovered in association with small mammals also susceptible to pit-fall traps, does it then discount the anura from human diet? How much does differential preservation bias and recovery play in assemblage identification? And even then, an anura assemblage still holds value as a palaeoenvironmental indicator.

As mentioned in Chapter 3, the Whyte and Compton (2020) experiment regarding a window well excavation acting as a proxy for pit-fall trapping on human settlements, as well as their experiment regarding the effect of sieve size on skeletal element recovery for amphibians, allowed the authors to re-examine a microfaunal assemblage from Coweeta Creek, in the Appalachian Summit, that had previously been assessed by earlier authors as pitfall victims. Runquist (1979) strongly suggested that the Indigenous people would have used toads for ceremonial purposes due to the toxic secretions of their skin (Runquist 1979 cited by Whyte and Compton 2020: 313). The reassessment of the anura assemblage showed that only 0.4% of cranial remains were present and that 16% of specimens were thermally altered, which suggested removal of the toxic glands in the head prior to cooking and consumption.

Evidence for the consumption of lizards has been reported from the late Pre-Islamic and Early Islamic levels (3rd century CE onwards) of the site, al-Yamâma, in Saudi Arabia (Monchot *et al*. 2014). 145 specimens of the Arabian spiny-tailed lizard (*Uromastyx*

aegyptia) were recovered from all but the earliest levels (3rd Century BCE to 3rd Century CE) of this site, and were usually found in external middens in association with other human food waste. This species of lizard is very large, with a body length that can reach up to 700mm and weigh up to 2.5 kg. Due to their inclusion in anthropogenic contexts the question is whether they were utilised in some way by the human inhabitants of the site, or whether their inclusion was incidental.

These animals are usually considered to be intrusive because they live underground in burrows, or as predatory-derived deposits because they are included in the diets of several avian predators (Monchot *et al.* 2014). Evidence for the consumption of this species has been confirmed from Neolithic Egypt (Van Neer and Uerpmann 1989 cited by Monchot *et al*. 2014: 96). However, it is rarely recorded from the Arabian Peninsula. The lack of standard sieving, destruction by taphonomic processes, and the difficulty of locating archaeological contexts associated with nomadic tribes have all been postulated as the reasons for the paucity of these remain being recovered. The specimens recovered at al-Yamâma, however, represented elements from the head, trunk, forelimbs, and hindlimbs, and a single tibia exhibited a cut mark suggesting an anthropogenic pathway as a method of accumulation (Monchot *et al*. 2014). The practice of eating lizards is also confirmed in historical written documentation, as well as ethnographic evidence that the practice continues to this day (Monchot *et al*. 2014). The additional protein and fat provided by these animals would be welcome in the harsh environments of the Arabian Peninsula.

Squamates being included in past human subsistence practices is also evident at the Natufian site at el-Wad Terrace, Mount Carmel, Israel (ca. 13000-9700 cal. BCE). The broadening Natufian diet aligns with the resource intensification that came with the Broad Spectrum Revolution. At el-Wad Terrace, squamate remains account for 33% of all faunal remains in the Early Natufian, and 39% in the Late Natufian with 95% of all squamate bones being represented by vertebrae, and yet they are rarely discussed as representing a broadening of the human diet at this time (Lev *et al.* 2020). Following a taphonomic analysis of the Natufian remains, in comparison with modern experimental data to examine assemblage formation and post-depositional pathways, Lev *et al.* (2020), showed that there were significant differences in the squamate remains between domestic and non-domestic contexts. The domestic contexts contained larger-bodied individuals, such as the European glass lizard and the Large whip snake; higher levels

of erosion and breakage; low levels of digestion; and potential butchery in what could be cut marks to the vertebrae. In contrast, the non-domestic contexts contained smaller -bodied species which had a larger variety of taxonomically identified specimens, and exhibited low levels of erosion and breakage, and higher levels of digestion. This allowed the authors to argue that the assemblages in the non-domestic contexts were most likely derived from predatory deposits or natural deaths, whereas the squamates in the domestic contexts were accumulated by human consumption. Evidence for the eating of small game was not new at this site, as it also produced evidence of the human consumption of the mole-rat (Weissbrod *et al*. 2012).

Evidence of burning and the biased number of limb bones are not the only evidence we have that anura and squamates, have been included in past diets. As well as the faunal remains themselves, archaeoparasitology has been used to evidence past diets and changing environments, through the identification of infectious or spurious parasites in human coprolites. Evidence of parasites that require lizards or frogs as a host in human faecal matter is direct evidence of that animal traversing the human digestive system (Sianto *et al*. 2012).

Four coprolites, morphologically identified as human in origin, were recovered from three archaeological sites in north-eastern Brazil (Sianto *et al.* 2012). Radiocarbon dates were obtained for the coprolites via bones found in the same archaeological layers or burials from which they were recovered and each were analysed to determine if they contained parasites. One of the coprolites, from Toca dos Coqueiros in the Archaeological Area of São Raimundo Nonato, was recovered from an archaeological layer and dated to 8640 ± 80 BCE. Two more from the same Archaeological Area were recovered from human burials from Tocas da Baxia dos Caboclos, and were dated to 1425-1635 cal CE, and 1420-1510 cal CE. The fourth specimen was recovered from another human burial at the archaeological site of Furna do Estrago, and was dated to 90±50 to 340±70 CE. All four coprolites were found to contain *Parapharyngodon sceleratus* eggs, which infect lizards and amphibians (Sianto *et al*. 2012). Further analysis of the make-up of the coprolites showed evidence of other items that would usually be associated with human food, and confirmed the morphological identification that they were indeed human. As well as parasites eggs that would usually be associated with herpetofauna rather than humans, the analysis also provided evidence of reptile scales within the coprolite itself. This was identified as a lizard scale and did not

show any evidence of thermal alteration. The combination of both the parasite eggs and scales in the human faeces gives direct evidence that lizards, in all these time periods, were being eaten by humans (Sianto *et al.* 2012).

It is clear that amphibians and squamates potentially have several taphonomic pathways into an archaeological microfaunal assemblage, but to date being part of the human subsistence strategy has not been one that has been routinely explored. More information on the taphonomic effects on herpetofaunal remains is required so that post-depositional processes and the role of these animals within human societies can be more fully explored.

4.2.3. Rodents as a food source

4.2.3.1. Ethnographic examples

Today, most people associate rodents with the commensal rat or house mouse, and equate these animals with filth and disease, so their association with human diet is often dismissed. In past times, these animals have been regarded in the same way as any other small game animal and are still consumed in many places around the world today, including Central and South America, the Unites States, Slovenia, Croatia, Ghana, Malawi, Mozambique, Nigeria, India, Thailand, Indonesia, Vietnam, and China. In the Philippines rat meat is even sold in cans in the supermarket (Gruber 2016). Fiedler (1990) listed 89 rodent species that are currently consumed by humans around the globe, from large rodents such as the beaver and coypu, through to the small pygmy gerbil.

Some inhabitants of countries within Asia still regularly consume rodents and even though they are often referred to as 'rats' they include multiple species of small mammals, such as the bandicoot rat, the rice field rat, the Asian house rat, as well as the house mouse (Meyer-Rochow *et al*. 2015).

For the Adi tribe, in north-east India, these 'rats' play not only an important part in the diet, but the giving and eating of them is part of the social tradition. Although 'rats' are eaten throughout the year, the Adi tribe celebrate '*unying aran*', a hunting festival held in March. For the festival, thousands of rats are procured, roasted over a fire and served

on a palm leaf. The internal organs are removed, with only the colon discarded, and the rest of the organs are then boiled together with the legs and tails to make a stew called 'bule-bulak oying', a local delicacy (Meyer-Rochow *et al*. 2015).

In Vietnam rats are a common food item and are sold by street vendors (Figure 4.3) and are often smoked, before being fried or grilled.

Figure 4.3 Rats are smoked and prepared before being sold in Co Dung, Vietnam. (Dell'Amore 2019: online)

Today, different species of rodents hold different levels of appeal as food items. In the United States of America, eating squirrel has been popular since colonial days and is still common today in the south. In the 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, squirrels were rated the most popular small game species with 1.5 million people hunting them over 11 million days in the same year (U.S. Department of the Interior *et al.* 2018).

In Britain the eating of Grey Squirrel is slowly becoming more popular with the rise of sustainable eating, due to the need to cull the invasive species in order to protect the endangered native Red Squirrel (Horton 2019). Using the culled animals for food, instead of wasting them, appeals to more and more people who are concerned with

reducing their carbon-footprint and being more environmentally aware. Indeed, the idea of eating small rodents, particularly rats and mice as micro-livestock, is one that has been suggested to combat future food shortages, due to a growing human population and the inability to sustain current meat farming regimes to meet the growing need. Also, by consuming rodents it could counter the loss of cereals and grain that are decimated by these species each year, as well as being a sustainable and viable protein source (Gruber 2016, Meyer-Rochow *et al*. 2015).

In Slovenia, dormouse hunting is an important part of the Slovene identity. The dormouse, or *polh*, is not only a food source but also provides fur for traditional hats, with the oil also being used in local medicine. Sneznik Castle, in the Loz Valley, Slovenia, also houses a dormouse museum dedicated to the culture around catching these creatures, as well as the mythology that surrounds them. Dormice are also eaten in neighbouring Croatia, and are called *puh*. Every year the village of Dol, on the island of Hvar, celebrates the *Puhijada*, the dormouse festival, where dormice are grilled and served on bread (Bradbury 2018; Matečić and Lewis 2018).

4.2.3.2. Historical and Archaeological evidence

As mentioned above many rodent species are still consumed around the world today but they were also consumed in antiquity. Historical and archaeological evidence exists to support Flannery's (1969) theory that economically, past humans ate rodents as small game to further food resources.

In recent history, the act of eating rats in particular has been linked to poverty; the last food item that stands between people and starvation. This is illustrated by the consumption of rats during the Siege of Paris, as part of the Franco-Prussian War in 1870 (Figure 4.4), when the inhabitants of the locked down city began to eat rats when other meat sources became scarce (Sibbet 1892).

Figure 4.4 Scene of a meat stall on the Rue Rochechouart during the Siege of Paris showing the sale of dogs, cats, and rats, with the rats being laid out on the left (Sibbet 1892; adjacent to page 250)

However, rat meat was considered such reasonable fare that it was actually more expensive than the meat of horse, cat and dog, with horsemeat sold at 20 cents per pound, cat and dog meat 20 to 40 cents per pound, and a plump rat costing 50 cents each (Sibbet 1892). Rats also graced the plates of the upper classes, with menus from the time showing dishes such as cat flanked by rats at a Christmas feast during the siege.

Archaeologically, however, it was not the anthrodependent rodents, for example the Norwegian rat or the house mouse, that were typically eaten. In Pre-Colonial New Zealand, the Māori regularly supplemented their diet with the Polynesian rat, digging specialised pit traps which were baited with berries (Downes 1926).

In Tang Dynasty China (CE 618-907), 'household deer' were eaten that were actually made up of the common rat and the bandicoot rat. It has also been suggested that during this time, new-born rats were dipped in honey and eaten alive (Hendrickson 1983 cited by Fiedler 1990:149).

Romans were well known consumers of the edible dormouse from the 2nd century CE, even having special containers called *gliraria,* with holes and internal ridges that were

used to store and fatten them. They were eaten stuffed with pork mince and walnuts, and roasted (Brothwell and Brothwell 1969).

Long before the Romans were consuming the dormouse, across the Atlantic in the Andean subregion the guinea pig was being domesticated. It was domesticated for both food and ritual purposes by 2500 BCE, if not earlier, due to its high-protein and low-fat content (Morales 1994). Guinea Pig is believed to be the earliest rodent domesticated (Fiedler 1990) and the only domestic animal in ancient Peru specifically kept for consumption (Morales 1994).

Small mammal bones associated with human occupation have also been recovered from rockshelter sites in the mountains of central Chile dating from the late-Archaic to the early Agro-ceramic period, 3000 BCE to 400 CE (Simonetti and Cornejo 1991). Multiple species of small mammal were recovered and were found to show varying degrees of taphonomic alterations in particular burning, with an interesting pattern of human use and incidental incorporation into the archaeological assemblage. The species recovered included chinchilla, degu, and coruro, which all exhibited thermal alteration, as well as others which had not been burned, such as several species of mice, and a rat. Evidence of thermal alteration on some species of small mammal, and not on others, suggested that not all species were eaten and that consumption of small mammals was selective, rather than indiscriminate, and formed an important part of the palaeoeconomy (Simonetti and Cornejo 1991).

Butchery evidence on microvertebrates to indicate consumption is, however, distinctly lacking, although in animals the size of a dormouse little to no butchery of the carcass would be required (Biton *et al.* 2021).

In the Pampean Region of Argentina, a larger rodent was consumed by the hunter-gatherer-fishers who lived during the late Holocene. At several sites in the region the most numerous small mammal bones recovered belonged to *Myocastor coypus*, the coypu, which can weigh over 6 kg. The remains of these animals showed obvious evidence of butchering, including, skinning, filleting, and disarticulation of remains prior to cooking and consumption, although few bones showed evidence of burning (Escosteguy and Salemme 2012). Although this species is a rodent, due to its size it

would be excluded from microfaunal study and fall under the remit of the macrofaunal zooarchaeologist.

In Blombos Caves, South Africa, the remains of the Cape Dune mole-rat were frequently found within archaeological samples from the Late Stone Age c. 0-1700 CE. A distinct pattern of burning to the premaxilla and incisors, and a lack of obvious burrowing in the archaeological strata, suggested the remains had been brought to the site by humans and cooked before consumption (Henshilwood 1997). Analysis of remains from an ethnographic study of modern farmers cooking and eating these rodents, showed the same pattern of burning. This suggests that Later Stone Age people around Blombos Caves were catching and eating the Cape Dune mole-rat in a similar way in which they are still cooked and consumed today (Henshilwood 1997).

In Britain, the evidence for the consumption of rodents is scarce, however Orkney voles have been found in anthropogenic contexts in Skara Brae, a Neolithic settlement in the Orkney archipelago, and their partially burnt states appear to indicate that they were at least partly articulated at the time of burning, with soft tissue protecting portions of the bone (Romaniuk *et al*. 2016). Voles were introduced to Orkney by humans (Cucchi et al 2014; Romaniuk *et al*. 2016), and the evidence of partial burning and the inclusion of the remains in anthropogenic contexts has been taken to indicate that they were cooked for human consumption, as the remains were found amongst other food waste items including macrofaunal remains, fish bones and shellfish. Whether the people of Skara Brae were eating voles regularly as part of their diet, or as a consequence of pest control measures remains to be determined.

As mentioned in Chapter 3, experiments have been conducted on the digestive effect of humans on small mammals in order to provide taphonomic evidence that could be applied to archaeological samples. An experiment by Crandall and Stahl (1995) showed the majority of an unmasticated insectivore carcass, used as a proxy for any small mammal, exhibited high levels of both digestion and fragmentation in the human digestive tract.

Direct evidence of consumption of small mammals is extremely rare in the archaeological record. However, an assemblage of small mammals remains were recovered from the stomach and abdominal area of a human burial from a Later Stone

Age occupation site in Namaqualand, South Africa (Dewar and Jerardino 2007). The specimens were all postcranial remains and exhibited a high degree of fragmentation and digestion, most likely from mastication and exposure to gastric acids. 38% of specimens in the stomach area, higher in the abdomen, exhibited digestive corrosion, however 62% of the bones in the abdominal area, within the pelvic girdle, showed evidence of digestion, likely due to being exposed to gastric juices for longer. The complete lack of cranial remains suggests the heads were removed prior to ingestion, as the Crandall and Stahl (1995) experiment showed these did survive human ingestion. However, there may be differential survival of rodent compared to insectivore crania and teeth due to structural differences. The discovery of small mammal cranial remains in another area of the site lends weight to the theory of removal before ingestion, and as these showed the species to be a murid, the teeth would be less susceptible to digestive attack than those of microtines (Andrews and Fernandez-Jalvo 2012). Therefore, we would expect to find evidence of them in the digestive tract if they were ingested. This burial provides direct evidence for the consumption of small mammals at this site, as well as evidence for how they were eaten, and the direct effects of human digestion on these bones (Dewar and Jerardino 2007).

4.2.4. Summary

The conclusion that small mammals, amphibians, and squamates were being used for food appears to be predicated on the remains showing evidence of thermal alteration as well skeletal element bias towards the 'meatier' hind limbs (Chiquet 2005; Kyslеý 2007; Romaniuk *et al*. 2016; Kisilevitz *et al.* 2017), however an examination of the habitat preferences of the species found, as well as of the archaeology itself, could also help to determine the agency of accumulation (Beisaw 2006).

Taxonomy, taphonomy, skeletal element bias, thermal alteration, the presence of the bones in anthropogenic contexts, and even spurious parasites in human coprolites can all provide evidence of the use of microfauna in human diet, which is an area to date that has been consistently overlooked. We need to step away from only using microfaunal assemblasges for palaeoenvironmental reconstruction, as human agency can act as another biasing factor and distort the microfaunal assemblage.

Expanding microfaunal analysis to include a better understanding of context, as well as additional avenues of analysis, such as coprolites, will be required in order to fully

understand the role microfauna played in past human subsistence. Another method that may be used more frequently in the future to identify undiagnostic microfauna in human coprolites is ZooMS (Zooarchaeology by Mass Spectrometry). This method uses collagen fingerprinting to identify small pieces of bone that may not be formally identified by traditional zooarchaeological methods, and will therefore increase the ability to identify past food items (Buckley *et al*. 2016)

Going forward, the use of small mammals, particularly commensal animals that may be considered an agricultural pest or invasive species that requires control, may be the answer to increasing global meat demand whilst also tackling the environmental consequences caused by our current livestock production. Their reproductive rates and ability to produce many offspring, as well as a rapid maturation to adult size, make small mammals the ideal substitute for traditional livestock. The consumption of 'rats' from agricultural fields in India has proved to be a good way to control populations that, left unchecked, would destroy crops, and could also reduce the need for pesticides that endanger other, non-targeted wildlife species (Meyer-Rochow *et al.* 2015).

Given the volume of both ethnographic and archaeological data that supports consumption of rodents, amphibians, and squamates, it is important that the presence of these bones on archaeological sites is analysed in order to assess whether they were included as part of the overall subsistence strategies of these sites.

In addition to use in human diets, microfauna are also utilised for other purposes, such as those associated with ritual practices. The following sub-chapter will examine how and possibly why these ritualistic assemblages occur.

4.3. Ritual Practice

4.3.1. Introduction

The meaning of the term 'ritual' in archaeology is not currently well defined (Brück 1999; Kyriakidis 2007). It is often considered to be a 'special activity', which can have broad implications, however Kyriakidis (2007:10) defined it as;

> "An etic category that refers to set activities with a special (non-normal) intention-in-action, which are specific to a group of people."

Many actions that could be considered ritual may have little to do with material culture and therefore will be almost impossible to reconstruct from archaeological finds. Some ritual activities may also be difficult to distinguish from more mundane activities, such as large concentrations of manufactured goods found in workshop areas (Kyriakidis 2007), or extensive carcass processing areas, if what the archaeologist is looking for is an out-of-the-ordinary deposit within the context of a site. The assumption is that ritual activities will look different to everyday activities, but this is rarely applied to microfaunal assemblages recovered from environmental sampling.

There are copious articles that list the uses of microfauna in medical or religious activities (Costa-Neto and Oliveira 2000; Sezik *et al*. 2001; Bick *et al.* 2002; Zhou *et al*. 2006; Garg *et al*. 2007; Alves 2008; 2013; Jacobo-Salcedo *et al*. 2011), including historical documents. But what then makes a microfaunal deposit indicative of ritual activity? As most microfaunal deposits not linked to human consumption, are assumed to be derived from predators or to be naturally occurring, how do we recognise that their presence may derive from ritual activity?

Understanding the importance that microfauna plays in many cultures around the world, both in antiquity and today, will allow us to understand the importance of these often-overlooked animals, and can potentially open up avenues of research that will allow us to recognise their inclusion in ritual activity in the past, and build clearer pictures of past human lifeways.

4.3.2. Microfauna in Religion and Superstition

4.3.2.1. Magic, Witchcraft, and Folklore

Frogs and toads have long been associated with European witchcraft and are included in written sources depicting the actions of witches as far back as the 12th century and possibly earlier. Toads were used for the toxins in their glands and skin, which would then be directly administered to cure or curse, but they were also used in symbolic magic, where the toad could be pierced with needles or thorns (Figure 4.5) so that a third party would feel the pain (Hatsis 2015).

Toad poison, or the secretion from the parotoid glands which contain bufadienolides, can act as a powerful hallucinogen (Miller 2002) and were incorporated into many potions and powders (Hatsis 2015). Anyone who consumed a potion containing these hallucinogens would have readily believed in the powers to transmute oneself, as well as the potential ability for witches to fly, adding weight to the supernatural ability of the witch (Hatsis 2015).

Toads as a witch's familiar were common in English records from the 16th century onwards (Hatsis 2015; Parish 2019), and frogs are even mentioned in the Song of the Witches from Macbeth, by William Shakespeare, as were bats, snakes, newts, and lizards.

Figure 4.5 Frog with thorns driven into it, purportedly for a magical purpose. (Image: M. Feider, Pitt Rivers Museum, Oxford 2017)

Rats and mice have also been associated with witchcraft in Europe (Bowd 2008; Cole 2010), as well as with plague. Like toads, mice were known to act as witches' familiars, and during the witch trials in England in the mid-17th century, 'watchers' observed accused witches in prison to see if they were approached by rodents (Parish 2019). It is interesting to consider that rat and mouse infestations were noted in antiquity to coincide with times of climatological instability, which also coincided with plague and the rise in the persecution of witches in Europe (Cole 2010).

Along with rats and mice, other small mammals have often been associated with magic and superstition. In Slovenia, dormice are associated with the devil, where he takes the form of a shepherd and herds or chases dormice through the forest (Peršič 1998). In the Andes, guinea pigs were also used in divination and incorporated with burials, despite

first being domesticated for food. Archaeological evidence has shown that post c. 2500 BCE, as well as being included in middens, the bones of guinea pigs have been recovered from niches in temples, presumably used as offerings, whilst mummified guinea pigs have been recovered with longitudinal incisions to the abdomen suggesting removal of organs for divination (Sandweiss and Wing 1997).

4.3.2.2. Religion

Both amphibians and small mammals feature in religions throughout the ancient and modern world, sometimes in a positive light and sometimes reflected negatively.

In ancient Egypt, Hequet or Heqet, was the goddess of fertility and was represented by a frog headed goddess, most likely due to the appearance of frogs following the Nile flood, in the Predynastic and Early dynastic period C 2950 BCE (Attia 2020; Khamis 2021). Due to the life-giving properties of the Nile, Hequet was also the goddess of childbirth and midwives were often called Servants of Heket (Attia 2020). Another Egyptian deity associated with frogs was Hapi. Hapi was the god of the Nile flood, and another deity of fertility, as the flood kept the soil on the bank of the Nile fertile for crops. Hapi is depicted as an androgenous figure with a false beard, large belly and breasts. Other attributes regarding his depictions varied according to location. In Lower Egypt he was attended by frogs and adorned with papyrus, in Upper Egypt he was associated with lotus flowers and crocodiles, being geographical symbols (Budge 1904). The Ogdoad were eight Egyptian deities (four pairs) worshiped in Hermopolis. The four male gods were depicted with frog heads and the four female goddesses with serpent heads. References to the Ogdoad dated to the Old Kingdom, approx. 2686-2181 BCE, although most probably pre-date this. The earliest pictorial evidence (Figure 4.6) is from the New Kingdom, c. 1300 BCE, when they were rediscovered (Maspero 1897)

Figure 4.6 The Ogdoad, frog and serpent headed Egyptian deities (Maspero 1897;148)

In a less positive light, frogs are also mentioned in the Bible. According to the Book of Exodus 8:6, frogs were the instrument of the Second Plague of Egypt (Fretheim 1991), and in Revelation 16:13 frogs are associated with unclean spirits (Gallus 2008).

Small mammals also feature in religion, mostly reflected in a positive light. The Karni Mata Temple, in Rajasthan, is a Hindu temple dedicated to Karni Mata, where 20,000 rats live and are worshipped (Figure 4.7). Called *kabba,* and distinguished from rats outside the temple, they are believed to be the reincarnations of Karni Mata's sons and descendants of the Charan people. The huge number of kabba have become a draw for tourists as well as pilgrims (Trembley 2022).

Figure 4.7 Rats and people feeding at the Karni Mata Temple, Rajasthan (Buddhisaro et al. 2016; 99)

Ganesha, a Hindu god, is the remover of obstacles and Lord of the Harvest, and is often depicted as riding on, or attended by a mouse, shrew, or rat. Riding a rat was the primary depiction in the 7th century. It is believed that the symbolic conquering of rodents by using them as vehicles shows off Ganesha's power, as mice and rats would have been ruining crops and therefore been an obstacle to prosperity which is defeated by the Lord of the Harvest (Michael 1983; Jhala 2006).

4.3.3. Microfauna used in Sporting Activities

Renfrew and Bahn (2000) list a set of criteria for identifying ritual in archaeology. This list includes special places or buildings set apart for specific functions; conspicuous public display; use of cult images; consumption of food and drink; and sacrifice of animals, amongst other criteria (Gazin-Schwartz 2001; Renfrew and Bahn 2000). All of this can be found in certain sporting activities that had the potential to create large microfaunal assemblages associated with the sport, and as such they will be included in this chapter.

In 19th century Britain, following the 1835 Act of Parliament which prevented bulls, bears, and other large animals being used in baiting sports, rat baiting became a popular pastime, with 70 rat pits in London alone (Mayhew 1851). Rat baiting, or ratting, was a sport in which people would bet on how many rats could be killed by particular dogs in a specified amount of time, with a famous ratter, Billy, purported to have killed 100 rats in five and a half minutes (Mayhew 1851). A proprietor of one of these sporting houses, Mr Jimmy Shaw, reported that he purchased between 300 and 700 rats a week

for the sport, paying a single supplier 3d per head for 35 dozen rats (Mayhew 1851; Edelman 2020). As such, rats had an economic value that could be exploited by those who had once killed them (Pemberton 2014). Ratting continued as a popular sport in England until around 1912 when it fell out of favour, despite it remaining a legal sport.

Figure 4.8 Rat-baiting pit in the Graham Arms, Graham Street (Mayhew 1851;7)

Mayhew (1851: 6) also describes the scene of one of the ratting pits as being built up each week for the purpose of rat-killing matches (Figure 4.8). He described the walls of the public house used for the matches being covered with old collars, stuffed heads, and prints of past winners. With this description, several of the criteria from Renfrew and Bahn (2000) have been met, including the sacrifice of animals, with the rats being specifically bought for the purpose of being killed by dogs. As well as England, rat-baiting was also popular in France in the early 1800's, and in the USA by the mid-1800s (Richter 1954 cited in Lindsey and Baker 2006: 2). Whether or not sporting events like this took place at other times throughout history, or should even be considered as ritual activity is up for debate. However, we must recognise that activities such as these could accumulate a microfaunal assemblage of significant size that may appear anomalous in the context of the wider site.

4.3.4. Microfaunal Use in Medicine

4.3.4.3. Traditional Folk Medicine

Animals, their parts and products, have been used in traditional medicines for many thousands of years (Costa-Neto and Oliveira 2000; Sezik *et al*. 2001; Bick *et al*. 2002; Zhou *et al*. 2006; Alves 2008; 2013; Jacobo-Salcedo *et al*. 2011), with many now being incorporated into modern medicine and pharmacology.

Small mammals

The use of small mammals appears to be reasonably rare in folk medicine, with amphibians and reptiles being utilised much more widely, most likely due to the active compounds within skin secretions or venom actually affecting change in those with ailments.

Small mammals however, are used as medicinal animals with both the hedgehog and the weasel being used in Central Anatolia today as folk remedies. The fatty meat from hedgehogs is used to strengthen those suffering from tuberculosis, and weasel meat is eaten, either cooked or raw, as a treatment for jaundice (Sezik *et al.* 2001).

In Mexico, rabbit feet are said to bring luck (this is true for other countries as well including Britain), and hare soup is said to cure a stomach ache (Jacobo-Salcedo *et al*. 2011); and in Slovenia, dormouse fat is said to have medicinal properties, not just for people but also for livestock (Peršič 1998).

Reptiles

Large numbers of herpetofauna and squamates are still used in folk medicine around the world, which has socioeconomic and sociocultural repercussions for the conservation practices of several species (Alves *et al.* 2008; 2013). Over 284 reptile species, and 47 amphibian species are used today, of which 182 reptile and 42 amphibian species are listed on the IUCN Red List of species threatened with extinction (Alves *et al.* 2013).

Medicinal uses of animals such as the Caucasian agama (a lizard), the Levantine viper, and the Moorish gecko in medieval manuscripts from Azerbaijan, included treatments for leprosy and sexual impotence. Additional species that would have required

importing were also used to treat ailments, and included the monitor lizard, the chameleon, and the crocodile (Alves *et al*. 2008).

In India, parts of the monitor lizard are used to treat ailments such as haemorrhoids, rheumatism, and burns, and in Mexico rattlesnake pills are also sold as cures for haemorrhoids as well as for the treatment of cancer, sores, rashes, pimples, stress, heart disease and sexual impotence, amongst other ailments (Alves *et al*. 2013).

In Mexico, the mesquite lizard eaten as a soup is used to cure diarrhoea, whereas various parts of the rattlesnake can be either eaten or used topically to cure pneumonia, muscular pain, issues with sight, sore throat, gangrene, varicose veins, and ulcers (Jacobo-Salcedo *et al.* 2011). In Brazil, the meat and fat of the neotropical rattlesnake is used to cure rheumatism (Costa-Neto and Oliveira 2000).

The use of animal products for folk medicine in current indigenous societies has been used to suggest their continued use for millennia. In Brazil, Indigenous people use caiman fat to treat rheumatism (Alves *et al*. 2013), a practice that has been undertaken for at least 150 years, lending credit to the theory that practices such as these go back many centuries, if not longer.

Reptiles, and snakes in particular, have long been associated with the history of medicine, with Asclepius being the Greek god of medicine, and his snake-entwined staff, or rod, now being the symbol of modern medical practice. Both the Greeks and Romans also worshipped snakes (Nayernouri 2010; Alves *et al*. 2013).

Ancient Chinese medical books report using parts of snakes, including their livers and gall bladders, to treat ailments such as rheumatism, neuralgia, and muscle poliomyelitis (Guo *et al*. 1996 cited by Alves *et al.* 2013: 117).

Amphibians

Frogs and toads have been used in the treatment of ailments for centuries and the practice ties very closely with their use in magic potions. Many ancient cultures believed they possessed the ability to cure ailments, some of them contradictory, including sexual impotence and infertility, as well as to act as a contraceptive (Gomes *et al.* 2007).

Granular glands on amphibian skin, which includes the parotoid gland in toads, secrete compounds with a multitude of 'protective' roles, that can then be exploited by humans. Effects of these secretions are believed to be cardiotoxic, myotoxic, neurotoxic, vasoconstrictive, hypotensive, and/or hallucinogenic in nature, with the wide-ranging effects most likely due to the diversity of predators that prey on amphibians (Clarke 1997).

Ground up frogs heads have been used to treat fever (Hendricks 1966 cited by Alves *et al*. 2013: 120), whilst ground toad skin have been used to treat heart trouble, and whooping cough could purportedly be cured with a soup made from nine frogs (Hendricks 1980 cited by Alves *et al*. 2013:120). Although toads were thought by some to cause illness, they were also believed to be curative, and were used to try and cure plague, nosebleeds, smallpox, sprains, abscesses, as well as the 'kings evil', also known as scrofula (Parish 2019). Pliny the Elder recommended bones of the legs of toads as an aphrodisiac (Parish 2019). In Mexico, axolotl meat is used as a topical treatment for bronchitis (Jacobo-Salcedo *et al.* 2011).

Frog skin secretions have been used for centuries in a traditional Chinese medicine called Chan Su, and have been used to treat heart disease, palpitations, toothache, tonsillitis, sinusitis, bleeding of the gums, and sore throats as well as other illnesses (Bick *et al*. 2002; Gomes *et al*. 2007). Chan Su was actually introduced to Europe in the 17th century as a treatment for heart disease, eventually being replaced by digitalis. Drinking wine in which toad skin had been soaked was also prescribed until recently as a cure for leukaemia in traditional Chinese medicine (Gomes *et al*. 2007).

The dried skin of the Heilongjiang brown frog is also used in another Chinese traditional medicine, called lin wa pi. This treatment is used to treat ailments, as a general tonic, as well as a topical wound dressing due to its antimicrobial properties (Zhou *et al.* 2006)

In Brazil, toad bones are used to pick at teeth as a preventative for caries, and the skin is used to cure acne (Costa-Neto and Oliveira 2000). How the tooth picking activity would be reflected in a microfaunal assemblage is unclear, although the bones used may show evidence by way of potential wear or sharpening of the elements used.

Reptiles and amphibians were also used in healing by magically transferring the disease to the proxy animal (Hand 1980). In some cases, simply touching the proxy animal to the wound would be enough to transfer the disease, but would then require the animal to die. For example, in Ontario, touching a live frog to a goiter (a swelling of the thyroid gland) was believed to transfer the ailment to the frog. However, the frog would then need to be buried upside down until it had decayed, at which point the goiter would be cured (Alves *et al*. 2013). Sometimes the proxy animal needed to be bound to the affected area in order to cure it. For example, binding a live frog to the affected part was believed to cure a felon (finger abscess), chills, and asthma. In Kentucky, USA, a live toad bound to the back has been claimed to cure rheumatism, by passing the pain from the sufferer to the toad (Hand 1980) and in Brazil, a toad that is placed on the abdomen is believed to cure urinary retention (Costa-Neto and Oliveira 2000).

4.3.4.4. Modern Medicine

The pharmaceutical industry is relatively modern and until its recent rapid expansion, the treatment for many ailments relied on traditional medicine. Many of the active compounds of our common treatments, such as aspirin, have their origins in traditional medicine, and many species of plants and animals are studied in order to identify more active compounds for further treatments (Zhou *et al*. 2006).

The extensive use of frogs and toads in folk and traditional medicine paved the way for their use in modern medicine (Gomes *et al.* 2007). Several compounds found in the skin secretions of frogs and toads have properties that can be exploited by pharmaceutical companies to treat serious diseases. Science is now discovering that several of the Chinese traditional remedies that contained frog/toad skin or secretions, may have actually contained active compounds that helped to heal or treat illnesses, e.g., Chan Su (Gomes *et al.* 2007).

In fact, toad and frog skins contain compounds and peptides which have exhibited many properties invaluable to modern medicine such as cardiotonic and anti-arrhythmic activity, antidiabetic, immunomodulatory, antimicrobial, antiviral, analgesic, sleep inducing, contraceptive, and anti-tumour activity (Bick *et al*. 2002, Garg *et al.* 2007, Gomes *et al.* 2007). Their use in surgery, in particular the healing of wounds, is currently being trialled, as experiments have shown that wounds dressed with skin of freshly killed frogs, healed faster than wounds dressed with gauze and the antimicrobial

and antibacterial action of the skin protected the wound (Gomes *et al*. 2007; Rezazade Bazaz *et al*. 2015).

4.3.5. Evidence of potential use of microfauna in ritual activity at Çatalhöyük

Evidence of microfaunal inclusion in ritual activity is rare in the archaeological record, most likely due to the limited analysis done on these assemblages.

At Çatalhöyük, several inhumations were excavated that appeared to have dense clusters of microfauna purposely incorporated into the burial. Three burials contained very high levels of microfauna with an additional two showing higher than normal levels. Four out of five of these inhumations were dated to the early levels of the East Mound, approximately 7100 – 6700 cal. BCE and all were excavated in the South Area of the site (Jenkins 2012a; Feider and Jenkins 2021). One of the burials was excavated during the Mellaart excavations, so information regarding sieving methodologies is limited, however this was one of the three with very high levels of microfauna. The fifth burial was from the 4040 Area of the site (Jenkins 2012a).

The Mellaart level burial was of an adult female, interred within Building VIII.31, which at the time was identified by Mellaart as a shrine (Brothwell 1981). The skeleton was covered in fibrous material interpreted as either basketry or matting, and it was in this layer that the microfaunal bones were identified. The skeleton was also covered with ochre and accompanied by grave goods such as bead and shell necklaces, bone rings, and a limestone mace head (Mellaart 1966; Brothwell 1981; Jenkins 2012a). The burial was excavated from beneath the 'clean area' platforms, as were the majority of other burials at this site. This burial had a Minimum Number of Individuals (MNI) of microfauna as 76. Seventy-five of these were recorded as mice, with one shrew. The percentage of fill sampled for this excavation is unknown.

Burial 460 was of an adult male and the microfauna were recovered from the burial fill. Most elements, however, were noted by the excavator to be concentrated in pockets, rather than generally distributed throughout the fill. This was distinguished as different from fills around the burial where little to no microfauna were recovered. The MNI for this assemblage was 71, with 67% of the fill sampled.

Burial 513 was also under the floor of space 163, along with burial 460, from Building 6, from the same phase as the Mellaart burial. This was another adult female which also contained ochre. Microfauna was recovered from the fill of the burial. However, a layer directly over the torso of the skeleton was identified as being heavily organic, which also contained a concentration of microfauna (Figure 4.9). The MNI of microfauna for this burial was 421, again mostly represented by mice, with 73% of the fill sampled. Weasel remains were also recovered from this burial (Jenkins 2005; 2009; 2012a).

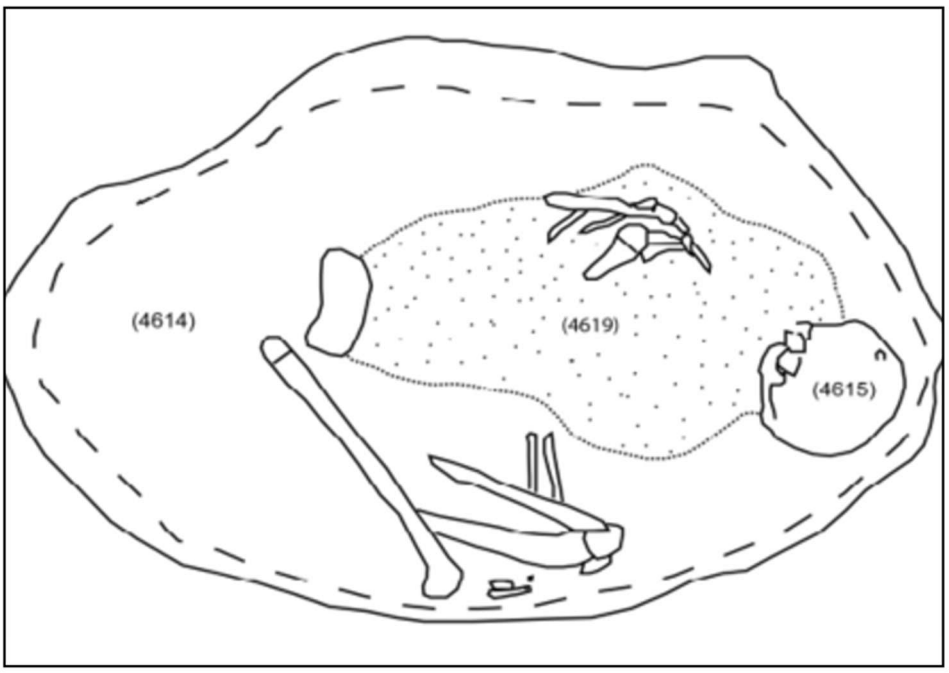

Figure 4.9 Burial 513 with microfaunal accumulation (4619) directly over torso (Jenkins 2009; 146)

The additional two burials had much lower levels of microfauna than the three burials outlined above, but both had significantly higher than the normal 'background' levels of microfauna for the site. Burial 492, also from Space 163 from Building 6, of a decapitated adult male that was covered by a partially carbonised hackberry board, had a Number of Identified Specimens (NISP), individual elements or parts of elements, of 80. Taxa included two rodents, one house mouse, and a single amphibian, although this was based on a 59% sample. Evidence of gnawing by a small mammalian carnivore was also noted in this context, as it had been for the previous burials. The second small microfaunal assemblage came from a burial (F.4000) in the 4040 Area, of a young female with a baby. The NISP for this assemblage was 146, and taxa included mice and

voles, but also snakes, weasels, reptiles and amphibians (no MNIs published) (Jenkins 2012a).

Evidence of digestion and gnawing on the remains suggests that the microfaunal assemblages from all the burial contexts were incorporated as scats, rather than as whole individuals. The gnaw marks on the microfaunal remains were too small to have been made by dogs which were present on the site, although the exact predator remains unknown. It is likely that the mammalian carnivore would be a small mustelid, such as a weasel, as these have been identified as present on the site and the gnaw marks recorded were consistently small. The burials excavated in 1999 by the Hodder team, showed no evidence of disturbance by animal burrowing, making it unlikely that the accumulation of scats occurred under natural conditions following burial (Jenkins 2012a). Inhumations at Çatalhöyük were most often beneath floors of houses, so it is unlikely that any grave cuts would have been left open for predatory derived assemblages of this size to accumulate naturally. There was also no disturbance to the human skeletal material, such as dislodged bones or evidence of mammalian or rodent gnawing, which would be likely if the bodies were left in the open (Jenkins 2012a).

This evidence therefore suggests that the scat material was incorporated into the burials via human agency. However, as this occurs in so few burials (six? out of over 800 inhumations on the site), the practice of incorporating carnivore scats is peculiar. With several of the burials also including grave goods and red ochre, it is unlikely that the inclusion of scats would mark these out as deviant burials, due to the care and attention they received. One of the theories is that the people buried may have had something to do with the small mammalian carnivores themselves, possibly in some form of pest control capacity (Jenkins 2012a).

A rectangular burial chamber was excavated in 2007 in the TP Area of Çatalhöyük East (Figure 2.2), dating to the final levels of the site's occupation (6300-5950 cal. BCE). The sides of the chamber were made of mud brick and were incised with spiral patterns (Pawlowska and Marciszak 2018). It contained 10 individuals, as well as evidence of secondary burials and head removal following skeletonization (Hager and Boz 2008). This burial feature also included articulated stone marten feet accompanying the burial of an infant. Stone marten were represented by cranial and autopodial elements only, with cut marks to the metapodials and a single phalanx, suggesting the animals had been

skinned, and that the skins had been placed into the chamber as grave goods (Pawlowska and Marciszak 2018). A weasel was also recovered from the chamber, represented only by mandibles, potentially as another skin (King and Powel 2007, Pawlowska and Marciszak 2018). The only felid remains recovered at Çatalhöyük until recently, were also cranial and autopodial elements, again suggesting that they were brought to site as skins and not as live animals (Russell and Martin 2005). However, the discovery of a complete kitten skeleton in the latest round of analysis now challenges this. The kitten was found in B.160 in the South area, and was interpreted as a votive offering (Taylor 2021; Twiss *et al*. 2021)

The incorporation of the skins of small mammalian carnivores, as well as the animals themselves and their scats, into human burials suggests that these animals had some form of symbolic significance (Jenkins 2012a; Pawlowska and Marciszak 2018). The Mellaart excavations also reported a plastered mustelid skull in the wall of a building (Nakamura and Meskell 2013), adding to the evidence that these animals were favoured in some way; either linked with pest control or perhaps a more ephemeral meaning, being nocturnal creatures that were unlikely to be living on the site itself but visiting after dark. If the importance of the inclusion of the scats was therefore linked to the predators, then the identification of this ritual behaviour relied on accurately identifying a predatory derived microfaunal assemblage, as, in many cases, the organic component of the scat has been lost.

4.3.6. Interpretation of microfaunal remains

It is clear that microfauna have played a more expansive role in the day to day life of some cultures than simply being pests or creatures best ignored. In order to assess the potential for archaeological accumulation of these bones on sites it is important to understand any potential cultural significance they could have had.

For example, one would expect the bodies of dead rats at the Karni Mata Temple to be curated in some way, as in life they represented the resurrection of gods. How would that assemblage look after a millennium, when the significance and meaning of the original curators had been lost? Would it be very different to the bodies of rats killed in a dog ring for sport? Would the difference only be in the deposit type or location of the feature from which they were recovered, or the inclusion of other material, for example additional refuse added to a midden but not to a careful burial? With regards to ratting,

depending on how and where the bodies of these rats were disposed of, the zooarchaeological assemblage could mistakenly be identified as one that placed greater importance on the rat than it deserved, even though it still may reflect the 'ritual' nature of the accumulation.

However, it is important to not be too hasty with labelling microfaunal remains as ritual. Some may ignore the taxonomic or taphonomic details in the analysis of these assemblages, and stress that their importance lies in them being in an unexpected location. This was the case when toad bones were recovered from an excavation at an Olmec capital in Veracruz in the 1960's. The presence of toad bones at this site led to conjecture that toad venom was being used in shamanistic rituals in the Early Preclassic period and is now something that is widely taught (Coe and Diehl 1980; Cyphers *et al.* 2005). Following a reassessment, the analysis now suggests that the archaeological context from which the bones were recovered was not secure and the toad remains, on which shamanistic evidence is based, may in fact be intrusive (Cyphers *et al*. 2005). Taxonomy and taphonomy, as well as analysis of secure contexts, can help to identify methods of deposition, which must be understood before the potential of ritual can be raised.

4.3.7. Summary

Small mammals and herpetofauna are regarded as everything from a scourge, a bringer of plague, to treatments for all types of ailments, all the way through to spiritual animals that are the reincarnation of the gods. It is important to understand some of the roles that microfauna have played, and still play, in cultures around the world, to understand the diverse associations that humans have with these animals, and to consider how they could become incorporated into archaeological features, and how those assemblages may appear today.

How past cultures could have interacted with the small vertebrates living with and around them must be considered and assessed so as to remove implicit bias created by modern thinking regarding these animals. Perhaps then, the importance of these animals on archaeological sites can be better addressed and we can conclude whether they were in fact seen as pests, or perhaps that they were associated with feasting, medicine, or magic, and perhaps seen and/or used in alternative ways.

The next sub-chapter will explore the relationships small mammals in particular have had with humans, and how human impact on the environments and movement around the globe has had a lasting effect in the form of anthrodependent relationships and what that can tell us about human sedentary practices.

4.4. Anthrodependency and Sedentism

4.4.1. Introduction

Humans have always had a close association with animals, whether we use them for food or function, and commensalism is another of these interactions. Commensalism has been defined as a semi-mutualistic relationship, where one participant gains a benefit from the other, and the other participant is neither benefitted nor harmed (Tchernov 1984). This can be as simple as animals taking advantage of the human refuse, or in the case of small mammals such as mice and rats, the niches they inhabit within human settlements can provide not just a more stable food supply, but protection from predators, and the reduction of competition with other species (Tchernov 1991a).

4.4.2. Sedentism and anthrodependant animals

The correlation between commensalism and sedentism was first postulated by Bar-Yosef and Tchernov (1966) in their paper on Hayonim Cave, Israel, where they reported that *Mus musculus* were not found at this location during the Kebaran levels (ca. 10,000 BCE), but were, however, the most common rodent during the Natufian (ca. 9,000 BCE). Due to the increase of *M. musculus* in the assemblages between these time periods, they concluded that the settlement had changed from sporadic to a more permanent occupation (Bar-Yosef and Tchernov 1966:125). Hesse (1979), also reported an increase in the levels of *M. musculus* at the Neolithic site of Tepe Ganj Dareh, Western Iran, c.7000-8000 cal. BCE (Hesse1979; Meiklejohn *et al*. 2017) that also coincided with the emergence of goat husbandry and the appearance of mud-brick architecture. He concluded that the increase in levels of *M. musculus* indicated a transition from irregular use of the site to one of year-round occupation, or a transition from a seasonal to a sedentary way of life. Sedentism has been defined as the act of settling permanently into the landscape as opposed to seasonal movement or occupation (Hesse 1979, Tchernov 1984, 1991a, 1991b, Weissbrod *et al.* 2017). This permanence creates changes in the immediate environment which can encourage local populations of fauna to adopt commensal behaviour, where they derive a benefit from the human presence, whereas the human inhabitants are neither benefited nor harmed. This behaviour has been applied to animals such as house sparrows, pigeons, rats and mice, as well as wolves, foxes, and wild boar (Tchernov 1984; 1991a; O'Connor 2013; Weissbrod *et al*. 2017). Commensalism is a behaviour found at population level, rather

than at species level, as many species that exist within a commensal setting are also present as feral or wild populations away from human settlements. Because of their exploitation of human-created niches, these species can therefore be used as indicators of sedentism. In addition, because they are associated with human habitation, they can also be transported via human mediated movement, and act as indicators of travel; showing up in archaeological deposits outside of their natural habitat range (Cucchi 2008; Cucchi *et al*. 2005; 2012; 2013; 2020).

Rodents can live in dense populations within human settlements and destroy food supplies and property, including both personal items and the structural integrity of buildings themselves (Jenkins 2009; Holt and Palazzo 2013). As well as eating human food, with just two mice being able to consume nearly two kilograms of food in six months (Holt and Palazzo 2013), they also contaminate more than they eat with urine and droppings. Because of this, the term 'commensal' does not really apply to many of the small rodents associated with human settlements. Commensal implies no harm to either species. However, these rodents are considered serious pests in modern towns and cities, and this is likely to have been the case in the past as well. As such this term is inappropriate when referring to house mice and rats in particular, and other terms such as "synanthropic", which derives from the Greek meaning 'together' and 'man', or "anthrodependent", meaning dependant on humans, are more accurate descriptions of the relationships between the species (Hulme-Beaman *et al.* 2016). Due to the requirement for human-mediated niches, or at least the absence of a 'wild' competitor, such as *Apodemus sylvaticus* or *Mus macedonicus*, these rodents are more anthrodependant than commensal, and the descriptor used for them should be amended (O'Connor 2013; Hulme-Beaman *et al*. 2016).

One of the biggest difficulties in using small mammals as indicators of sedentism is that their importance on archaeological sites has been underestimated due to the absence of adequate sieving programmes. As such, information on palaeoenvironmental reconstruction, phylogeography (using genetics to track the past geographic spread of a species, examined further below), human diet, human health, as well as indictors of sedentism is often lost. Although they may be invasive species spread by human movement, their consistent recovery from well-dated contexts, especially in areas where early human sedentism is believed to have occurred, is crucial to furthering our

understanding of the impacts of small mammals, and indeed additional microfauna such as amphibians and squamates, on human lives, and vice versa.

An increase in sedentism following the transition from mobile hunter-gatherer to settled foraging communities that preceded farming, altered the relationship between humans and the natural world around them (Cucchi *et al*. 2012; Weissbrod *et al*. 2017). These changes created new niches that were then exploited by different species, and altered their evolutionary trajectories, as well as their ecology and species range. This can be seen in the association of the *Mus musculus* sub-species with human dwelling houses, and the vast increase of the species' range following human expansion. The sub-species of *Mus musculus* first appeared in association with human settlements during the Natufian in the Levant, c.10,000 BCE (Bar-Yosef and Tchernov 1966; Hesse 1979; Tchernov 1984; 1991a; 1991b; Weissbrod *et al*. 2017). The Natufian culture was one which was sedentarising, despite being a hunter-gatherer society, and therefore it has been suggested that the human-built environment, rather than the act of farming, was the catalyst for the niche construction exploited by the house mouse (Weissbrod *et al*. 2017).

Species susceptible to commensal behaviour need several traits in order to fully exploit the niches created by intensification of human settlements. They must have high fecundity rates in order to support populations, as well as rapid sexual maturity. *Mus musculus* has a gestational period of approximately three weeks, a litter of around four to nine pups, reaching sexual maturity at between six and eight weeks of age (Phifer-Rixey and Nachman 2015). If conditions are right, for example having consistent access to resources, females may breed year-round, rather than seasonally (Pocock *et al*. 2004; Phifer-Rixey and Nachman 2015). Traits such as reduced wariness and aggression, and a shift from territorial behaviour to hierarchies also allow commensal populations to live at higher densities than would be expected in feral or 'wild-type' populations (Frynta *et al*. 2005; Weissbrod *et al.* 2017).

The House Mouse

Mus musculus is believed to have originated in northern India (Cucchi *et al*. 2012; Jones *et al.* 2013), and later, following geographical isolation during the Pleistocene, it split into three separate subspecies, *M. m. castaneus* the southeastern Asian House Mouse, now found in Southern and south eastern Asia; *M. m. musculus,* the Eastern European

House Mouse, now found in Eastern Europe and northern Asia; and *M. m. domesticus,* the Western European House Mouse, now found in Western Europe, North America, South America, Africa, and Oceania. These subspecies independently exploited human habitation and the anthrodependant niche (Belmaker and Brown 2016; Jones *et al*. 2013).

Due to the phylogeographic spread of the main three subspecies and the proliferation of genetic sequencing studies, at least another four sub-species of *Mus musculus* have been identified; *M. m. bactrianus*, found in Afghanistan, Pakistan and Nepal; *M. m. gentilulus*, found in Yemen and Madagascar; *M. m. isaticus,* found in central Iran; and *M. m. helgolandicus*, found on a small island off Germany. Many of these additional subspecies are derived from mixing of the main three haplogroups, with some also affected by geographical restriction to a small area or island (Suzuki *et al*. 2013; Babiker and Tautz 2015; Haddadian-Shad *et al*. 2016; Adhikari et al. 2018).

M. m. domesticus versus M. m. musculus

Out of the three main sub-species of *Mus* to come out of the Indian sub-continent, only two made their way west towards southwest Asia and Europe. *M. m. domesticus* travelled south west and was the primary commensal in the Middle East, being associated with Natufian and then Neolithic settlements, and subsequently dispersed into western Europe via the Mediterranean. *M. m. musculus*, however, travelled north of the Black Sea and into Northern Europe (Cucchi *et al.* 2012; O'Connor 2013), creating a hybrid zone through Europe (Figure 4.10).

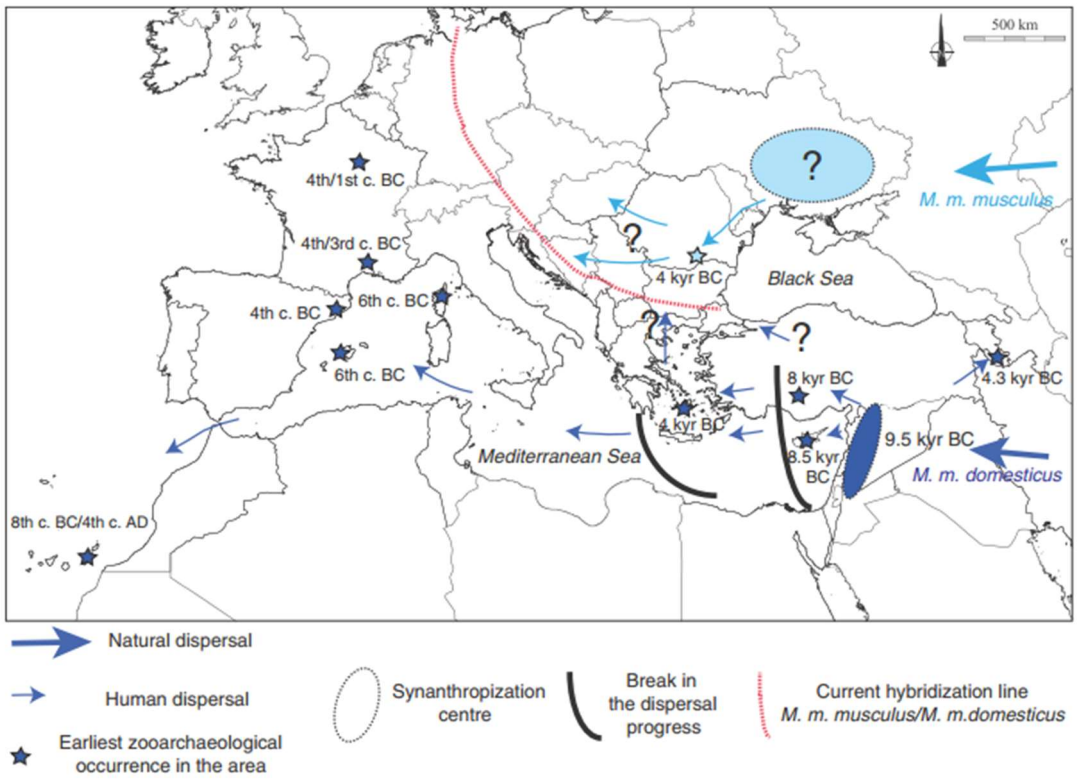

Figure 4.10 Range of dispersal in M. m. musculus and M. m. domesticus (Cucchi et al. 2012; 83)

An analysis of the Natufian site of Ain Mallaha where both, *M. m. domesticus*, and the wild type, *Mus macedonicus* were recovered from different phases, suggested that human occupational pressure at the site allowed *M. m. domesticus* to out-compete *Mus macedonicus* as habitat partitioning, or the impact of the human created niche, took effect (Weissbrod *et al.* 2017). During the early Natufian levels of the site, evidence of permanent occupation was accompanied by an assemblage in which only *Mus musculus domesticus* was found, suggesting it was able to outcompete *Mus macedonicus*. Following a return to seasonal mobility during the Younger Dryas phase at the site, the mouse assemblage shifted to being dominated by *Mus macedonicus,* as habitat partitioning fell apart and the 'wild type' were able to out-compete the commensal population. In the final levels of the Natufian where there was some seasonal mobility but also long-term occupation of the site, the proportion of *M. m. domesticus* to *Mus macedonicus* reached 80/20%, with *M. m. domesticus* taking advantage of the partial reinstatement of habitat partitioning (Weissbrod *et al*. 2017). As all this takes place on an archaeological site that predates the introduction of farming, it demonstrates that the settlement types and ecological niches created by human impact on the local environment was more of a driving force behind commensalism of the house mouse than the introduction of agriculture. Sedentary living, by either hunter-gatherers or

farmers would have led to increased levels of stored and discarded foods, with the intensive storing of wild grains known from Pleistocene sites, such as Ohalo II (21,000 BCE) (Snir *et al*. 2015; Weissbrod *et al*. 2017). The changing levels of anthrodependant versus 'wild type' mouse populations also shows that there is a cost involved in exploiting a new niche (Hulme-Beaman *et al.* 2016); and that when those niches disappear the advantages gained are then removed.

There is evidence that the average size of settlements increased following the Natufian, which had settlement sizes around 0.2ha with a mean population of approximately 59 people (Kuijt 2000, 2008; Cucchi *et al*. 2012). Average settlement sizes then increase to 1 ha during the PPNA, with a mean population of 332, and up to 12 ha in the PPNB, with a mean population of approximately 4000 (Kuijt 2000). As a consequence, the carrying capacity for rodents on these sites increases, in large part due to the increased level of food storage which provided a more stable food source.

Archaeological evidence for food storage has been recovered from PPNA sites in the Levant, such as Dhra' (9300 – 9175 cal BCE), which included buildings identified as granaries with suspended floors, potentially to protect the stored cereals from rodents (Kuijt and Finlayson 2009; Colledge *et al.* 2018). Direct evidence of a *M. m. domesticus* infestation has also been reported, with bones and droppings being recovered from within a building at Jerf el Ahmar, Syria (Willcox *et al*. 2008). Evidence of burnt seeds and the architectural design also indicated these buildings were granaries or communal storage facilities (Willcox and Stordeur 2012), and this is echoed in the later site of Çatalhöyük, with mouse remains and their droppings recovered from inside the food storage bin in Building 52 (Twiss et al. 2009: Bogaard *et al*. 2010). This then raises the question, were mice already considered a pest at this early stage so that humans took steps and stored food in a particular way in order to protect it from rodents?

Pottery fragments of a 3rd millennium BCE mouse trap were recovered from Bampur, Iran, (De Cardi 1967) showing that the pest status of small mammals, most likely mice, had reached levels that required technology to deal with them (Figure 4.11). This type of find is rare in the archaeological record. However, more mundane objects could also have been used to trap pests that may not be readily identified as such. One possible example is of a Roman amphora that was sunk into the floor of a building in

Manchester (Yalden 1984). Is it that little evidence exists for the control of pest populations, or is it an identification problem with the material culture?

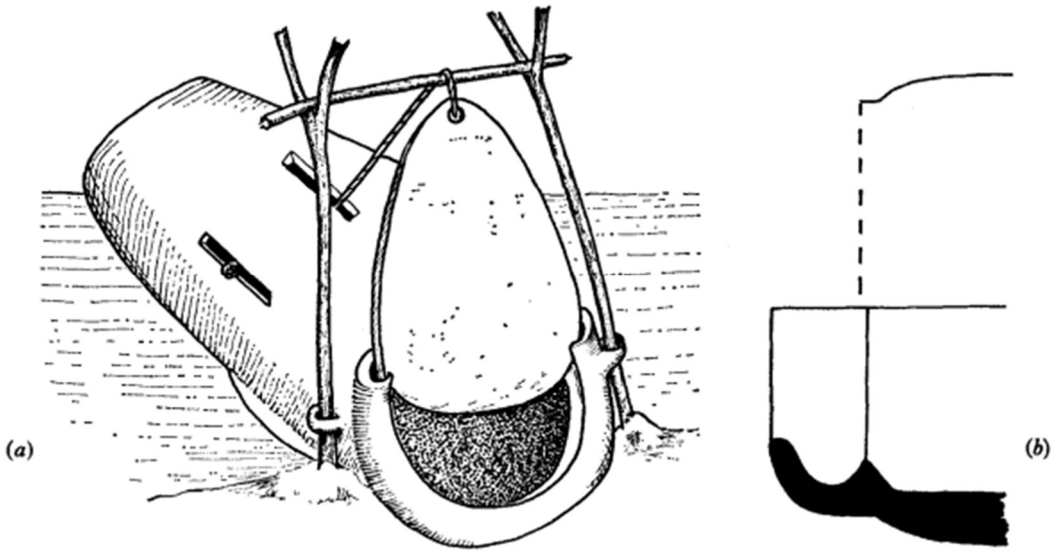

Figure 4.11 (a) Reconstruction of a ceramic mouse trap, (b) cross section showing the rim. (De Cardi 1967:39)

As stated above, the *M. m. domesticus* sub-species has successfully colonised Western Europe, the Americas, Africa, and Australasia, using human mediated movement as transport. However, although they were one of the earliest commensal small mammals in south west Asia, their association with human settlements in Western Europe has not been proven prior to the Iron Age, making their use in understanding sedentism in Western Europe, especially Britain, more problematic (Jones *et al*. 2013). It was initially believed that house mice were introduced into Europe via the first cultural dispersals from Neolithic Anatolia. However, zooarchaeological evidence does not support this. There is no evidence of *M. musculus* infestations in Neolithic or Bronze Age west European contexts, suggesting that either populations that were introduced were unable to outcompete the existing commensals, or that settlement sizes were unable to sustain the populations (Cucchi *et al.* 2012).

It has been suggested that the small size of the human settlements in the pre-Iron Age, meant the house mouse was unable to out compete the local commensal rodent, *Apodemus sylvaticus*, and therefore did not become a fixture in Western European sites until settlement sizes increased and the commensal niche became much tighter (Cucchi *et al*. 2012). Evidence of *A. sylvaticus* in human settlements has been recovered from the early Neolithic in Europe, with bones of that species being discovered in a granary

in a settlement to the south-east of Dijon, France (Vigne 1997 cited by Cucchi *et al.* 2012:79). Western expansion of *M. m. domesticus* therefore, was not driven by neolithization and the spread of people along with their farming techniques, but much later, by maritime trade and the expansion of the Greeks and the Phoenicians into the Mediterranean (Cucchi *et al*. 2012).

The Rat

Rats are another anthrodependent rodent and there are three main rat species that have been denoted as commensal; *Rattus rattus*, the black rat, *Rattus norvegicus*, the brown rat, and *Rattus exulans*, the Pacific rat.

Rattus rattus have been recorded on Natufian sites at similar times to mice, although whether they were living in association with people is currently unknown due to a lack of clear stratigraphy (O'Connor 2013). This also holds for Europe and the date at which they are first thought to be found on archaeological sites is disputed, with some researchers dismissing their remains entirely and others suggesting that *R. rattus* was widespread in the Fertile Crescent at the beginning of the Holocene (Tchernov 1984; Audoin-Rouzeau and Vigne 1994; Toskan and Krystufek 2006). *R. rattus* was recovered from a 1st millennium BCE Slovenian site which demonstrates that the black rat was moving into Europe before its common association with the Romans (Toskan and Krystufek 2006).

The expansion of the Roman Empire facilitated its spread, and by the 2nd century CE *R. rattus* could be found in Britain. Unlike the house mouse, populations of *R. rattus* declined following the roman administration's abandonment of Britain, and the species appears to have gone extinct in Britain at this time (O'Connor 2013). In the 9th Century CE, with increased maritime traffic from Scandinavia, *R. rattus* was once again introduced to Britain (Armitage 1994).

Rat remains, primarily those of *R. rattus*, have been recovered from several shipwrecks, providing primary evidence of being transported by humans (Migaud 2011), although these ships do date to post-1500 CE. *Rattus rattus* found on ships also show evidence of stress and disease, perhaps highlighting that the commensal niche was a much tighter fit than for that of the house mouse (Migaud 2011).

The translocation of *R. exulans* is discussed later in this chapter, as is the association of *R. rattus* and the devasting plagues in Europe.

4.4.3. Phylogeography

Phylogeography is the study of species distribution using genetic lineages (Emerson and Hewitt 2005; Avise 2009). With more work being done with aDNA and geometric morphometrics, relationships between ancient and historical mouse populations are being identified, increasing our understanding of how and when these species were being moved around the world by people.

Sub-species of *Mus musculus* and *Rattus* sp. are found all over the globe, having been unwittingly moved by people (Atkinson 1973; Bonhomme et al. 2011; Cucchi *et al*. 2012; 2013; 2020; O'Connor 2013; Azaza and Colominas 2020). *M. musculus* can be found in both wet and dry conditions, from tropical to the subarctic. They have been found living 600m underground in mines, and up to 400m in elevation, taking advantage of human mediated changes to local environments (Phifer-Rixey and Nachman 2015; Latham and Mason 2004). *Mus musculus* is one of the most widely spread species on the globe, second only to humans (Cucchi et al. 2020).

Anthrodependant species of *Mus* sp. can be used to track human migration around the globe as they are generally only successful in new environments when they occupy niches created by human settlements. They take advantage of increased protection from predators, the warmth of the buildings, and the lower rates of nutritional stress due to stored human food supplies in comparison to seasonally derived food supplies in the wild (Cucchi *et al*. 2012; Jones *et al*. 2013).

Mus sp. had not been present in Europe since the end of the last Glacial, approximately 24,000 to 18,000 years BCE. As such, current *Mus* sp. dispersal in Europe is the result of human mediated movement during the Holocene, with *M. m. domesticus* travelling via the Mediterranean route, and *M. m. musculus* moving via the Black Sea (Cucchi *et al*. 2012).

The most common rodent found *in-situ* on shipwrecks is *Rattus rattus*, although *R. norvegicus* was recovered from a French, 18th century wreck, the Ca Ira (Cucchi 2008; Migaud 2011). Infested hay or grain transport is the most likely vector for early rodent

translocation (Baker 1994; Cucchi 2008). Direct evidence of human mediated dispersal was discovered in the Bronze Age Uluburun shipwreck discovered off the coast of southern Turkey, when the mandible of a specimen of *Mus* was discovered on-board during recovery of the wreck. The first molar was *in-situ* which enabled species identification using geometric morphometrics, (for more details see Chapter 5 of this work), which identified this specimen as *Mus musculus domesticus* (Cucchi 2008). Geometric morphometrics, in addition to identifying specimens to species, can also be used to identify the geographical region the specimen originates from due to variation in molar phenotype (Cucchi 2008). The mandible from this young specimen, approximately 3 months old was stained green from prolonged contact with the copper ingots it was recovered with, providing evidence that the mandible on the ship was contemporary with the wreck and was not an intrusive element (Cucchi 2008). Also, biological markers associated with the mandible itself, such as a lack of morphological drift, a change in shape brought about by adaptations to isolated environments such as island life or living in the hold of a ship, suggest this specimen was added to the ship immediately prior to its final voyage. As such this specimen allows for the tracing of its geographical origin, which gives additional direct evidence of the route of the vessel. The biometrical data, along with other historical and archaeological sources, suggest that the mouse was accidentally loaded alongside cargo in the port of Ugarit, Syria (Cucchi 2008).

Through direct evidence of the dispersal of mice being tied into human movements, such as the Uluburun shipwreck (Cucchi 2008), genetic studies are expanding our understanding of the relationship between mice groups, and can therefore be used to explore how these genetically distinct 'Clades' could have been moved around the globe. This led to a re-examination of the Madeira Archipelago, on the Atlantic coast of North Africa, and the established understanding of its original discovery by the Portuguese in the 15th century (Jones *et al*. 2013). Only 1% of the genetic sequences of the house mice discovered on the island matched the dominant haplotype of those found in Portugal, and instead 99% matched the genetics of those from northern Europe (Berry 2009; Förster 2009). Another explanation for the presence of northern European mice is required on these islands, as the estimates of times of expansion would suggest a much earlier date for colonisation than the 15th century Portuguese voyagers, which may be explained by Viking boats landing in the 9th century, for which no other archaeological evidence exists (Berry 2009; Förster 2009; Jones *et al*. 2013).

Another instance is suggested by house mice on the Azores having no relation to Portuguese mice, another island that was supposedly first discovered by the Portuguese. The mice on the Azores are again linked with northern Europe, this time with Norwegian Clades. Medieval maps support the theory that Norwegian Vikings may have travelled to the Azores, but again there is no archaeological evidence, just the distinct genetics of co-travellers humans might not have even been aware of (Jones *et al*. 2013).

Using the genetics of *Mus musculus* sp. as bio-proxies to infer human trade routes, especially by sea, can also be applied to the genetic link between the house mouse in the Middle East and those of north western Europe. The Phoenicians trading routes of the 2nd Millennium BCE, were typically centred on the eastern and southern Mediterranean, however genetic links of mice suggest they may have travelled further afield, up to north-western Europe, potentially to trade in tin (Jones *et al*. 2013). The potential for using the house mouse as a bio-proxy for human trade routes, and general human movement, especially in situations where no other archaeological evidence is available, illustrates how valuable these bio-cultural remains can be. The genetic links and dispersal in mice have also been found to reflect those in human populations for Norwegian Vikings from the late 8th century, suggesting that this information is accurate and could be used to trace trade or migration routes where no human aDNA evidence is available, and may even be able to shed light on re-colonisation episodes following collapse of previous settlements (Jones *et al*. 2013).

Mice can be used to explore human movements, even as late as the 19th century. Mice from Lake Casitas, California, which were all assumed to be of the sub-species *M. m. domesticus*, were actually shown to be hybrids of *M. m. domesticus*, and *M. m. castaneus*, the Asian sub-species (Orth *et al*. 1998 cited by Phifer-Rixey and Nachman 2015). This suggests that the original settlers of the Lake Casitas area during the 1800's, were from China, and brought the sub-species *M. m. castaneus* with them (Gardner *et al*. 1991 cited by Phifer-Rixey and Nachman 2015:6).

Rattus exulans, the Pacific rat, also provides excellent evidence of prehistoric human dispersal in the Pacific, most likely between 1400 BCE and 1280 CE (Wilmhurst *et al*. 2008; West *et al*. 2017). Introduction of the Pacific Rat has been recorded on 126 Pacific Ocean Islands (Long 2003 cited by O'Connor 2013:95). Whether these animals

were dispersed accidentally as commensal animals, as per *M. musculus* and *R. rattus*, is up for debate. The inclusion of *R. exulan* bones in middens, with rats eaten until very recently (Downes 1926), suggests that they may have been intentionally transported as a food species (O'Connor 2013).

4.4.4. Disease

Rodents are well known vectors of human disease, the most famous of which is *Yersina pestis*, the plague, transmitted by *Xenopsylla* sp. fleas carried by the black rat, *R. rattus,* although this is now in contention (Welford and Bossack 2010; O'Connor 2013). Rodents are known vectors of over 60 zoonotic diseases that can have serious consequences for humans living in close association (Morand *et al*. 2015), including leptospirosis, hantavirus, haemorrhagic fever, and murine typhus, amongst others. The majority of rodents associated with the spread of zoonotic diseases are those considered to be commensals or anthrodependant, due to their altered ecological niches that put them in close proximity with human habitation. Animals such as *M. m. domesticus*, *M. m. musculus*, *Rattus rattus*, *R. exulans, R. tanezumi*, and *R. norvegicus* have dramatically altered their geographic range as they moved with human populations, thus exacerbating the spread of diseases associated with them. The diseases spread by rodents can be caused by bacteria, viruses, or even parasites.

As mentioned above, the most widely known disease spread by *R. rattus* was the Black Death, or plague, caused by the bacterium *Yersina pestis*, however this is questioned by some studies which suggest the rate of the spread of infection in the Medieval period was too fast to be caused by plague (Welford and Bossack 2010). Transmission of plague is not spread person to person, but by bites of infected fleas found on rats (Welford and Bossack 2010). Rats have a limited home territory, which means the spread and therefore the transmission of the disease would be slow. This is also borne out by two possible Medieval Black Death (MBD) events in Iceland in the 15th century, despite rats, and therefore their infected fleas, not being present on the island (Cohn 2002; Welford and Bossack 2010). Medieval Black Death infections travelled at a rate of 0.9 to 6km per day (Benedictow 2004), which is exceptionally fast compared with modern infections of the Bubonic plague, averaging 25km per year in the USA since 1900 and 13-19km per year between 1866-1994 in China (Benedict 1996; Welford and Bossack 2010). However, aDNA sequences for *Yersina pestis* have been recovered from the dental pulp of victims of the Black Death, from plague pits in Europe, seeming

to confirm the spread of plague, despite the differences in transmission rates (Haensch *et al*. 2010).

As well as spreading actual diseases, rodents can spread diseases like *Salmonella* sp. which causes food poisoning (Meerburg and Kijlstra 2007). Rodents are also known for eating and fouling stored food in human dwellings, so the transmission of bacteria that cause food poisoning onto food would have been very problematic in the ancient world.

Disease ecology in large, urban archaeological sites can also be explored using microfauna. Species data can be used in association with phasing data to explore patterns of human health. This especially applies to sites that have a documented history of disease and death, for example large Roman sites such as Rome or Pompeii. Species data for small rodents is especially important as the ability to transmit diseases is closely linked to niche construction of the commensal populations and their lifestyles (Holt and Palazzo 2013). As mentioned above *Mus musculus* is able to out complete 'wild type' mice, such as *Mus macedonicus* or *Apodemus* sp., and although both can live in association with humans, they occupy slightly different niches. For example, *M. m. domesticus* have very limited home ranges of only a few square meters (Holt and Palazzo 2012, Bronson 1979), whereas *Apodemus* range over an area with a 50+ meter diameter. It should be stressed that *Apodemus* sp. and *Mus macedonicus* are routinely forced out of areas of human habitation by *M. m. domesticus*, however in western Europe, the ability for *M. m. domesticus* to out-compete *Apodemus* sp. may have been more dependent on levels of urbanisation and human density (Holt and Palazzo 2013) than on other early sites in the Neolithic Middle East or Anatolia, such as Çatalhöyük, where the house mouse was ubiquitous even in the early levels (Jenkins 2005; 2009; Feider and Jenkins 2021). The take-over of the commensal niche by *M. musculus* may have actually been favourable when it came to rodent-borne disease transmission to humans, as the small home ranges meant they were less likely to introduce new diseases, whereas *Apodemus* survive in a wider range of environments and would have an increased opportunity to pick-up disease carrying parasites and carry them back to human habitation (Holt and Palazzo 2013). Although *Mus* can transmit disease like *Salmonella*, they would be less likely to import new diseases and as a result *Apodemus* may have spread more diseases, and more dangerous diseases, than *Mus* due to their expanded range, and therefore *Mus* would be considered less effective vectors of disease (MacKay 2010 cited in Holt and Palazzo 2013, p.142).

As with palaeoenvironmental data, using modern rodent vectors of disease as analogues for the past effect of rodents on human health is conjectural to a degree due to the differing nature of archaeological human settlements, and how they were occupied by people.

4.4.5. Summary

There is a correlation between commensal animals on a settlement and how intensively that settlement is occupied due to the requirements for human mediated niches. As such, levels of commensal animals, such as mice and rats, can be used as indicators of sedentism. Due to their presence in 'pre-agricultural' sites, such as those belonging to the Natufian culture, it is much more likely that permanent occupation of the landscape was the driver for commensalism than farming (Weissbrod *et al*. 2017).

The increasing use of aDNA in zooarchaeology has led to an expansion of studies related to phylogeography, in particular anthrodependant mice as proxies for ancient and historical human movement (Bonhomme *et al*. 2011; Cucchi 2008; Jones *et al*. 2013; Phifer-Rixey and Nachman 2015; Searle *et al.* 2009). This has uncovered unknown movements of Vikings into area where no other archaeology supports evidence of their visitation, except the genetics of the mice they accidentally left behind (Jones *et al*. 2013).

Synanthropic *Mus* sp. are also important to study due to the valuable information they hold regarding the history of human health. They brought with them a whole suite of new pathogens into human settlements (Shlyakhov 1983 cited by Cucchi *et al*. 2012:66).

The study of commensal or anthrodependant small mammals, especially mice and rats, has much to offer in teasing out early changes to human settlement use, such as the transition from mobile lifeways to permanent occupation of the landscape, as well as understanding human mediated movement, including trade routes, around the world.

The next chapter will look at the methodology that will be used to analyse the microfaunal assemblages from three archaeological sites, and how the data will be analysed.

5. Materials and Methods

5.1. Materials

Microfaunal assemblages from three sites in Anatolia were analysed. The Pınarbaşı assemblage includes samples collected from Areas A, B, and D, with 2522 identifiable specimens recorded from 35 contexts. The Boncuklu microfaunal assemblage was recovered from Areas H, K, and M, and contained 4215 identifiable specimens from 31 contexts. The Çatalhöyük assemblage came from the North, South, and TPC areas of the site, and comprised 8342 identifiable specimens from 26 contexts.

5.2. Recovery and Recording

Microfauna from all three sites were recovered from the heavy residue (HR) as part of the environmental sampling and flotation process. The heavy residue samples were then sieved through 4 mm, 2 mm, 1 mm, and in some cases 0.5 mm, stacking sieves. Due to the sizes of the environmental samples taken, the heavy residue was then sorted to varying degrees, for example 6.25% to 100% at Çatalhöyük, 25% to 100% at Pınarbaşı, and 50% to 100% at Boncuklu. This was determined by the person responsible for HR processing at each site. The degree to which each context was sorted can be seen in Figure 5.1.

At Boncuklu, 1 mm sieved samples were sorted to 50% and 100%. Early on in the sampling strategy this was deemed to be too time consuming and yielded few finds and so the sorting of the 1 mm samples was discontinued. During the 2018 season, a sub-sample of the 0.5 mm and 1 mm samples from Areas K, M, N, and P were sorted to determine whether important microfaunal specimens were being missed. The 0.5 mm and 1 mm samples from Area M, yielded a considerable amount of fish bone, but few other microfaunal specimens, the bones of which were limited to the metapodials and phalanges of amphibians, with occasional fragmentary long bones in the 1 mm samples. The 0.5 mm samples were sorted from Area K, and these contained very little microfauna, with fish still being the predominant inclusion. Area N, which contained buildings and had similar contexts to Area H, was sampled at 1 mm and although more rodent bones were recorded in these contexts at this sieve size, they were of little diagnostic use. This area however, did produce a loose *Mus* sp. mandibular M1 (molar), however this was after the export of samples back to the UK had been sent.

The 2 mm and 4 mm samples were all sorted to 100% on site by students overseen by the faunal team.

At Pınarbaşı the microfauna was sorted from the heavy residue by the macrofaunal team.

At Çatalhöyük contexts are referred to as units (Jenkins 2009; Farid and Hodder 2013), and published material about the site uses this nomenclature. To make discussion between the three sites clearer in this thesis only, a decision was made to refer to the Çatalhöyük units as contexts, so all three sites use the same wording.

At Çatalhöyük, contexts were assigned unique numbers, however at Boncuklu and Pınarbaşı, contexts were labelled with letters, the first of which denoted the Area or Trench they were excavated from e.g., ADJ, from Area A at Pınarbaşı, or KAR from Area K at Boncuklu. Contexts that started with the letter Z denoted human burials, and the second letter then denoted which Area it was from, for example ZKM, would be a burial context in Area K.

Pınarbaşı

Context	1mm	2mm	4mm
ADJ		✓	✓
ADN	✓	✓	✓
ADX	✓	✓	✓
AER			✓
AFA			✓
AFC			✓
AFI			✓
AHA			✓
BBH			
BDF	✓		✓
BFV			✓
BHL			✓
BIA		✓	✓
BIB		✓	✓
BIE	✓	✓	✓
BIF	✓	✓	✓
BIH	✓	✓	✓
BIJ		✓	✓
BIK	✓		
BIL	✓		✓
BIP	✓		✓
BJY		✓	✓
DCI			✓
DCL			✓
DFA			
DFH	✓		
DFM			✓
DGK			✓
DGL			✓
DGN	✓		✓
DGS			✓
DGT		✓	✓
ZAM			✓
ZBB		✓	✓
ZBD			

Boncuklu

Context	1mm	2mm	4mm
HBG			✓
HEJ	✓		✓
HFG			✓
HFO			✓
HFW			✓
HGG			✓
HJW			✓
HLD			✓
KAJ		✓	✓
KAN			✓
KAR		✓	✓
KAZ			✓
KBB			✓
KDD			✓
KGV			✓
KJI			
KRK		✓	✓
KWA			✓
KWT			✓
KWV			✓
MAL		✓	✓
MCW			✓
MCX		✓	✓
MDC			✓
MDJ		✓	✓
MEO			✓
MNZ			✓
ZHH			✓
ZHI			✓
ZKJ			✓
ZKM			✓

Çatalhöyük

Context	1mm	2mm	4mm
18523			✓
18578			✓
19802		✓	
21367			
21573		✓	
21810	✓	✓	
21814		✓	
21842	✓	✓	
21849	✓	✓	
22512	✓		
22513		✓	
22515	✓	✓	
23215	✓		
30217		✓	
30269		✓	
30543		✓	
30554		✓	
30591		✓	
32334	✓	✓	
32403			✓
32611	✓	✓	
32616	✓	✓	
32632	✓	✓	
32717	✓	✓	
32782	✓	✓	
32793	✓	✓	

Figure 5.1 Recovery sizes for contexts at Pınarbaşı, Boncuklu and, Çatalhöyük showing the different mesh sizes the contexts were sieved to

Due to a general lack of facilities and expertise, samples from Pınarbaşı and Boncuklu were not well sorted on site and contained a large number of small fragments of macrofauna as well as avian and fish bones. The Boncuklu assemblage was further sorted at Bournemouth University with the assistance of an undergraduate student on placement, and the Pınarbaşı assemblage was sorted by the author prior to recording.

At Çatalhöyük, following sieving, percentages of the heavy residue were then sorted for microfauna by local women who remove 'shaped' and potentially diagnostic elements. Export of material from Çatalhöyük is problematic, and so the number of specimens selected has to be kept to a minimum. Accordingly identifiable elements and

taphonomically interesting specimens were further sorted from the priority contexts by Jenkins, prior to export to the UK in 2017.

No record of the numbers of unidentifiable elements was recorded from any of the three sites as they were mixed in with small fragments of macrofaunal bones and other small animals not part of this analysis, such as birds and fish.

A Microsoft Access database was used to record the Çatalhöyük dataset, and was designed to reflect previous analysis of microfauna at the site, so that recorded information would be compatible. This design, however, was not suitable for the Boncuklu assemblage, due to the difference in species present, and so the Access database was redesigned to reduce redundancies and make it more efficient for amphibian recording. The database design was altered again prior to the recording of the Pınarbaşı assemblage, to maximise efficiency and include additional categories.

5.3. Taxonomy

Identifications were made using a Brunel Stereomicroscope and a comparative collection of Turkish micromammals, curated by Jenkins, and held at Bournemouth University, as well as collections held at the Harrison Institute, Kent. Literature was also used to identify small mammal, amphibian, and snake elements, as well as to identify amphibians to genus and species, where possible (Greene 1935; Jepson 1938; Cook 1965; Bohme 1977; Hillson 1986, 2005; Bailon 1999; Krystufek and Vohralik 2001, 2005, 2009; Ratnikov 2000, 2001; Aulagnier *et al*. 2009; Yalden 2009; Blain *et al*. 2015; Andjelkovi *et al*. 2017).

Due to the differing nature of small mammal, anura, and squamate remains, taxonomy was assessed accordingly. Micromammals were identified to genus or species, where possible, using teeth, either *in-situ* or loose. *Mus* sp. was also identified using maxillary incisors, as these elements exhibit a 'notch' only found in this genus (Lawrence and Brown 1974). *Arvicola amphibius* cranial elements were also identified by size, as they are the largest vole species, and are considerably larger than other *Arvicolinae*.

Previous analyses on the *Mus* sp. at Çatalhöyük, have identified this species as *Mus musculus domesticus*, by both skeletal identifications using the malar process on the skull (Harrison and Bates 1991), as well as through geometric morphometrics (Cucchi

et al. 2020). As *M. m domesticus* out-competes the other mouse species present in the region, *Mus macedonicus*, in commensal niches (Weissbrod *et al.* 2017), it has been assumed that all *Mus* sp. at Çatalhöyük are *M. m. domesticus*.

The term "insectivore" is also used in this thesis to describe a small mammal that feeds primarily on insects, worms and other invertebrates. This term replaces the obsolete order *Insectivora* (now largely replaced with *Eulipotyphla*).

Identification of amphibian post-crania to species were limited to diagnostic elements such as the scapula, and ilia, with speciated cranial elements limited to the frontoparietal, and sphenethmoid, with the assistance of Dr Chris Gleed-Owen, a herpetofauna specialist.

Unfortunately, there is also no easy taxonomic system for denoting the difference between frogs and toads, despite significantly different lifestyles and obvious skeletal differences. For the purpose of this thesis frogs are identified as having long hind limbs adapted for leaping, and moist, smooth skin (Whyte and Compton 2020, Dorcas and Gibbons 2008), and have been recorded on the database, and analysed as 'anura' when no genus or species identification has been possible. In contrast, toads are identified as having shorter legs for walking and small hops, rather than leaping, and they have dry and generally warty textured skin (Whyte and Compton 2020, Dorcas and Gibbons 2008). At several sites both the green toads (*Bufo* sp.) and the spadefoot toads (*Pelobates* sp.) are present. However, when genus or species identification was not possible, for example with elements such as the tibio-fibula, these have been recorded in the database as generic 'toad'.

Snakes were represented primarily as vertebrae; however, a number of skull elements were also found. These were primarily identified based on advice from Dr Chris Gleed-Owen, as well as the use of the skeletal reference collection at Bournemouth University, and literature such as Ratnikov (2000), and Andjelkovi *et al*. (2017).

5.4. Quantification

Number of Identified Specimens (NISP)

Number of **I**dentified **Sp**ecimens (NISP) was calculated for all contexts at the three sites, and the term denotes both complete specimens and identifiable fragments of

specimens (O'Connor 2000). NISPs were adjusted to represent the number had 100% of the sample been available, and a NISP per litre calculated so that contexts could be compared for microfaunal density or other patterns. For contexts for which no percentage sorting information was given, the assumption has been made that it was sorted to 100% so that corrected NISPs are not over-inflated.

Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI)

Minimum **N**umbers of **E**lements (MNE) was calculated for every context based on the most abundant 'portion' of each element. MNE calculations took into account siding information, percentage completeness, and 'part' of the bone, e.g., proximal, shaft, or distal. Following analysis at Çatalhöyük, it was determined that a zoning system would have made MNE calculations more accurate, and so this was added to the database for use at Boncuklu and Pınarbaşı. The zoning information was used to determine the most abundant zone for each element, as zones are non-repeatable as more than 50% of each zone must be present before that zone can be counted.

Once the MNE was obtained the **M**inimum **N**umber of **I**ndividuals (MNI) was calculated. This is the smallest number of animals to account for the skeletal assemblage present on the site. MNIs can be a problematic quantification because it represents the minimum number, and does not represent actualistic numbers of animals present on site at any one time. MNI calculations should not be added together, as this could inflate the MNI because elements from a single individual may be present in multiple contexts. This is especially true for contexts with limited specimens. For example, a single grass snake, *Natrix* sp. can have between 150-250 precaudual (potentially identifiable) vertebrae (van Wijngaarden-Bakker and Troostheide 2003). Once skeletonised, several of these can be incorporated into multiple contexts, which would each then lead to an MNI of one for that animal in each context. By adding them together, we would erroneously infer that more than one snake was present in a building, for example, and we would over-estimate the numbers of snakes on site. The MNIs for higher taxonomic groups was also calculated, which included individuals that are already represented by species counts. For example, *Mus* sp. were identified by cranial elements only and their MNIs will derive from this. The MNI for rodents was calculated based on post-crania which cannot be identified to species. Therefore, potentially all of the individuals of *Mus* sp. identified within a context will also have

been counted in the rodent MNI for the same context. If these MNIs are added together then the numbers of rodents would be greatly over-estimated.

Body Part Representation and Frequency

Body Part Representation was calculated for each context with a species MNI greater than 10. RPE was calculated by comparing the elements present against what would be expected based on skeletal frequency. This was done to identify any biases towards preferential retention of elements. For example, a hind limb bias in amphibian remains could suggest human consumption of these animals.

Element frequency was calculated based on MNE and MNI counts, taking into account skeletal frequency, giving a percentage of observed over expected. For example, if a context had an MNE of 300 for *Mus* sp. mandibles (both lefts and rights), and an MNI of 151 based on upper right incisors, then this would give a mandible frequency of 99.3% (300 observed out of 302 expected), suggesting that preservation and representation of mandibles in this context is good, with nearly all we would expect to find being represented.

In grouping the skeleton into distinct areas, such as the forelimb, axial skeleton, hindlimb, and head, some of the elements were categorised into different areas for different species. For example, the sacrum is included in the axial skeleton in anura, but in the hind limb in micromammals (Table 5.1). This is due to the fact that the sacrum and pelvis occupy the same physical space in micromammals. However, in anurans the sacrum is a modified vertebra that articulates with the urostyle, so the sacrum and the ilia, although they articulate are in separate physical spaces, with the urostyle taking the physical space of the sacrum in anura.

Also, not every bone in the skull is included in the 'cranial' count. This is due to recovery and identification bias, both for anura and micromammals. The bones included represent those most frequently recovered and that are identifiable when fragmentary.

*Table 5.1 Table showing the different elements assigned to cranial, forelimb, axial, and hindlimb categories for small mammals and amphibians. (§ Palate fragments recovered from Arvicolinae sp. have been counted as two maxilla fragments rather than a single element. * Number of caudal vertebrae vary by species. The count here represents M. m. domesticus).*

Elements in small mammals	Skeletal frequency	Elements in amphibians	No. in single specimen
Molar	12	Premaxilla	2
Incisor	4	Maxilla with teeth	2
Mandible	2	Mandible without teeth	2
Maxilla§	2	Frontoparietal	2
Premaxilla	2	Parasphenoid	1
		Sphenethmoid	1
		Pterygoid	2
		Squamosal	2
Total cranial elements	**22**		**14**
Scapula	2	Clavicle	2
Humerus	2	Sternum	2
Radius	2	Scapula	2
Ulna	2	Humerus	2
		Radio-Ulna	2
		Coracoid	2
Total forelimb elements	**8**		**12**
Atlas	1	Atlas	1
Axis	1	Axis	1
Vertebra*	52	Vertebra	6
Rib	26	Sacrum	1
Total axial elements	**80**		**9**
Sacrum	1	Urostyle	1
Pelvis	2	Ilium	2
Femur	2	Ischium	1
Tibia	2	Femur	2
		Tibio-Fibula	2
Total hindlimb elements	**7**		**8**
Astragulus	2	Carpals	4
Calcaneus	2	Tarsals	4
Metacarpal	10	Astragalus	[2]
Metatarsal	10	Calcaneus	[2]
Metapodials	[20]	Metapodials	18
Phalanges	56	Phalanges	54

Body size

During the recording of the Boncuklu microfauna, it became apparent that there were stark size differences in the specimens of anura recovered. As one of the aims of this thesis is to look at whether microvertebrates were being used as part of a broad-spectrum economy, a decision was made to record broad size categories for the specimens. No measurements were put in place to denote the size ranges and as such the categories were subjective, and what constituted a small or large specimens changed

throughout recording due to exposure to the assemblage. As such the data produced by this method of recording is biased and not useful for scientific analysis of the body size of animals at Boncuklu or Pınarbaşı, with the exception of separating small mammals into small and large, for example separating *Microtus* sp. versus *Arvicola amphibius*. Interesting questions were raised regarding body size of anura and a more scientific method of estimating body size will be valuable in future, potentially using metrics, such as those in Esteban *et al.* (1995).

5.5. Taphonomy

Taphonomic processes affecting the microvertebrate specimens were also recorded and included observations of fragmentation and breakage, digestion, gnawing, weathering, and burning. The taphonomic methodology followed Andrews (1990), Fernández-Jalvo and Andrews (1992), Jenkins (2009), and Fernández-Jalvo *et al.* (2016) for micromammals, and Pinto Llona and Andrews (1999) for amphibians. Taphonomy was assessed in all contexts, with a NISP greater than 50. Specimens with potentially interesting taphonomy, as well as those exhibiting gnaw marks, were examined under a JEOL JSM-6010PLUS/LV Scanning Electron Microscope (SEM), at Bournemouth University, in order to further understand or confirm the taphonomy, as well as to measure puncture marks. This machine is an environmental SEM, meaning the specimens do not need to be coated prior to examination, and is therefore non-destructive.

Percentage completeness as well as the part of the element present, such as proximal, shaft, or distal, was used to assess fragmentation and breakage at Çatalhöyük where the breakage methodology followed Andrews (1990:51). A zoning system was introduced for amphibians at Boncuklu and Pınarbaşı (Figure 5.2), and subsequently also for micromammals at Pınarbaşı (Figure 5.3), based on feedback from preliminary analysis at each site. Fragmentation was analysed at both ‘site’ level, to assess how fragmented the assemblage was as a whole, as well as at element level to assess whether differential preservation and/or the effect of predation was evident.

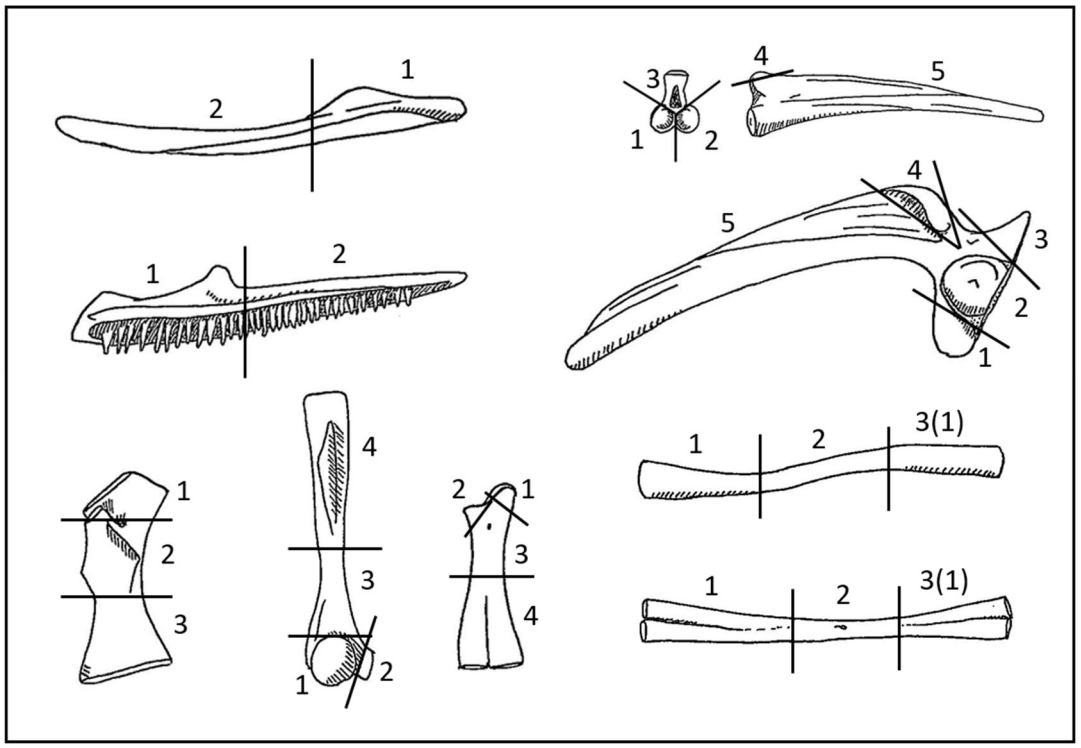

Figure 5.2 Amphibian zoning system for selected elements (amended from Bailon 1999; Ratnikov 2001;2011).

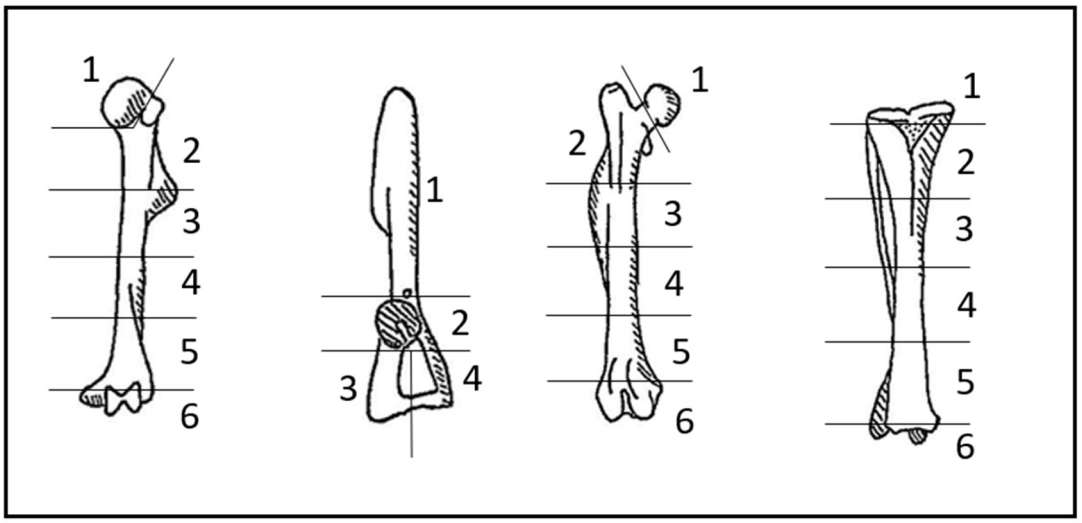

Figure 5.3 Micromammal zoning system for selected elements (amended from Greene 1935).

Micromammal skull and mandibular breakage were initially assessed using Andrews (1990), and then extended (Figure 5.4), to include additional categories when those originally used were deemed to be insufficient. Skull and mandibular breakage categories can be found in Table 5.2 and Table 5.3 respectively.

Table 5.2 Skull breakage categories with descriptions for each one. To be read in conjunction with Figure 5.4 (amended from Andrews 1990; 53).

Skull Breakage Categories	
Category	**Description**
A	complete with the zygomatic intact
B	Complete but includes a break to the base of the skull
C	is broken with zygomatic intact
D	maxilla fragment lacking the zygomatic
E	palate fragment
F	is the Premaxilla
G	Squamosal process

Table 5.3 Mandible breakage categories with descriptions for each one. To be read in conjunction with Figure 5.4 (amended from Andrews 1990; 56).

Mandibular Breakage Categories	
Category	**Description**
A	Complete
B	Broken acsending ramus
C	Ascending ramus missing
D	Ascending ramus missing with inferior border broken
E	Anterior mandible missing
F	Symphysis only
G	Ascending ramus only

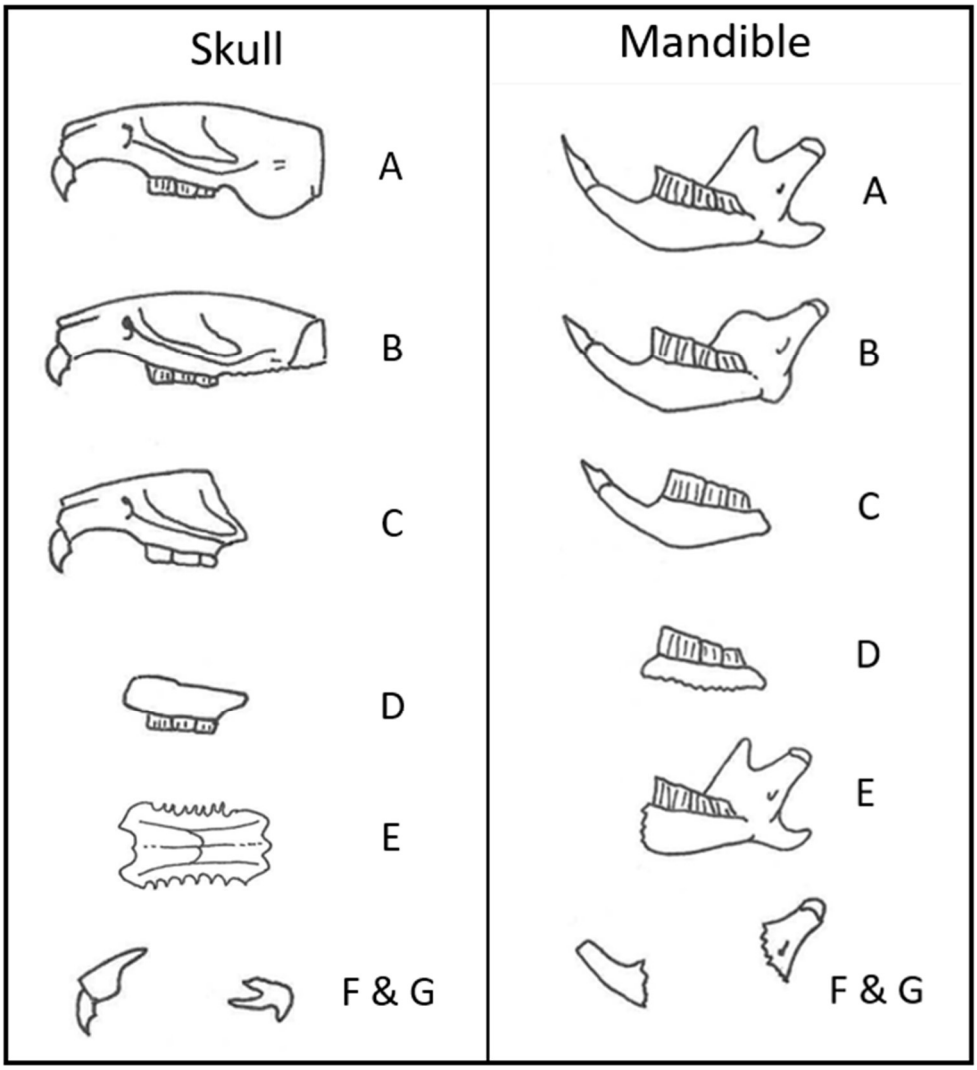

Figure 5.4 Skull and mandible breakage categories with details of each of the categories found in Tables 5.2 and 5.3 (amended from Andrews 1990; 53 and 56).

The recording of arvicolid, murid, and soricid molar digestion followed the methodology of Fernández-Jalvo *et al.* (2016: Figs. 2, 3, and 5), with incisor digestion following the methodology of Fernández-Jalvo and Andrews (1992). The recording of post-cranial digestion for micromammals followed Andrews (1990) and Jenkins (2009), and amphibian digestion followed that of Pinto Llona and Andrews (1999).

Isolated and multiple puncture marks were recorded and examined via SEM. A sample of puncture marks were measured and the maximum and minimum dimensions recorded in order to aid identification of the predator responsible.

The recording of weathering followed the methodology of Andrews (1990: 11, Table 1.3).

Burning at Çatalhöyük was recorded as either present or absent due to the low levels of occurrence. However, at Boncuklu and Pınarbaşı, where burning was more prevalent, specimens were recorded as burnt or partially burnt, if the whole element was not affected, and the thermally altered colour change was noted from brown through to white. These were based on colours changes associated with known temperatures (Ellingham *et al*. 2015). However, the majority of experimental burning data to date is based on macrofauna, and Lev *et al.* (2020) noted that squamate vertebrae turn black at lower temperatures than expected. In order to fully understand the processes of burning on microfauna, and how we use it to interpret the taphonomic pathway of the specimens affected, more experimental work needs to be undertaken.

5.6. Geometric Morphometrics

Geometric Morphometrics (GMM) is a shape-based computational analysis that can examine the minute difference in the shape of teeth and bones between different species or sub-species, in this case *Mus* sp. 2D geometric morphometric analysis of the occlusal surface of a lower first molar (M1) was undertaken using Elliptic Fourier Transform with MorphoJ software. In order to do this a sample of 'known' specimens of all species being considered are analysed in order to create a baseline of data. The differences between 'known' species are assessed using a Multivariate Analysis of Variance (MANOVA) test, and the different species are plotted, and generally cluster. The 'unknowns' are then compared with this baseline data. The 2D analysis of the occlusal outline is assessed as the outline of the occlusal surface of *Mus* sp. molars do not change with age related wear to the tooth (Cucchi 2008). However, age-based wear assessments were made following the methodology of Lidicker (1966). The methodology for the geometric morphometrics follows the protocol in Cucchi *et al.* (2013). Geometric morphometric analysis allowed us to identify *Mus* sp. specimens to species at Boncuklu and Pınarbaşı.

Training in GMM analysis was underway in January to March 2020. Due to the Covid-19 impact on research institutions, it was no longer possible to continue training, due to a lack of access to the software, trainer, and baseline data needed to undertake analysis at institutions such as the Natural History Museum, London, or the Harrisons Institute, Kent. As such, the GMM analysis was outsourced.

5.7. Summary

The recording methodology was designed using the principles of established methods that have been used successfully elsewhere, but these have been enhanced by the addition of more detailed levels of recording as required for the sites under assessment. The next chapter will present the results of the analysis for all three sites.

6 Results

This chapter presents the results of data analysis for the three microfaunal sites, including contextual, taxonomic, and taphonomic analysis. A discussion of the results will be presented in the next chapter.

6.1 Çatalhöyük

6.1.1 Site Details

A total of 8342 specimens, were recorded from 26 contexts excavated during the 2008-2017 field seasons at Çatalhöyük. Details of the data and interpretive categories for each context, as well as building and phasing information, can be found in Table 6.1. Dates for the Hodder Levels can be found in Table 2.1, while South.J dates to 7100-6700 cal. BCE, and North.F, and G date to 6700-6500 cal. BCE.

Table 6.1 Details of contexts analysed for microfauna (amended from Feider and Jenkins 2021)

Context	Data Category	Interpretive category	Building	Building phase	Space	Space phase	Feature	Area	Hodder Level
18523	Construction/make up/ packing	Burnt collapse	79	B.79.B	134			South	South.O
18578	Fill	Dump roomfill	80	B.80.3	135			South	South.O
19802	Fill	Fill between walls	76, 80	B.76.1	135, 137			South	South.O
21367	Fill	Infill	119	B.119.1	512, 513			North	North.F
21573	Construction/make up/ packing	Oven superstructure	119	B.119.2	513		7322	North	North.F
21810	Fill	Burial infill	17	B.17.2.2	170	Sp170.E	8015	South	South.J
21814	Fill	Burial infill	17	B.17.2.3	170	Sp170.E	8017	South	South.J
21842	Fill	Niche infill	17		170		8024	South	South.J
21849	Fill	Oven debris	17	B.17.2.3	170	Sp170.E	579	South	South.J
22512	Fill	Burial pit fill	17	B.17.2.3	170	Sp170.E	8204	South	South.J
22513	Fill	Burial pit fill	17	B.17.2.3	170	Sp170.E	8205	South	South.J
22515	Fill	Burial pit fill	17	B.17.2.3	170	Sp170.E	8206	South	South.J
23215	Floor (use)	Oven base			620		8044	South	South.?I
30217	Fill	Infill layer	110		486			TPC	TPC.N
30269	Fill	Infill	110		486			TPC	TPC.N
30543	Floor (use)	Dirty floor		B.102.B	17			North	North.?G
30554	Floor (use)	Dirty floor		B.102.B	17			North	North.?G
30591	Floor (use)	Dirty floor patches, occupational surface	132		511			North	North.F
32334	Fill	Basin fill	131	B.131.4	500		7988	North	North.G
32403	Fill	Burial infill	160	B.160.2.3	551		7828	South	South.K
32611	Fill	Arbitrary infill of burial	161	B.161.2	605, 606		7849	South	South.J
32616	Fill	Roof collapse, primary room infill	161	B.161.2	605, 606			South	South.J
32632	Construction/make up/ packing	Oven superstructure	161	B.161.1.1 B.161.1.3	605,606		8160	South	South.J
32717	Fill	Burial infill	132	B.132.3.B	531		8320	North	North.F
32782	Floor (use)	Dirty floor	132	B.132.2	531, 633			North	North.F
32793	Floor (use)	Occupational sediment	132	B.132.1	633			North	North.F

6.1.2 Number of Identified Specimens (NISP)

The Number of Identified Specimens (NISP) for each context, and NISP per litre can be found in Table 6.2, with NISP by taxa and context in Table 6.3. Nine contexts had a NISP greater than 50. These were (19802), a fill between walls of Buildings 76 and 80; (21573), an oven superstructure in B.119; (21814), a burial fill in B.17; (21842), a niche infill in B.17; (21849), oven debris within B.17; (32611), an arbitrary fill of a burial in B.161; (32616), primary room infill of B.161; (32632), oven superstructure in B.161; (32782), and a dirty floor in B.132.

Table 6.2 Number of Identified Specimens (NISP) by context, including corrected NISP and NISP per litre for context comparison (amended from Feider and Jenkins 2021). HR=Heavy residue.

Context	Flot No	NISP	% samples (HR)	Corrected NISP for 100%	Sample Volume (L)	NISP per litre
18523	8973?	4	100	4	24	0.17
18578	9122	3	100	3	24	0.13
19802	9825	231	100	231	59	3.92
21367		9	0	Hand collected		
21573	11610	79	100	79	24	3.3
21810	12807	10	12.5	80	300	0.27
21814	13007	57	25	228	473	0.48
21842	12924	423	100	423	27	15.67
21849	12935	66	25	264	24	11
22512	12220	19	100	19	216	0.09
22513	12206	13	100	13	55	0.24
22515	12107	9	100	9	155	0.06
23215	13256	1	100	1	2.5	0.4
30217	10356	1	50	2	37.5	0.05
30269	10528	1	100	1	27	0.04
30543	10624	2	100	2	4	0.5
30554	10629	10	100	10	27	0.37
30591	10777	2	100	2	35	0.06
32334	12712	3	100	3	7	0.43
32403	12823	24	100	24	263	0.09
32611	13008	836	75	1115	105.25	
32611	13008	301	100	301		
32611				1416	105.25	13.44
32616	12940	1265	100	1265	40	31.63
32632	13038	592	100	592	24	
32632	13138	1779	87.5	2033	1	
32632	13138	2517	100	2517		
32632				5142	25	205.68
32717	13163	15	100	15	28	0.54
32782	13376	8	25	32	75	
32782	13376	4	50	8		
32782	13378	24	100	24	49	
32782	13379	1	100	1	60	
32782	13386	13	100	13	10	
32782	13387	10	100	10	25	
32782				88	219	0.4
32793	13392	3	100	3	28	
32793	13394	5	100	5	35	
32793	13396	2	100	2	25	
32793				10	88	0.1

Table 6.3 Number of Identified Specimens (NISP) by taxa and context at Çatalhöyük.

	Anura	*Pelophylax ridibundus*	*Pelobates sp.*	*Bufo viridis*	Toad	Rodent	*Mus sp.*	*Murinae*	*Apodemus mystacinus*	Apodemus sp.	*Microtus sp.*	*Meriones sp.*	*Crocidura sp.*	Insectivore	Micro-mammal	Snake	*Natrix sp.*	Testudine	Microfauna	Total NISP
18523	4																			**4**
18578		2															1			**3**
19802	3					123	65					1	1		37				1	**231**
21367	1																	8		**9**
21573						19	6								35				19	**79**
21810	1					3	1								5					**10**
21814	7					22	6						1		21					**57**
21842	3					111	27						3	6	236	37				**423**
21849						17	19								30					**66**
22512	5					4	3								7					**19**
22513	6						1								6					**13**
22515						4	1								4					**9**
23215																			1	**1**
30217	1																			**1**
30269			1																	**1**
30543	2																			**2**
30554	7			2		1														**10**
30591						2														**2**
32334							1							1	1					**3**
32403						8	5						1		10					**24**
32611	2					534	188							1	411		1			**1137**
32616	3					611	328			1		1		2	319					**1265**
32632	1					1744	1196	3	1	1	1		26	10	1898				7	**4888**
32717	7					1	1								3	2			1	**15**
32782	1				1	11	7								26				14	**60**
32793	1					2									2				5	**10**
Total	**55**	**2**	**1**	**2**	**1**	**3217**	**1855**	**3**	**1**	**2**	**1**	**2**	**32**	**20**	**3051**	**39**	**2**	**8**	**48**	**8342**

6.1.3 Species composition

The assemblage is dominated by rodents (Figure 6.1) which comprise 61% of the assemblage and micromammals at 36.6%. The remaining categories accounted for a total of only 2.4% of the assemblage, this included 0.7% herpetofauna and 0.6% insectivores. When higher taxonomic groupings are removed, the taxa are dominated by *Mus musculus domesticus* at 97.7% of identified species (Figure 6.2).

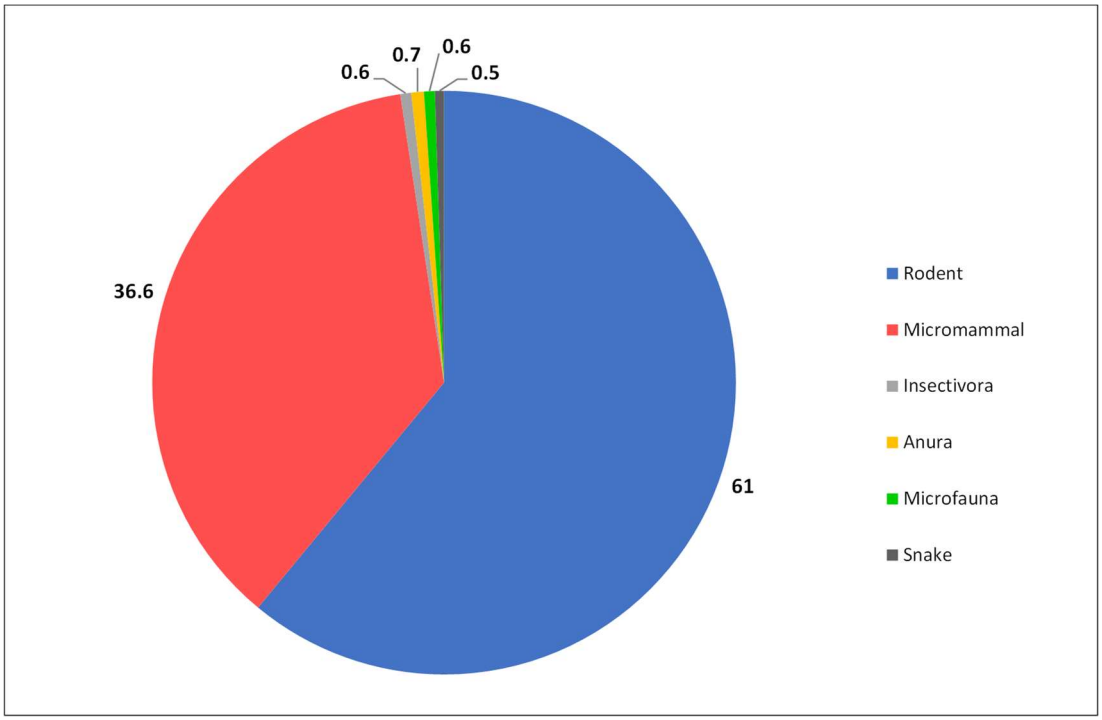

Figure 6.1 Higher taxonomic composition by percentage of the whole assemblage at Çatalhöyük by NISP. N=8,342 (amended from Feider and Jenkins 2021).

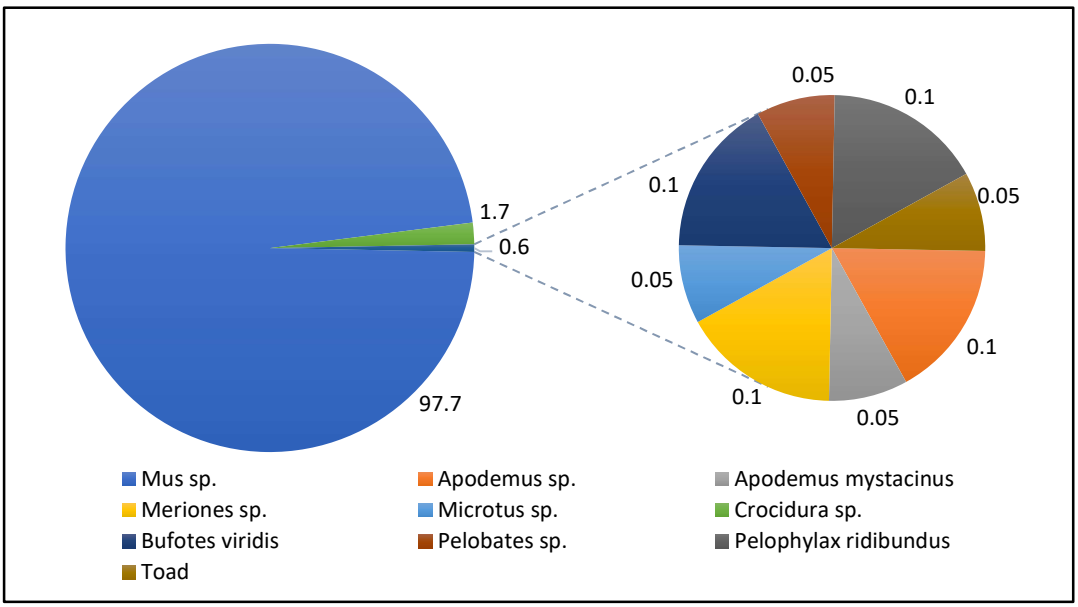

Figure 6.2 Taxonomic composition of identified genera or species by percentage of NISP. N=1899 (amended from Feider and Jenkins 2021)

6.1.4 Microfauna by context data category

Fill.

In total 17 out of the 26 contexts analysed were categorised as fills. This included seven burial fills, two room infills, one fill between the walls of two buildings, and five general fills, which included anthropogenic contexts such as niche, basin and oven fills, as well as more general infill layers. The average adjusted NISP per litre for this category is 2.17. However, if the largest contexts are removed the NISP per litre becomes 0.38, which better reflects the other contexts within this category. Microfauna identified from this category include anura, snake, and testudines, as well as *Crocidura* sp. However, the assemblage was dominated by rodents, in particular *Mus musculus domesticus*. A single element from *Meriones* sp. was also recovered in this category. The testudines were represented by several hand-collected carapace fragments, and therefore had no NISP per litre because the sediment volume was not recorded.

The *burial fills* consisted of contexts (21810), (21814), (22512), (22513), (22515), (32403), and (32611) had an average adjusted NISP per litre of 1.13. This however, was biased by the inclusion of (32611), which was the fill of an arbitrary cut around human remains. The burial was atypical of those found at Çatalhöyük and the number of microfauna recorded from this fill was significantly higher than the other burial fills. With this context removed, the adjusted NISP per litre is 0.26, which again better reflects the results for the other contexts within this sub-category. Taxa were again

dominated by rodents, with *M. m. domesticus* being the most abundant species, however *Crocidura* sp. and snake remains were also present in low numbers.

The *room infill* sub-category contained two contexts, (18578) and (32616) and had an adjusted NISP per litre of 19.8. This sub-category also contained one of the dense clusters of microfauna, (32616), which came from the primary room infill during demolition and closure of the building. Excluding this context, the adjusted NISP per litre is 0.13. Context (18578) contained only anura, specifically *Pelophylax ridibundus*, and a single specimen belonging to *Natrix* sp. The assemblage from context (32616) is primarily made up of rodents, with high numbers of *M. m. domesticus*. Specimens of *Meriones* sp. and *Apodemus* sp. were also found in this context, along with small numbers of insectivores.

The *fill between walls* sub-category (19802) had an adjusted NISP per litre of 3.92. The taxa were represented predominantly by rodents, *M. m. domesticus* in particular, but also included anura, *Meriones* sp. and *Crocudura* sp. in low numbers.

The *general fill* sub-category contained six contexts, several of which were from distinctly anthropogenic environments, including (21842), the fill of a niche; (21849), oven debris; and (32334) the fill of a basin. The niche and the oven debris had a significantly higher adjusted NISPs per litre of 15.67 and 11 respectively. As a group, the NISP per litre is 5.66, but with (21842) and (21849) removed the NISP per litre for the remaining contexts is 0.08. Microfauna in this category are dominated by rodents including *M. m. domesticus*. However, *Crocidura* sp. and insectivores are also represented, as are anura, including a single specimen of *Pelobates* sp.

Construction/make-up/packing.

The assemblages from three contexts were analysed from this category, including the largest analysed from this site. The overall adjusted NISP per litre for this category was 71.6. However, this figure is inflated by the large number of specimens in context (32632), an oven superstructure, which produced an adjusted NISP per litre of 205.68. Excluding this context, the adjusted NISP per litre falls to 1.7. This density of microfauna in context (32632) is not typical of building features generally. Context (21573), another oven superstructure, produced an adjusted NISP per litre of only 3.3. The third context in this category is (18523), comprised of burnt collapse of building

material, had a NISP per litre of 0.17. Due to the inclusion of context (32632), this category contained a broad variety of microfauna, dominated by rodents and *M. m. domesticus*, but it also included *Apodemus mystacinus*, *Apodemus* sp., *Microtus* sp., *Crocidura* sp., and anura.

Floors.

This category did not contain any dense microfaunal clusters and therefore the adjusted NISP per litre was not artificially over-inflated by a single context. It contained contexts (23215), (30543), (30554), (30591), (32782), and (32793), which produced an overall adjusted NISP per litre of 0.3. The microfauna represented were rodents, including *M. m. domesticus*, and anura, including the only specimen of *Bufotes viridis* identified during this analysis. No insectivores were recovered from floor deposits.

6.1.5 Minimum Number of Elements (MNE) & Minimum Number of Individuals (MNI)

Minimum Numbers of Elements (MNE) was calculated for all species or higher taxonomic groups within a context, with the exception of 'micromammal' and 'microfauna', as these could represent a variety of different species. MNEs were then used to calculate the Minimum Number of Individuals (MNI) based on MNE by context (Table 6.4). MNIs for species represented by very few specimens will be inflated but have been included in the table to show from which contexts these species were identified. Also, MNIs calculated from the post-cranial bones for higher taxonomic groupings, such a 'rodent' could have been from the same individuals as the cranial elements of those that were identified to species, such as *M. m. domesticus*. Therefore, these numbers should not be combined.

Table 6.4 Minimum Number of Individuals (MNI) based on Minimum Number of Elements (MNE) calculations, with Micromammal and Microfauna removed (amended from Feider and Jenkins 2021)

	18523	18578	19802	21367	21573	21810	21814	21842	21849	22512	22513	22515	30217	30269	30543	30554	30591	32334	32403	32611	32616	32632	32717	32782	32793
Rodent			17		3	1	5	11	5	2		1				1	1		2	61	101	250	1	3	1
Mus sp.			16		2	1	2	6	8	3	1	1						1	2	43	70	192	1	2	
Murinae																						1			
Apodemus mystacinus																						1			
Apodemus sp.																					1	1			
Microtus sp.																						1			
Meriones sp.			1																		1				
Crocidura sp.			1				1	1											1			6			
Insectivora								1										1		1	1	1			
Anuran	1		1	1		1	1	1		1	1		1			1				1	1	1	1	1	1
Pelophylax ridibundus		1													1										
Pelobates sp.														1											
Bufo viridis																1									
Toad																								1	
Natrix sp.		1																							
Snake								1												1			1		
Testudinae				1																					

6.1.6 Body Part Representation and Element Frequency

Body part representation was calculated for all contexts with a species MNI of over 10. Totals for rodent body part representation were derived from MNE calculations for *Mus* sp., rodents, and micromammals (Appendix A). Calculations were based on MNEs for all major elements, which were then converted into percentages of cranial, axial, forelimb, and hindlimb based on skeletal frequency, e.g., how often those bones occurred in the skeleton of a single complete individual (Figure 6.3). MNEs for indeterminate side were not considered due to concern that they would artificially inflate numbers, due to potentially being 'portions' of the bone that would be duplicated, for example proximal ends where the distal portion has largely made up the sided MNE. For elements that were not sided, for example radii, the indeterminate MNE has been included as it is the only value recorded. These elements were not used to calculate MNI.

Calculations also did not include 'insectivores', *Crocidura* sp., anura, or snakes, and represent only rodents. Although some elements, for example those of the axial skeleton, are not able to be speciated between rodents and insectivores, the inclusion of 'micromammals' in the calculations may have slightly inflated the numbers of these elements due to the inclusion of insectivore vertebrae etc. However, this will not be significant due to the low level of these species present in any one context.

Cranial elements are generally over-represented, when compared with the expected elemental frequency should whole animals have been incorporated into the assemblage. The axial skeleton, in particular, is poorly represented (Figure 6.3), with the exception of (21842). The majority of the vertebrae recovered were caudal vertebrae. However, the paucity of 'trunk' vertebra is not enough to account for the under-representation. Despite hindlimbs being better represented than forelimbs, in most contexts, humeri are more abundant than femora (Appendix A), suggesting that the over-representation of hindlimbs is due to the high numbers of tibiae, rather than an overall bias towards hindlimbs.

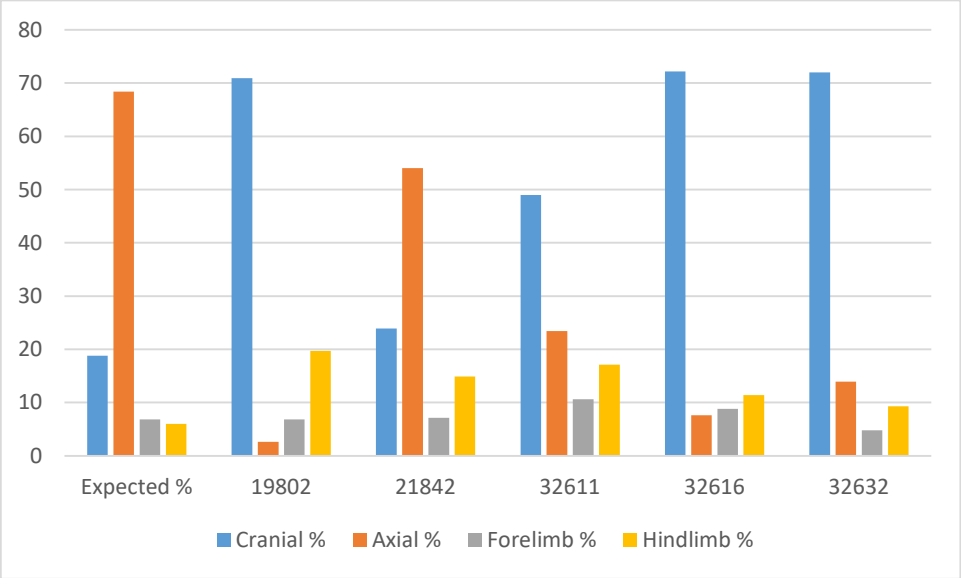

Figure 6.3 Body Part Representation based on percentages of cranial, fore limb, axial, and hind limb specimens recovered from contexts with a species MNI over 10, for small mammals. Expected frequency shows what would be expected from a single complete individual.

Element frequency was calculated as a percentage of observed elements over what would be expected based on the context MNI for each species or taxonomic group. For example, if 99 *Mus* sp. mandibles had been recovered for a context, and that species had an MNI of 50, then the mandible frequency percentage would be 99%, as there are two mandibles in a single individual. This analysis was done for both rodents, and *Mus* sp. Rodent frequencies (Table 6.5) show high numbers of lower incisors, which cannot be identified to species, but very low numbers of molars (many of which were speciated). Percentages for tibiae range from 10% to 95.5% across the contexts. As mentioned under body part representation, although hindlimbs are over-represented compared to the expected figure, shown in Figure 6.3, the frequencies of humeri range from 16.6% to 83.3%, whereas the frequencies of femora are much lower at 8.4% to 50%.

Mus sp. frequencies (Table 6.6) were restricted to the cranial elements used for species identification, and show very low frequencies for lower incisors, which would have been restricted to *in-situ* incisors in mandibles identified as *Mus* sp., due to molar identification. In contrast to the rodent data, molar frequencies are much higher, ranging from 20.8% to 57.6%. Upper incisor frequency, also low in rodents, is much higher in Mus sp., 25% to 93.8%, due to the ability to identify this element to species.

Table 6.5 Frequency of elements from contexts with a 'Rodent' MNI greater than 10

Element	Skeletal frequency	19802%	21842%	32611%	32616%	32632%
Molar	12	2				0.3
Lower incisor	2	88.2		54.9	87.1	98.8
Upper incisor	2	2.9		0.8	3.5	7.6
Mandible	2	8.8	4.5	11.5	8.4	19
Maxilla	2	8.8		0.8	7.4	8.8
Premaxilla	2	8.8	4.5	8.2	9.4	27.2
Scapula	2		13.6	3.3	1.5	3.4
Humerus	2	29.4	59.1	38.5	27.2	16.6
Radius	2	14.7		1.6	12.4	5.4
Ulna	2	2.9	36.4	23.8	15.8	13.2
Sacrum	1					0.2
Pelvis	2	14.7	13.6	1.6	5	5.4
Femur	2	26.5	31.8	30.3	14.8	8.4
Tibia	2	91.2	95.5	90.2	52.5	68.4
Rodent MNI		17	11	61	101	250

Table 6.6 Frequency of elements from contexts with a Mus sp. MNI greater than 10

Element	Skeletal frequency	19802%	21842%	32611%	32616%	32632%
Molar	12	32.3	51.4	36.8	45.4	57.6
Lower incisor	2		8.3	8	7.1	16
Upper incisor	2	93.8	25	89.5	85.7	99.5
Mandible	2	50	75	59.3	64.3	75.3
Maxilla	2	44.1	66.7	66.3	78.6	92.7
Premaxilla	2			2.3		7.6
Mus sp. MNI		16	6	43	70	192

6.1.7 Fragmentation

Fragmentation was analysed to determine the state of preservation of the assemblage as well as to help identify any potential predator that may have been responsible for accumulation. Assemblages from contexts with a NISP of over 50 were analysed for breakage. Analysis of maxillary and mandibular breakage was undertaken on *M. m. domesticus*, and elements identified as murines or rodents. Insectivores were not included in this analysis due to the differences in skeletal structure, such as the lack of a diastema in shrews, which could affect breakage patterns. Analysis of post-cranial breakage was carried out for elements identified as rodents or micromammals, and was restricted to the humeri, ulnae, femora, and tibiae (Andrews 1990).

Maxillary breakage (Table 6.7) was exceptionally high, with all recorded maxilla highly fragmented.

Mandibular breakage (Table 6.8) was slightly more variable as mandibles are more robust than maxillae. A large percentage were still highly fragmented, with fewer specimens in each of the categories as they became more complete. No complete elements were present.

Table 6.7 Maxillary breakage for all contexts with a NISP greater than 50 at Çatalhöyük (amended from Feider and Jenkins 2021)

	A Complete, with zygomatic region		zygomatic but break to base of skull		C Broken with zygomatic intact		D Maxilla fragment lacking the zygomatic process	
Context	N	%	N	%	N	%	N	%
19802							19	100
21573							3	100
21814							1	100
21842							8	100
21849							2	100
32611							58	100
32616							127	100
32632							464	100
32782							2	100

Table 6.8 Mandibular breakage for all contexts with a NISP greater than 50 at Çatalhöyük (amended from Feider and Jenkins 2021)

	A Complete		B Broken ascending ramus		C Ascending ramus missing		D Ascending ramus missing and inferior border broken	
Context	N	%	N	%	N	%	N	%
19802					4		16	
21573					1	100		
21814							2	100
21842					3	33.3	6	66.7
21849							2	
32611					13	20.3	51	79.7
32616			7	6.5	26	24.3	74	69.2
32632			16	4.2	92	24	275	71.8
32782								

Loose and *in-situ* incisors and molars were also recorded (Table 6.9), and the analysis showed that there were very low levels of *in-situ* incisors compared with molars. Most breakage in the mandible was to the ascending ramus and inferior border. The latter

would have a greater effect on the incisors than molars with regards to tooth loss. Also, the high instance of breakage in the maxilla would increase the number of loose maxillary incisors. The majority of the species recorded for these contexts were also murids, which have rooted teeth in comparison with other species, such as Arvicolinae, which may also affect molar retention in a broken mandible or maxilla with rooted teeth potentially more likely to remain *in-situ*.

Table 6.9 Loose and in-situ incisors and molars for rodents and Mus sp. at Catalhoyuk.

	Incisor	Loose Incisors		In-situ incisors		Molar	Loose molars		In-situ molars	
Context	NISP	No.	%	No.	%	NISP	No.	%	No.	%
19802	65	65	100	0	0	66	4	6.1	62	93.9
21573	2	2	100	0	0	7	0	0	7	100
21814	12	12	100	0	0	5	0	0	5	100
21842	22	21	95.5	1	4.5	37	7	18.9	30	81.1
21849	12	12	100	0	0	14	5	35.7	9	64.3
32611	169	160	94.7	9	5.3	190	3	1.6	187	98.4
32616	326	313	96	13	4	380	9	2.4	371	97.6
32632	1021	939	92	82	8	1415	146	10.3	1269	89.7
32782	8	8	100	0	0	5	0	0	5	100

Post-cranial fragmentation analysis examined which part of the element was recovered (Table 6.10), as well as the degree to which each element was broken (Table 6.11), for example, proximal versus distal, and less than ¼ versus complete. Few complete post-cranial elements were recovered for small mammals, not including insectivores, with the vast majority of complete specimens made up of metapodials, followed by vertebrae. The majority of the long bones were fragments, with shafts (not those attached to proximal or distal ends) in low numbers. With the exception of the tibia, many long bone shafts are difficult to identify unless diagnostic features remain. The tibia however, due to its unique shape, is identifiable along the length of the shaft, accounting for the higher numbers across most contexts. The lack of shafts for elements other than the tibia, therefore, may be an identification issue, rather than an actual absence. The percentages of the proximal versus distal part of the specimen most likely has more to do with fusion rates, survivability, and adequate diagnostic features.

Analysis of the degree to which each element was broken found that specimens in the ¼ to ½ category were the most common, showing that breakage of post-cranial remains was high, concurring with the cranial data. With the exception of (21482), in which the highest fractions were in the 'less than ¼' category for all elements, the percentages for the 'less than ¼' category are lower than one would expect for a highly fragmentary

assemblage, although this could be due to the difficulty of identifying very small portions of elements, rather than an actual absence of these fractions. The vast majority of the epiphyses recorded were similar ends for each element, for example proximal humeri, and distal femur. As small mammal bone fusion is not related to age, epiphyseal fusion cannot be used to examine age profiles of the assemblage to analyse attritional versus catastrophic age profiles (Mehta *et al*. 2002, Roach *et al*. 2003). The distal tibia, however appears to commonly fuse, whereas the proximal epiphysis does not. The proximal tibia epiphysis is made up of a thin, flat disk, which due to the level of breakage within the assemblage, would be unlikely to survive. Although recovered in low numbers, the majority of the tibia epiphyses were proximal, suggesting that the burial environment was favourable for bone survival.

Table 6.10 Post-cranial fragmentation in rodents examining the differential recovery of parts of each specimen (amended from Feider and Jenkins 2021)

		19802		21573		21814		21842		21849		32611		32616		32632		32782		All other contexts	
Element	**Category**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus	Less than 1/4							19	82.6	2	25	26	32.5	3	4.3	41	30.8				
	1/4 - 1/2	7	58.3	1	16.7			3	13	4	50	34	42.5	39	56.5	43	32.3				
	1/2 - 3/4	5	41.7	2	33.3	1	33.3	1	4.4			10	12.5	21	30.4	13	9.8			1	50
	More than 3/4					1	33.3					3	3.8	3	4.4	13	9.8			1	50
	Complete			3	50	1	33.3					1	1.3	3	4.4	9	6.8	1	100		
	Epiphysis									2	25	6	7.5			14	10.5				
	Total	**13**		**6**		**3**		**23**		**8**		**80**		**69**		**133**		**1**		**2**	
Ulna	Less than 1/4							5	62.5	3	100	7	20	6	16.2	6	11.1				
	1/4 - 1/2					1	33.3	3	37.5			14	40	15	40.5	15	27.8				
	1/2 - 3/4	1	100			1	33.3					11	31.4	13	35.1	14	25.9				
	More than 3/4											2	5.7	3	8.1	6	11.1			2	100
	Complete					1	33.3					1	2.9			11	20.4				
	Epiphysis															2	3.7				
	Total	**1**		**0**		**3**		**8**		**3**		**35**		**37**		**54**		**0**		**2**	
Femur	Less than 1/4					1	25	27	75	3	42.9	30	44.1	11	22.4	26	24.5			1	20
	1/4 - 1/2	6	54.5	1	33.3			4	11.1	1	14.3	18	26.5	22	44.9	27	25.5			2	40
	1/2 - 3/4	3	27.3			1	25					7	10.3	9	18.4	9	8.5	1	100	2	40
	More than 3/4			1	33.3									1	2	5	4.7				
	Complete	1	9.1	1	33.3	1	25	1	2.8			1	1.5	5	10.2	6	5.7				
	Epiphysis	1	9.1			1	25	4	11.1	3	42.9	12	17.6	1	2	33	31.1				
	Total	**11**		**3**		**4**				**4**		**68**		**49**		**106**		**1**		**5**	
Tibia	Less than 1/4	2	5.7			1	100	19	63.3	1	33.3	26	16.1	17	12	54	14.2				
	1/4 - 1/2	24	68.6	4	57.1			7	23.3	2	66.7	92	57.1	72	50.7	232	60.9	3	60	3	50
	1/2 - 3/4	7	20	3	42.9			4	13.3			38	23.6	35	24.6	66	17.3	2	40		
	More than 3/4	2	5.7									4	2.5	15	10.6	16	4.2			2	33.3
	Complete													3	2.1	5	1.3			1	16.7
	Epiphysis											1	0.6			8	2.1				
	Total	**35**		**7**		**1**		**30**		**3**		**161**		**142**		**381**		**5**		**6**	

Table 6.11 Post-cranial breakage for rodents examining the percentage of each specimen recovered (amended from Feider and Jenkins 2021)

	19802		21573		21814		21842		21849		32611		32616		32632		32782		All other contexts	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus																				
Complete			3	50	1	33.3					1	1.2	3	4.3	9	6.6	1	100		
Proximal			1	16.7			2	8.7	2	25	19	23.5	1	1.4	36	26.5				
Shaft only	2	16.7			2	66.7	9	39.1	1	12.5	16	19.8	13	18.8	16	11.8				
Distal	10	83.3	2	33.3			12	52.2	5	62.5	45	55.6	52	75.4	75	55.1			2	100
Ulna																				
Complete					1	33.3					1	2.9			11	13.6				
Proximal	1	100			2	66.7	8	100	2	66.7	28	80	32	74.4	56	69.1			2	100
Shaft only									1	33.3	6	17.1	1	2.3	2	2.5				
Distal													10	23.3	12	14.8				
Femur																				
Complete	1	10	1	33.3	2	50	1	2.8			1	1.4	5	10.2	6	5.7				
Proximal	8	80	2	66.7	2	50	27	75	5	71.4	34	48.6	26	53.1	44	41.5	1	100	3	50
Shaft only							3	8.3			10	14.3	11	22.4	8	7.5			1	25
Distal	1	10					5	13.9	2	28.6	25	35.7	7	14.3	48	45.3			1	25
Tibia																				
Complete	1	2.7											3	2.1	6	1.6			1	16.7
Proximal	3	8.1	3	42.9	1	100					16	9.9	5	3.5	18	4.7				
Shaft only	4	10.8					9	30	1	33.3	35	21.7	31	21.8	57	14.8	1	20	1	16.7
Distal	29	78.4	4	57.1			21	70	2	66.7	110	68.3	103	72.5	305	79	4	80	4	66.7

6.1.8 Burning

Burning in the assemblage as a whole (Table 6.12) was exceptionally low and limited to only a few contexts, with only 0.2% of elements burnt.

Table 6.12 Burnt elements from whole assemblage

Context	Taxa	Element	NISP	Burn type	Burn colour
21814	Anuran	Indeterminate metapodial	2	Burnt	Black
21814	Anuran	Phalanx	1	Burnt	Black
21814	Rodent	Loose lower tooth	1	Partly burnt	
21814	Rodent	Loose lower tooth	1	Burnt	
22512	Anuran	Indeterminate metapodial	1	Partly burnt	Black
22512	Anuran	Phalanx	1	Burnt	Black
22513	Micromammal	Caudal vertebra	1	Burnt	Black
32334	Micromammal	Caudal vertebra	1	Burnt	Black
32334	Insectivora	Mandible without teeth	1	Burnt	Black
32334	Mus	Maxilla with teeth	1	Burnt	Black
32717	Anuran	Amphibian tibio-fibula	1	Burnt	Brown
32717	Anuran	Phalanx	1	Partly burnt	Black
32717	Anuran	Phalanx	1	Burnt	Black
32717	Anuran	Indeterminate metapodial	1	Burnt	Brown
32782	Rodent	Tibia	1	Partly carbonized	

Table 6.13 burning by taxa for the whole assemblage

Taxa	Taxa NISP	Burnt NISP	% Burnt by taxa	% Burnt by assemblage
Anuran	55	9	16.4	56.3
Insectivore	20	1	5	6.3
Micromammal	3051	2	0.07	12.5
Mus	1856	1	0.05	6.3
Rodent	3217	3	0.09	18.8
Total	**8166**	**16**		**0.2**

Despite their low frequency in the assemblage, the majority of burnt elements (Table 6.13) belonged to anura. Elements of *Mus* sp., rodent, and micromammal were also burnt, but in very low numbers that would suggest we are dealing with accidental burning of individual bones, rather than the disposal of whole carcasses in fires.

Many of the burnt elements came from contexts with a small NISP (Table 6.14), inflating the percentage of burning within them. Four of the contexts were burial fills, three of which were from the same phase within building 17, suggesting the back filling of graves with additional material other than what was originally excavated to create the

grave. One context was a dirty floor, and the last, (32334) was the fill of a basin in B.131, in which all three elements were burnt.

Table 6.14 Burning by context for the whole assemblage

Context	Interpretive category	Context NISP	Burnt NISP	% Burnt
32782	Floor use	60	1	1.7
21814	Burial fill	57	5	8.8
22512	Burial fill	19	2	10.5
22513	Burial fill	13	1	7.7
32717	Burial fill	15	4	26.7
32334	Basin fill	3	3	100
Total		**8342**	**16**	**0.2**

6.1.9 Gnawing

Gnawing, including both isolated and multiple puncture marks, was recorded for all elements, included both loose and *in-situ* teeth, and reported here for all contexts with a NISP over 50. Gnawing was not seen on any specimens of insectivores or anura.

SEM micrographs showing examples of gnawing on several different types of elements are provided in Figures 6.4-6.8

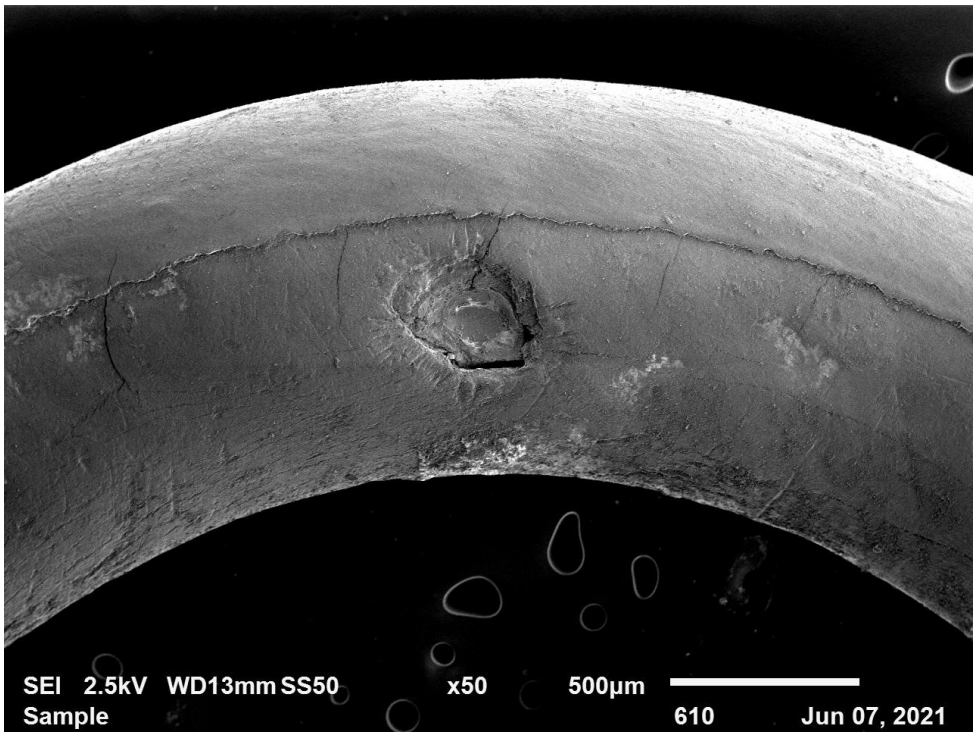

Figure 6.4 SEM micrograph showing gnawing on a Mus sp. maxillary incisor

Table 6.15 shows the percentage of gnawing by elements for each context, and Table 6.16 shows the percentage of the gnawed assemblage by element. Context (21842) had the highest level of gnawing, with 8.1% of the assemblage gnawed. Seven different elements were affected, with 50% of the gnawing occurring on vertebra. The second most affected context was (21849), with 6.7% of the assemblage gnawed. Context (32632) produced the most gnawed bones, with 14 different elements affected, including a basisphenoid, not included in Tables 6.15 or 6.16 (Feider and Jenkins 2021).

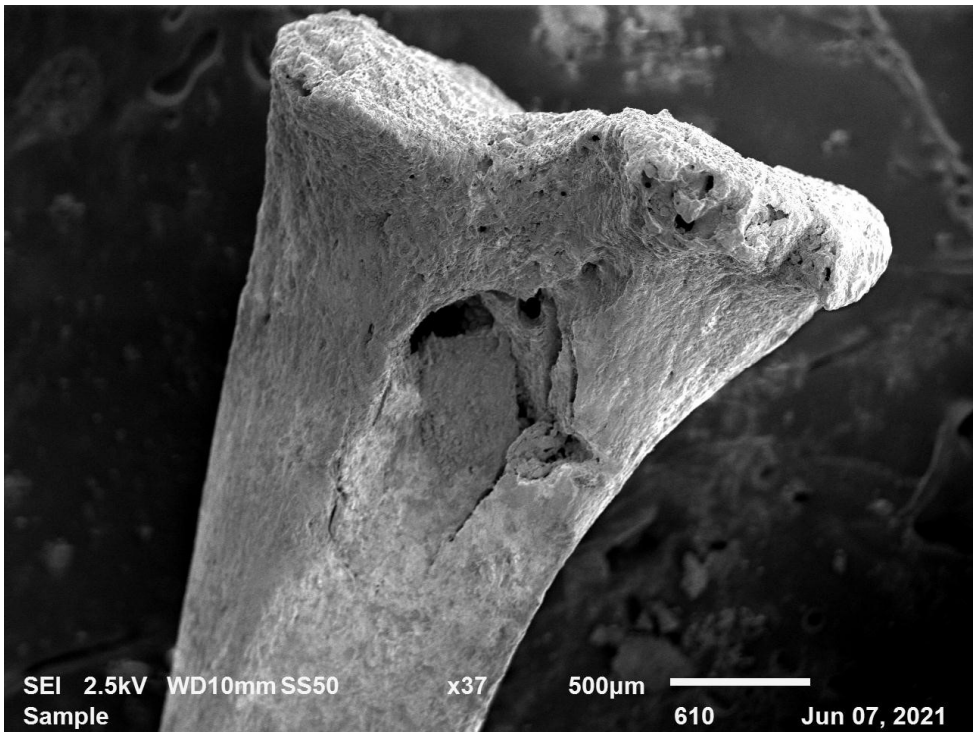

Figure 6.5 SEM micrographs showing an isolated puncture mark on a proximal tibia

The most commonly gnawed elements in context (32632) were tibiae (Figure 6.5), 23% of which were gnawed providing 30.1% of the total number of gnawed specimens from that context. Other commonly gnawed elements in this context were incisors at 12.2% (Figure 6.4), vertebrae at 11.1%, and mandibles at 10.5%. Consistent puncture marks on the mandible, just above the masseteric ridge and below the molars (Figure 6.8) occurred in all contexts where gnawing was observed on this element. Context (32616) had eight different elements affected by gnawing, with 4.7% of the assemblage gnawed. The most commonly affected were mandibles, 26% of which were gnawed, comprising 35.9% of the gnawed assemblage. The next most commonly damaged were the tibiae, at 19.2%, humeri, at 14.1%, and femora at 11.5% of the gnawed assemblage. However, only 11% of tibiae in this context were gnawed, with femora at 18%, and humeri at

16%. Gnawing was observed on only 2.4% of the large assemblage from (32611). Mandibles and femora each made up 32.3% of the gnawed elements, with vertebrae at 19.4%. The five other elements affected were each represented by a single specimen. Only six different elements were affected by gnawing in (19802), with 4.3% of the assemblage exhibiting gnaw marks. Tibiae were once again the most common, providing 25% of the gnawed assemblage, followed by the mandible, pelvis, and femora, each at 16.7%. Only 8.1% of all tibiae in this context were gnawed, compared with 10% of the mandibles, 25% of the pelves, and 18.2% of the femora. Context (21573) only contained two gnawed elements, a scapula and a pelvis, making up only 3% of the assemblage.

Of the contexts with a NISP over 50, no gnawing was recorded for context (21814), burial infill, and (32782), dirty floor.

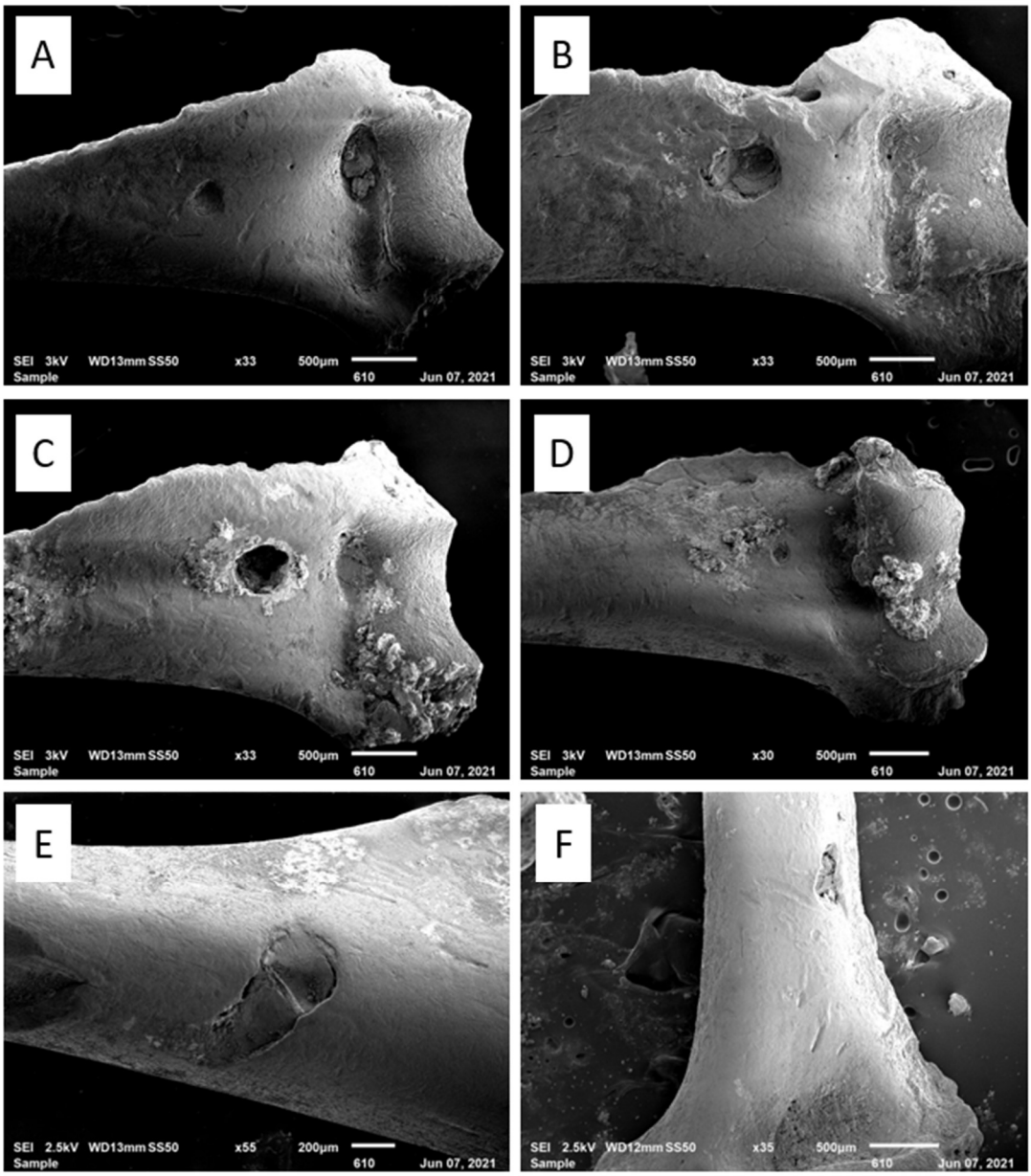

Figure 6.6 SEM micrographs showing isolated puncture marks on humeri

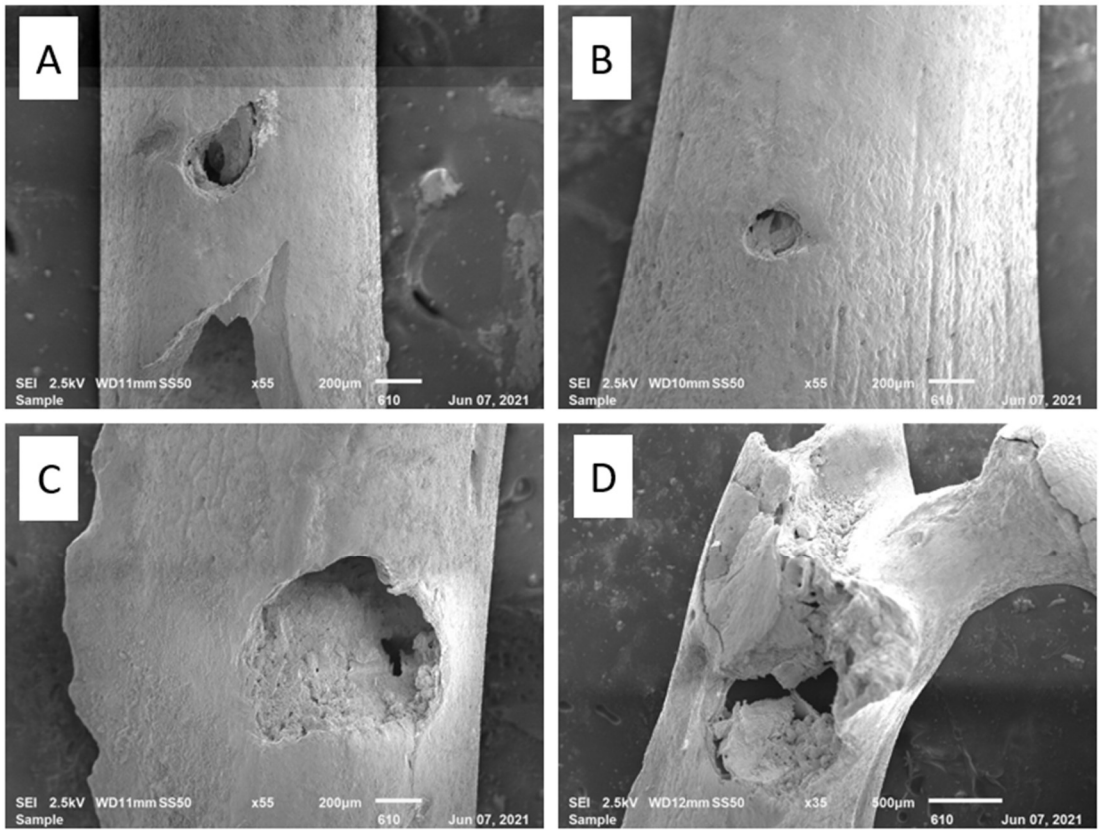

Figure 6.7 SEM micrographs showing isolated puncture marks on femora

Table 6.15 Percentage of gnawing by element for all contexts with a NISP greater than 50. Calculations include elements identified as 'rodent', 'Mus sp.', and 'micromammal' and the total NISP for each context includes in-situ teeth not counted as separate elements in site NISP calculations (amended from Feider and Jenkins 2021)

	19802			21573			21842			21849			32611			32616			32632		
Element	**NISP**	**N**	**%**	**NISP**	**N**	**%**	**NISP**	**N**	**%**	**NISP**	**N**	**%**	**NISP**	**N**	**%**	**NISP**	**N**	**%**	**NISP**	**N**	**%**
Molar	67			7			37			14			190			383			1418		
Incisor	65	1	1.5	2			22			12			170	1	0.6	326	3	0.9	1021	36	3.5
Mandible	20	2	10	1			10	1	10	3	1	33.3	65	10	15.4	107	28	26.2	388	31	8
Maxilla	19			3			8			2			58			127			464	1	0.2
Premaxilla	3			1			1			1			12			19			165	5	3
Vertebra	6			26			174	16	9.2	12	1	8.3	226	6	2.7	98	6	6.1	612	33	5.4
Rib	1												4			2			25		
Scapula				3	1	33.3	3			1			13			3			17	5	29.4
Humerus	12	2	16.7	6			23	4	17.4	8	1	12.5	81	1	1.2	69	11	15.9	137	23	16.8
Radius	5			1						1			21			37			77	8	10.4
Ulna	1						8			3			35			43	5	11.6	83	14	16.9
Sacrum	2			1									2			2			3		
Pelvis	8	2	25	5	1	20	6	1	16.7				32	1	3.1	22	1	4.5	60	22	36.7
Femur	11	2	18.2	3			36	1	2.8	7			70	10	14.3	49	9	18.4	106	24	22.6
Tibia	37	3	8.1	7			30	4	13.3	3	1	33.3	161	1	0.6	142	15	10.6	386	89	23.1
Astragulus																			13		
Calcaneus							35	5	14.3	1	1	100	45	1	2.2	14			95	5	5.3
Metacarpal										1			3			3			140		
Metatarsal	23			1			1			6			99			199			923		
Phalanx																			43		
Total	**280**	**12**	**4.3**	**67**	**2**	**3**	**394**	**32**	**8.1**	**75**	**5**	**6.7**	**1287**	**31**	**2.4**	**1645**	**78**	**4.7**	**6176**	**296**	**4.8**

Table 6.16 Percentage of the gnawed assemblage by element and context (amended from Feider and Jenkins 2021)

	19802		21573		21842		21849		32611		32616		32632	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Molar														
Incisor	1	8.3							1	3.2	3	3.8	36	12.2
Mandible	2	16.7			1	3.1	1	20	10	32.3	28	35.9	31	10.5
Maxilla													1	0.3
Premaxilla													5	1.7
Vertebra					16	50	1	20	6	19.4	6	7.7	33	11.1
Rib														
Scapula			1	50									5	1.7
Humerus	2	16.7			4	12.5	1	20	1	3.2	11	14.1	23	7.8
Radius													8	2.7
Ulna											5	6.4	14	4.7
Sacrum														
Pelvis	2	16.7	1	50	1	3.1			1	3.2	1	1.3	22	7.4
Femur	2	16.7			1	3.1			10	32.3	9	11.5	24	8.1
Tibia	3	25			4	12.5	1	20	1	3.2	15	19.2	89	30.1
Astragulus														
Calcaneus					5	15.6	1	20	1	3.2			5	1.7
Metacarpal														
Metatarsal														
Phalanx														
Total	**12**		**2**		**32**		**5**		**31**		**78**		**296**	

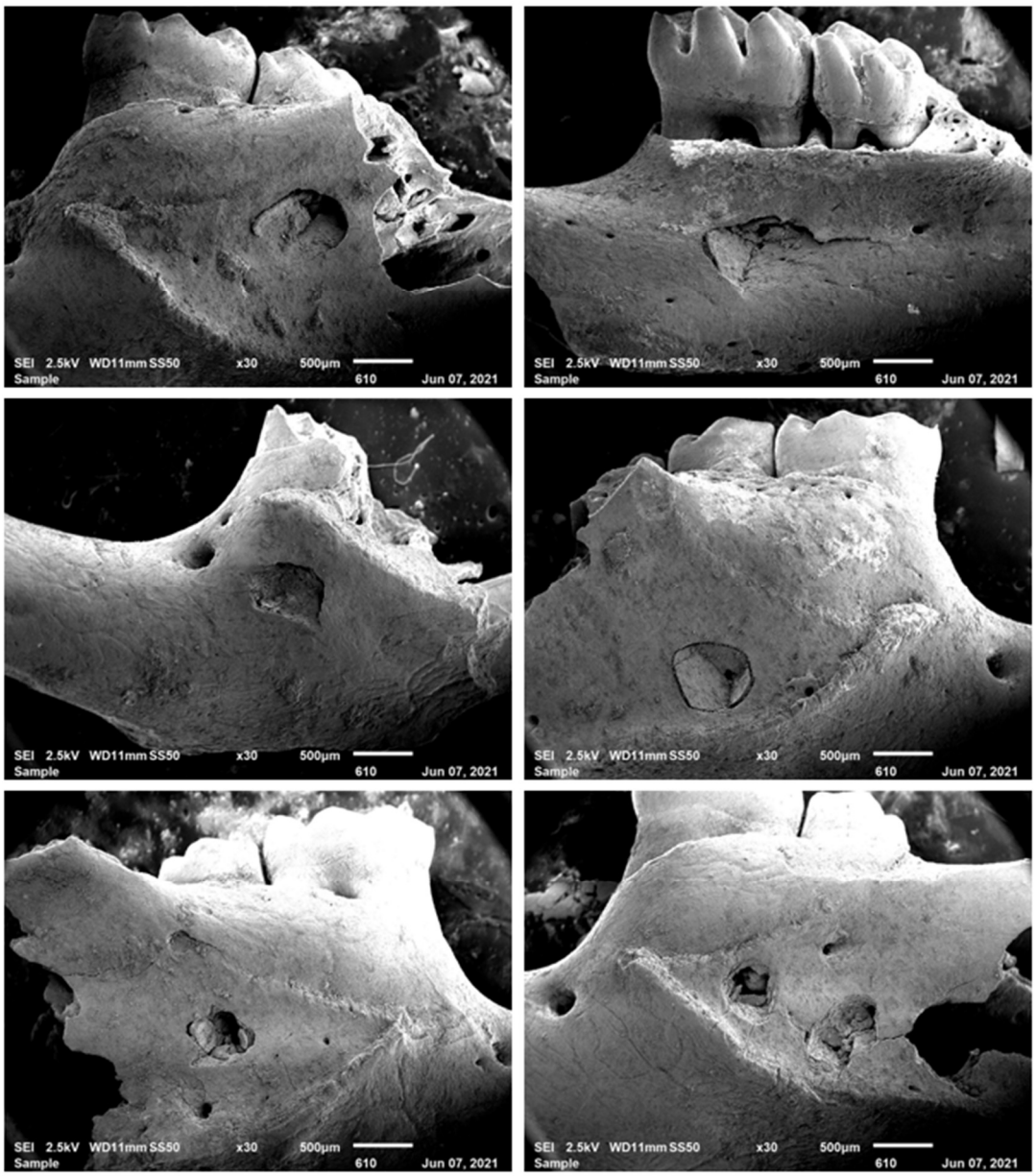

Figure 6.8 SEM micrographs of mandibles from (32632) displaying isolated and multiple puncture marks

Measurements of individual puncture marks were taken using the SEM, and can be found in Table 6.17. Where there were multiple puncture marks no measurements of the distance between them were taken, however this is an avenue for further analysis.

Table 6.17 Measurements of gnaw marks taken on a selection of elements from Çatalhöyük.

Contex	Element	Gnaw marks	
		Width	Length
32616	Humerus	0.25 mm	0.28 mm
32616	Humerus	0.56 mm	0.42 mm
32616	Humerus	0.38 mm	0.37 mm
32616	Humerus	0.15 mm	0.17 mm
32616	Humerus	0.36 mm	0.37 mm
32632	Mandible	0.74 mm	0.55 mm
32632	Mandible	0.60 mm	0.44 mm
32632	Mandible	0.68 mm	0.57 mm
32632	Mandible	0.58 mm	0.41 mm
32632	Mandible	0.37 mm	0.34 mm
19802	Femur	0.28 mm	0.27 mm
19802	Femur	0.25 mm	0.21 mm

6.1.10 Digestion

Digestion was observed on incisors and molars, both loose and *in-situ*, as well as on proximal femora and distal humeri only (Table 6.18). None of the non-murid molars showed evidence of digestion, although these were extremely limited in number.

Levels of digestion observed on teeth were generally low, with the average from the contexts with a NISP over 50 being 3.8% for incisors and 2.5% for molars. Humeri had the highest incidence of digestion (16.5%), and it was observed on 3.9% of the femora. The majority had light digestion damage, some had moderate damage and a few had heavy damage. No elements recorded extreme levels of digestion. SEM micrographs showing digested elements can be seen in Figure 6.9.

Table 6.18 Digestion categories for contexts with a NISP over 50 (amended from Feider and Jenkins 2021). Categories for digestion follow the methodology of Andrews 1990; Jenkins 2009; Fernandez-Jalvo and Andrews 1992; and Fernandez-Jalvo et al. 2016.

		Incisor		Molar		Humerus		Femur	
Context	Category	N	%	N	%	N	%	N	%
19802	Light	2	3.1	2	3	1	8.3	1	9.1
	Moderate					1	8.3		
	Heavy								
	Extreme								
21814	Light			2	40			1	20
	Moderate								
	Heavy								
	Extreme								
21842	Light	3	13.6	8	21.6	3	13		
	Moderate	1	4.5						
	Heavy								
	Extreme								
21849	Light	1	8.3	3	21.4	2	25		
	Moderate							1	14.3
	Heavy								
	Extreme								
32611	Light	20	11.8	15	7.9	14	17.3	1	1.4
	Moderate			2	1.1	2	2.5		
	Heavy								
	Extreme								
32616	Light	26	8	10	2.6	4	5.9		
	Moderate			3	0.8	7	10.3		
	Heavy			2	0.5				
	Extreme								
32632	Light	5	0.5	8	0.6	17	12.4	5	4.7
	Moderate	4	0.4			3	2.2	1	0.9
	Heavy					1	0.7		
	Extreme								
32782	Light							1	100
	Moderate								
	Heavy								
	Extreme								

Table 6.19 Percentage of digestion by context based on a combined NISP for the four element categories

Context	NISP				Total NISP	Digested NISP	% digested
	Incisor	Molar	Humerus	Femur			
19802	65	66	12	11	154	7	4.5
21814	12	5	3	5	25	3	12
21842	22	37	23	36	118	15	12.7
21849	12	14	8	7	41	7	17.1
32611	169	190	81	70	510	54	10.6
32616	326	380	68	49	823	52	6.3
32632	1021	1415	137	106	2679	44	1.6
32782	8	5	1	1	15	1	6.7
Element total	1635	2112	333	285	4365	183	
Digested NISP	62	55	55	11	183		
Digested %	3.8	2.6	16.5	3.9	4.1		

Levels of digestion for the contexts with a NISP exceeding 50 (Table 6.19), ranged from 1.6% to 17.1%. These variations may have been due to the limited sample sizes in several of these contexts, although (32611) is of considerable size, with a total NISP of 1137, of which loose and *in-situ* incisors and molars, humeri, and femora account for 511, with a context digestion level at 10.6%.

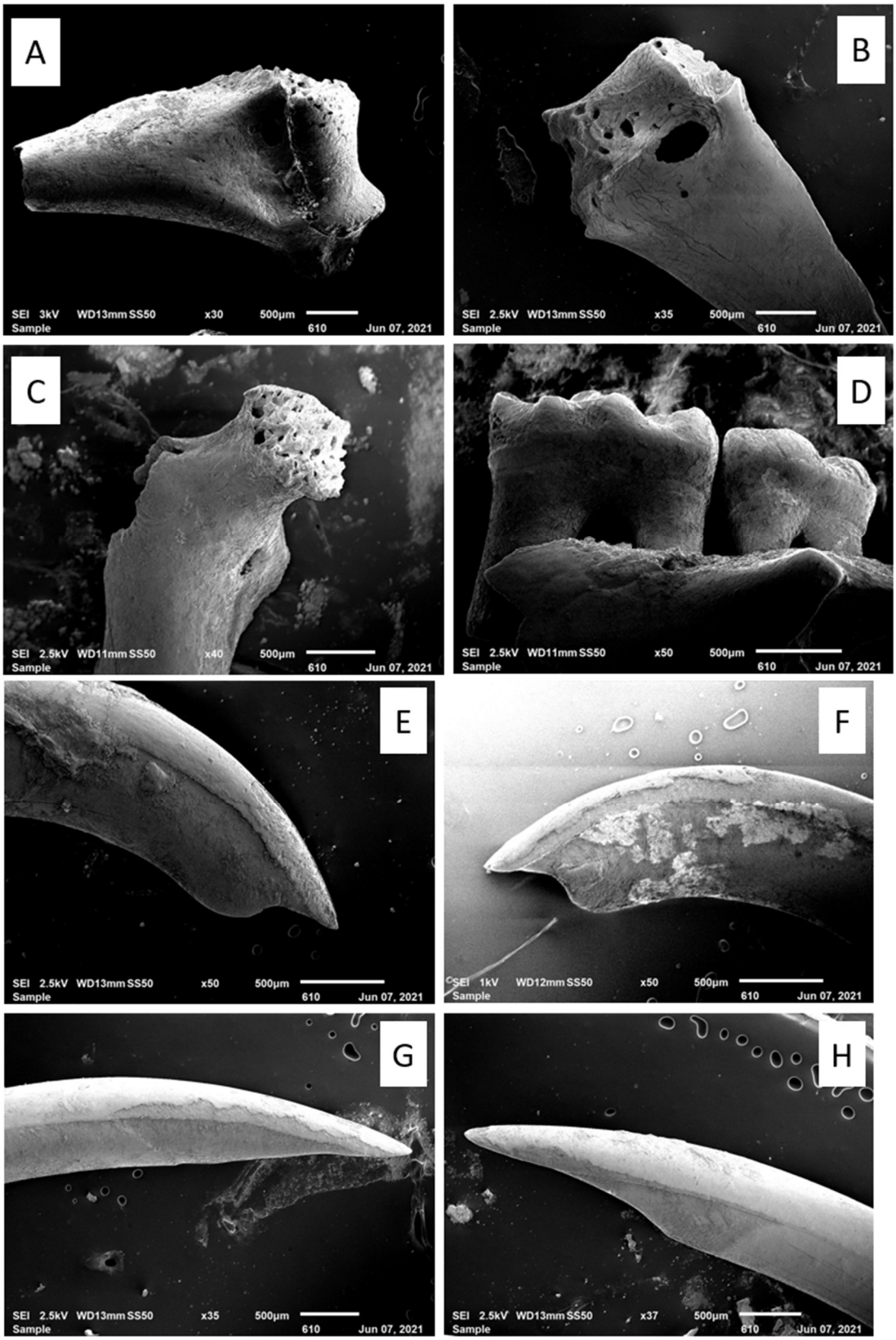

Figure 6.9 SEM micrographs showing digested elements from Çatalhöyük. A: humerus with light digestion, B: humerus with moderate digestion, C: proximal femur with moderate digestion, D mandibular molars with light digestion: , E:maxillary incisor with light digestion, F: maxillary incisor with moderate digestion, G: mandibular incisor with light digestion; H: mandibular incisor with light digestion

6.1.11 Skeletal Anomalies

Twenty-five maxillary first molars (M1) of *Mus musculus domesticus* at Çatalhöyük were recorded as having anomalies on the buccal aspect of the tooth (Figures 6.10 to 6.13). This consisted of an additional enamel 'pillar' or cusplet in the majority of cases. However, five specimens actually exhibited supernumerary, or paramolar teeth, or the alveolar space for one. This phenomenon was noted in three separate contexts (32611), (32616), and (32632), all within Building 161. Further analysis of these teeth, and the implications for their restricted range at Çatalhöyük, is currently being undertaken in association with Dr Sabrina Renaud, Laboratoire de Biométrie et Biologie Evolutive, Université Lyon.

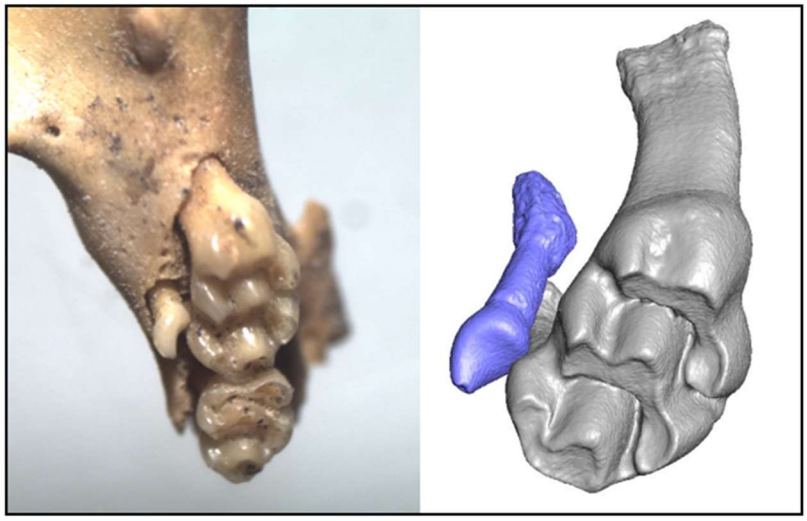

Figure 6.10 Paramolar tooth on specimen from context 32632. (Micro-CT scan courtesy of Dr Sabrina Renaud)

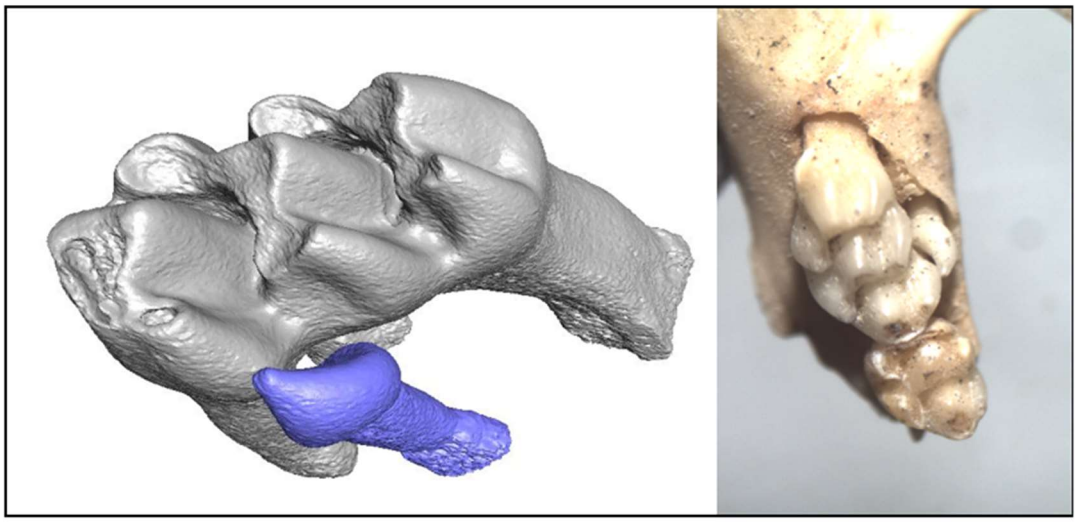

Figure 6.11 Paramolar tooth on specimen from context 32632. (Micro-CT scan courtesy of Dr Sabrina Renaud)

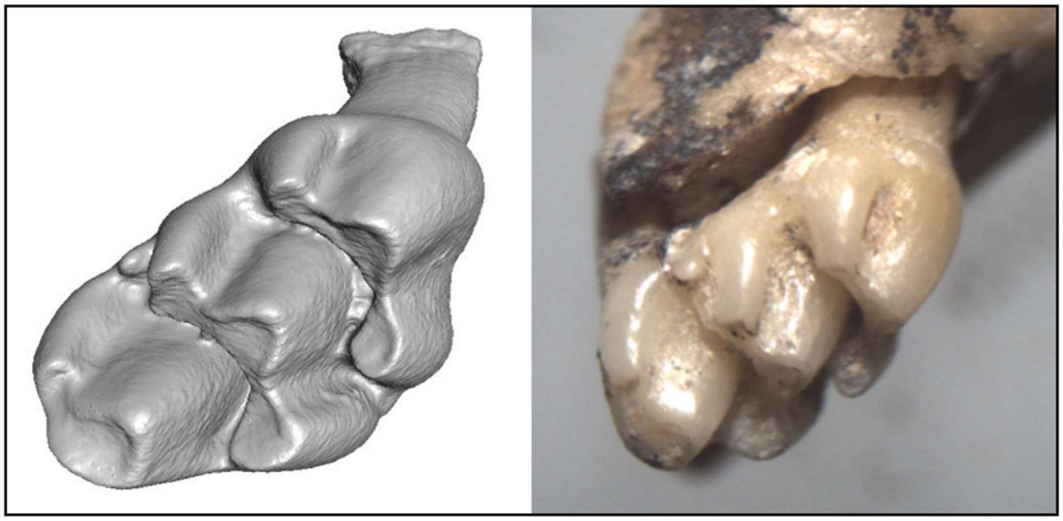

Figure 6.12 Cusplet on specimen from context 32632. (Micro-CT scan courtesy of Dr Sabrina Renaud)

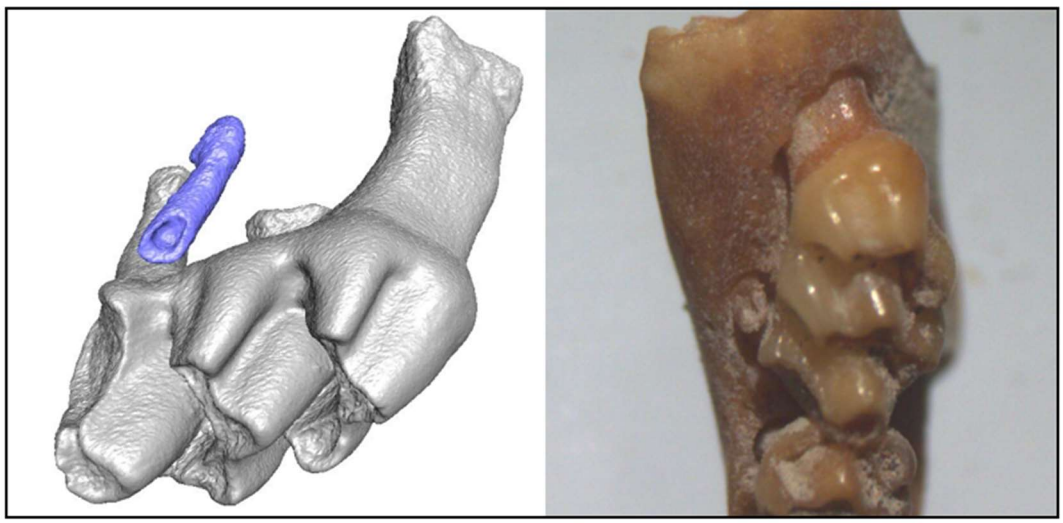

Figure 6.13 Root of paramolar tooth on specimen from context 32611. (Micro-CT scan courtesy of Dr Sabrina Renaud)

6.2 Boncuklu

6.2.1 Site Details

A total of 4215 specimens were recovered from 31 contexts excavated at Boncuklu, from three different areas; Area H, Area K, and Area M. Details of the interpretive category for each context, as well as phasing data can be found in Table 6.20, with the site dated to 8300-7800 cal. BCE.

Features in Area H were a mix of buildings and middens, and 10 contexts from this area were analysed. Area K was composed of a sequence of six consecutive buildings, one on top of the other, with a total of 14 contexts recorded from this area. Area M contained more varied features, and consisted of a single 'conventional' building, as well as non-standard structures. The area mostly represented outside space, and was made up of midden deposits, as well as fire pits and cooking areas. Seven contexts from this area were recorded.

Table 6.20 Site details for Boncuklu

Context	Interpretive Category	Building	Feature	Area	Phase	Brief Description
HBG	Midden			H	H.X	Spit through midden deposits along southwest of trench, below HAU
HEJ	Floor/Surface	4		H	H.II	Spit of laminate surfaces, dirty area of Building 4
HFG	Midden	5		H	H.V	Spit across area against south wall Building 5
HFO	Floor contact	5		H	H.V	Occupational layer directly above floor of Building 5, southeast area
HFW	Midden	5		H	H.V	Midden deposit spit inside building 5
HGG	Pit fill	4	58	H	H.II	First fill of pit cut HGH, F58
HJW	Arbitrary spit			H	H.V	Spit to south of HST
HLD	Structural debris	4		H	H.II	Upper compact building rubble fill of building 4
KAJ	Floor contact	7		K	K.V	Deposit on top of floor KAK
KAN	Structural debris	1		K	K.II	Building collapse debris overlying floor KAD, equivalent to KAR
KAR	Structural debris	1		K	K.II	Building collapse debris overlying floor KAD, equivalent to KAN
KAZ	Post fill	3	4	K	K.IV	Fill of Feature 4 (cut is KBA)
KBB	Structural debris	1		K	K.II	Structural debris and collapse in interior of Building 1, equivalent to KAR and KAN, overlying KAD
KDD	Hearth fill	3	10	K	K.IV	Burnt ashy fill in F44 hearth, below KCA (ASSIGNED 2007, EXCAVATED 2008)
KGV	Floor/Surface	3		K	K.IV	Plaster plug of great depression, below KFN, above KHA
KJI	Floor/Surface	1		K	K.III	Plaster floor under inner, later wall row, abutting earlier southwest wall, equivalent to KFN
KRK	Hearth fill	9		K	K.VI	Hearth fill
KWA	Surface makeup in dirty area	9		K	K.VI	Surface in central part space 1 "high part" of space 1, dirty floor area, below KVI, KVM
KWT	Surface makeup in dirty area	9		K	K.VI	Thick plaster surface, possibly packing or levelling material, it is part space 1, dirty floor area, below (KWS).
KWV	Levelling fill	2		K	K.VII	Lowest part of NE. quadrant make up. Levelling of Building 9, below KWR
MAL	Midden			M	M.V	Layer below MAD, east side midden lump
MCW	Midden			M	M.II	Arbitary spit through midden deposits at northeast corner of trench
MCX	Structural debris			M	M.II	Compact, plastery material
MDC	Midden			M	M.II	Arbitary spit through midden deposits at north end of 2007 trench extension
MDJ	Ash/ Charcoal			M	M.VII	Thin blue grey ashy lense, below MDD
MEO	Fill of vessel		F.21	M	M.VII	Fill from within plaster object MEN
MNZ	Midden			M	M.IX	Midden deposit
ZHH	Burial	14		H	H.VII	Fill of G15 ZHK
ZHI	Burial	14	113	H	H.VII	Lower fill of grave 15 ZHK
ZKJ	Burial	3	42	K	K.IV	Fill of Burial 10 (infant, cut is ZKL), west end of southwest Building 3 wall cut
ZKM	Burial	9		K	K.VI	Fill of Burial 12

6.2.2 Number of Identified Specimens (NISP)

The Number of Identified Specimens (NISP) for each context, and NISP per litre can be found in Table 6.21, with a breakdown by taxa for each context, including totals, can be found in Table 6.22.

Fifteen contexts had a NISP greater than 50 and represented all three areas. The contexts were HBG, HFG, HFW, MAL, and MNZ which were all midden deposits; as well as HEJ a floor surface; KAJ a floor contact; HGG a pit fill; HJW an arbitrary spit; KWV a levelling fill; MDJ an ash/charcoal deposit; and HLD, KAR, KBB, and MCX which were all structural debris deposits.

Table 6.21 Number of Identified Specimens (NISP) by context, including corrected NISP and NISP per litre for context comparison.

Context	Flot Number	Sample Number	NISP	% samples (HR)	Corrected NISP	Sample Volume (L)	Nisp per litre
HBG	8005	39	40	100	40	21	
HBG	8020	39	101	100	101	25	
HBG	8044	714	64	100	64	35	
HBG	8055	714	33	100	33	32	
HBG	8057	714	107	100	107	30	
HBG					345	143	2.4
HEJ	10009	49	82	100	82	30	
HEJ	9025	821	52	100	52	45	
HEJ					134	75	1.8
HFG	9043	832	77	100	77	18	
HFG	9163	832	146	100	146	40	
HFG					223	58	3.8
HFO	9046	845	22	100	22	7	3.1
HFW	10042	504	18	100	18	29	
HFW	10043	504	142	100	142	28	
HFW	10097	971	85	100	85	21	
HFW	10104	971	127	100	127	38	
HFW	10114	971	112	100	112	26	
HFW					484	142	3.4
HGG	9038	842	138	100	138	48	2.9
HJW	10089	511	187	100	187	33	5.7
HLD	10084	516	45	100	45	22	
HLD	10087	516	20	100	20	13	
HLD	10094	511	40	100	40	33	
HLD					105	149	0.7
KAJ	6002	11	99	100	99	8	
KAJ	6015	9	218	100	218	10	
KAJ	6055	25	63	100	63	1.5	
KAJ					380	19.5	19.5
KAN	6031	29	14	100	14	10	
KAN	6034	28	12	100	12	7	
KAN	6037	27	12	100	12	12	
KAN					38	29	1.3
KAR	6030	30	7	100	7	12	
KAR	6033	34	8	100	8	8	
KAR	6036	32	8	100	8	12	
KAR	6072	31	24	100	24	12	
KAR	6073	33	23	100	23	11	
KAR					70	55	1.2
KAZ	6070	158	9	100	9	5	
KAZ	6071	157	12	100	12	9	
KAZ					21	14	1.4

Context	Flot Number	Sample Number	NISP	% samples (HR)	Corrected NISP	Sample Volume (L)	Nisp per litre
KBB	6081	162	10	100	10	10	
KBB	6083	161	16	100	16	12	
KBB	7001	160	24	100	24	12	
KBB					50	34	1.5
KDD	8052	767	21	100	21	15	1.4
KGV	9065	298	13	100	13	10	1.3
KJI	9074	666	7	100	7	4	1.8
KRK	9162	915	35	100	35	17	2.1
KWA	10120	1130	3	100	3	4	0.8
KWT	10119	1147	10	100	10	5	2
KWV	10116	1148	50	100	50	19	2.6
MAL	6044	94	354	100	354	14	
MAL	6045	93	230	100	230	16	
MAL	6046	104	173	100	173	15	
MAL	6047	105	278	100	278	16	
MAL	7051	92	259	100	259	15	
MAL					1294	76	17
MCW	7019	5	2	100	2	9	
MCW	7036	306	24	100	24	19	
MCW					26	28	0.9
MCX	7002	17	28	100	28	11	
MCX	7018	17	32	100	32	11	
MCX	8012	320	71	100	71	15	
MCX	9125	326	46	100	46	18	
MCX					177	55	3.2
MDC	7022	6	1	100	1	22	
MDC	7028	11	41	100	41	24	
MDC					42	46	0.9
MDJ	8065	321	99	100	99	10	9.9
MEO	10021	327	23	100	23	1	23
MNZ	12093	725	90	100	90	109	
MNZ	12448	2084	35	100	35	83	
MNZ					125	192	0.7
ZHH	10188	1235	6	100	6	15	
ZHH	10189	1235	6	100	6	15	
ZHH	10190	1235	3	100	3	12	
ZHH	10191	1235	10	100	10	16	
ZHH					25	58	0.4
ZHI	10184	1239	11	100	11	14	
ZHI	10186	1239	15	100	15	12	
ZHI	10187	1239	8	100	8	13	
ZHI					34	39	0.9
ZKJ	9136	756	12	100	12	20	0.6
ZKM	9138	900	22	100	22	119	0.2

Table 6.22 Number of Identified Specimens (NISP) by taxa and context at Boncuklu.

	Anura	*Pelophylax sp.*	*Pelophylax ridibundus*	*Bufo viridis*	Toad	Rodent	*Arvicola amphibius*	Arvicolinae	*Microtus guentheri*	*Mus sp.*	*Crocidura suaveolens*	*Erinaceus concolor*	Micro-mammal	Snake	Microfauna	Total NISP
HBG	189	8				25	21						2	100		**345**
HEJ	91	12				3	5						3	20		**134**
HFG	147	7				6	6	2					2	53		**223**
HFO	20													2		**22**
HFW	344	20			1	11	10						1	97		**484**
HGG	108	9				3	13							2	3	**138**
HJW	136	8			2	12	11			1			8	8	1	**187**
HLD	84	2		1	2	10	2						4			**105**
KAJ	216	1				12	8	1					7	134	1	**380**
KAN	30	2											0	6		**38**
KAR	50	7	1			2				1			3	6		**70**
KAZ	14	0				2							0	5		**21**
KBB	39	6					2							3		**50**
KDD	11	1				1	1						0	7		**21**
KGV	10	2					1						0			**13**
KJI	7															**7**
KRK	25					2	2	1					1	4		**35**
KWA	3															**3**
KWT	8	2														**10**
KWV	36	4				1	1			1			1	6		**50**
MAL	977	39	1		2	64	91	18	1		3		36	58	4	**1294**
MCW	20						2							4		**26**
MCX	123	13				10	20				1			10		**177**
MDC	29	5			1	1	4						1	1		**42**
MDJ	70	3	2		1	7	9	2						2	3	**99**
MEO	13	1											2	7		**23**
MNZ	23	1				10	54	4				1		32		**125**
ZHH	20	1				2	2									**25**
ZHI	26	5				1				2						**34**
ZKJ	7													5		**12**
ZKM	16	1				4	1									**22**
Site total	2892	160	4	1	9	189	266	28	1	5	4	1	71	572	12	**4215**

6.2.3 Species Composition

The assemblage is dominated by anura (Figure 6.14), accounting for 72.7% of the assemblage. Snake is the second most represented taxon, although their bones could not be assigned to species; they accounted for 13.6% of the assemblage. Rodents (including all specimens identified as rodents, and those identified to rodent species) comprise 11.6% of the whole assemblage, with insectivores, micromammals, and the more ambiguous microfauna comprising the rest of the assemblage.

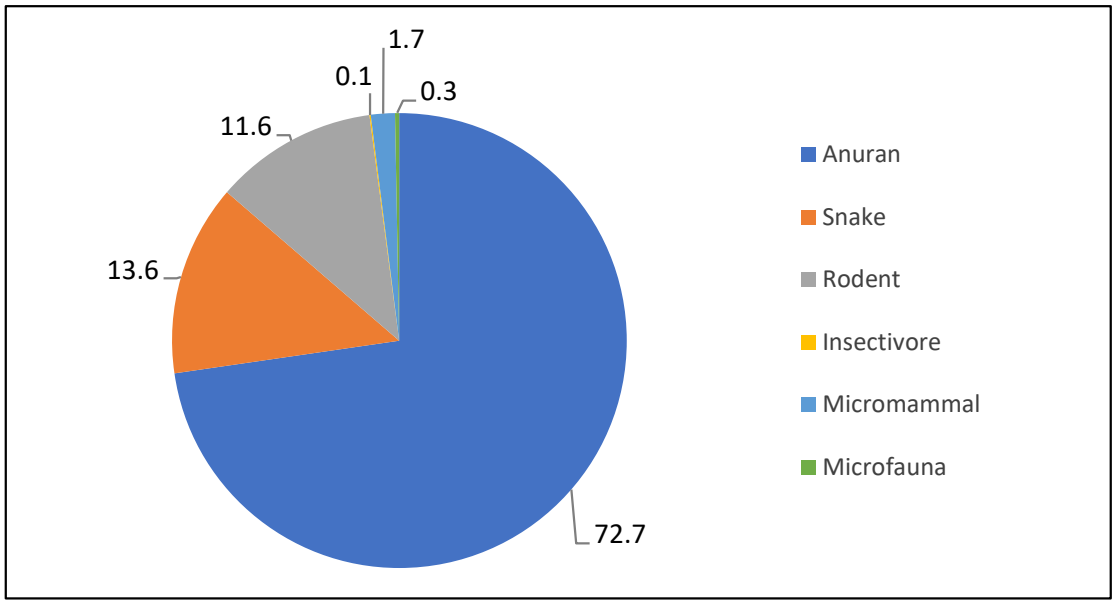

Figure 6.14 Higher taxonomic composition of whole assemblage at Boncuklu by percentage by NISP. N=4215

When higher taxonomic groupings were removed (Figure 6.15), specimens identified to species were dominated by rodents, with *Arvicola amphibius* comprising 55.5% of the assemblage. However, this is misleading as anura dominate the assemblage but the elements used to identify species require complete or mostly complete specimens meaning that they are under-represented in the species list. *Pelophylax* sp. comprised 33.4% of the assemblage, with the other species present in low numbers.

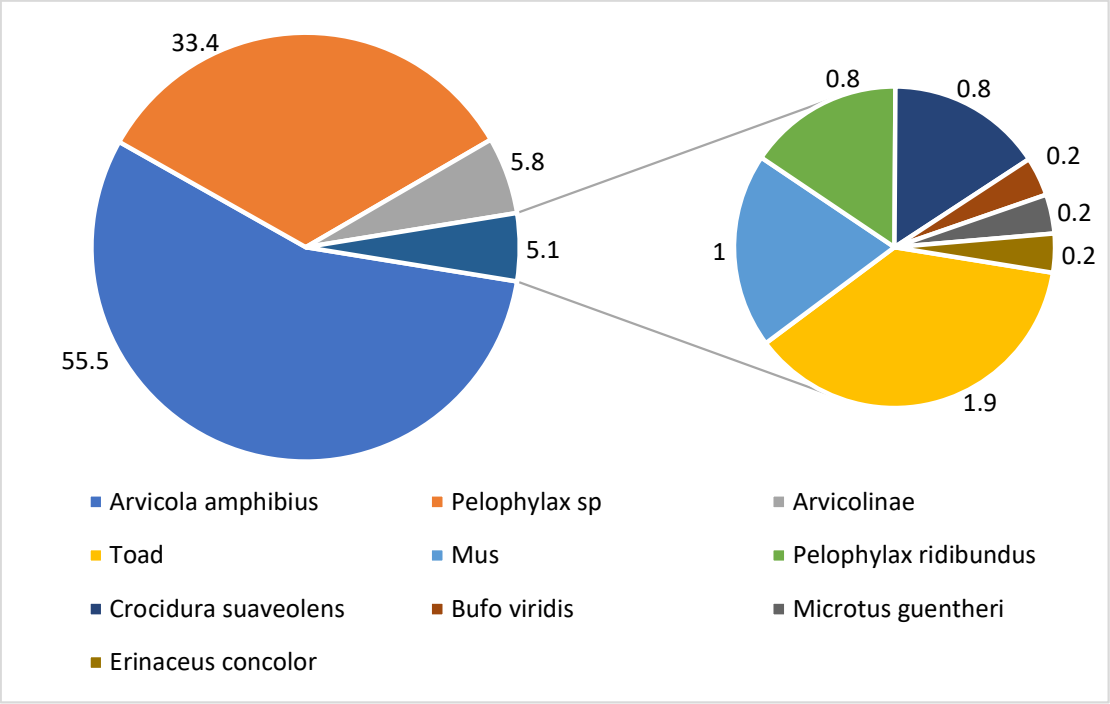

Figure 6.15 Taxonomic composition of identified genera or species by NISP. N=479.

Taxa were also analysed by phase for each area to identify whether there are any patterns to taxa distribution. NISP by phase can be found in Table 6.23.

Table 6.23 NISP by phase for Areas H, K, and M at Boncuklu.

Area H Phase	Total NISP	Area K Phase	Total NISP	Area M Phase	Total NISP
H.II	243	K.II	158	M.II	245
H.III	863	K.III	7	M.V	1294
H.IV	345	K.IV	67	M.VII	122
H.V	187	K.V	380	M.IX	125
H.VII	59	K.VI	70		
K.II	158	K.VII	50		

All taxa by phase were examined (Figure 6.16) and, with the exception of phase M.IX, anura dominate all phases in all areas of the site.

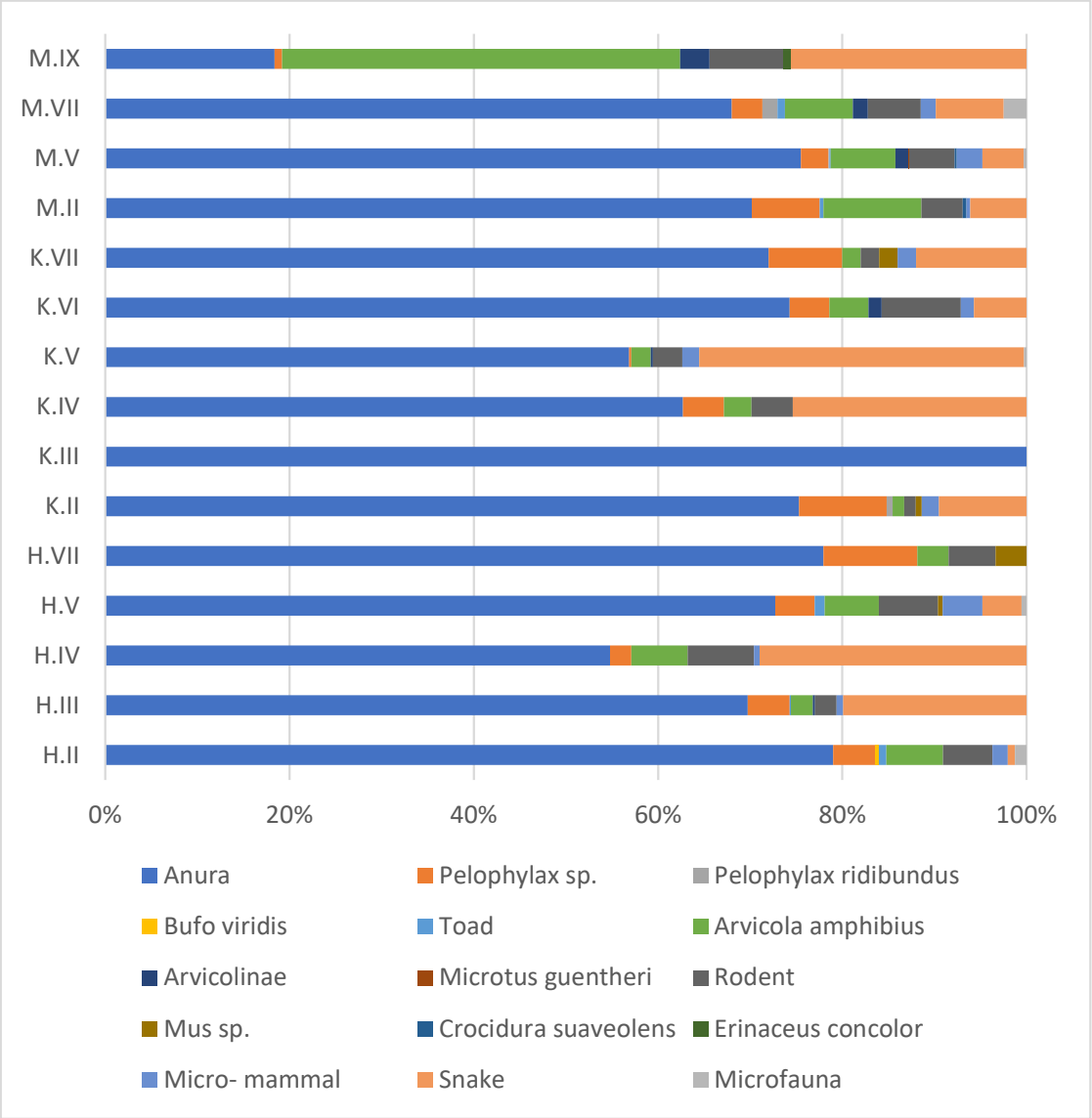

Figure 6.16 Taxa by phase at Boncuklu (Key reads left to right).

Higher taxonomic groups were also analysed by phase. As previously noted, all phases in Area H were dominated by anura (Figure 6.17). Very few snake specimens were recovered from phase H.II, with numbers increasing through phases H.III and H.IV. Fewer snakes were recorded in phase H.V, with none in H.VII. Rodents were recovered in all phases, with numbers relatively constant, except for phase H.III, in which numbers were low. No specimens of insectivores were recovered in any phase for Area H.

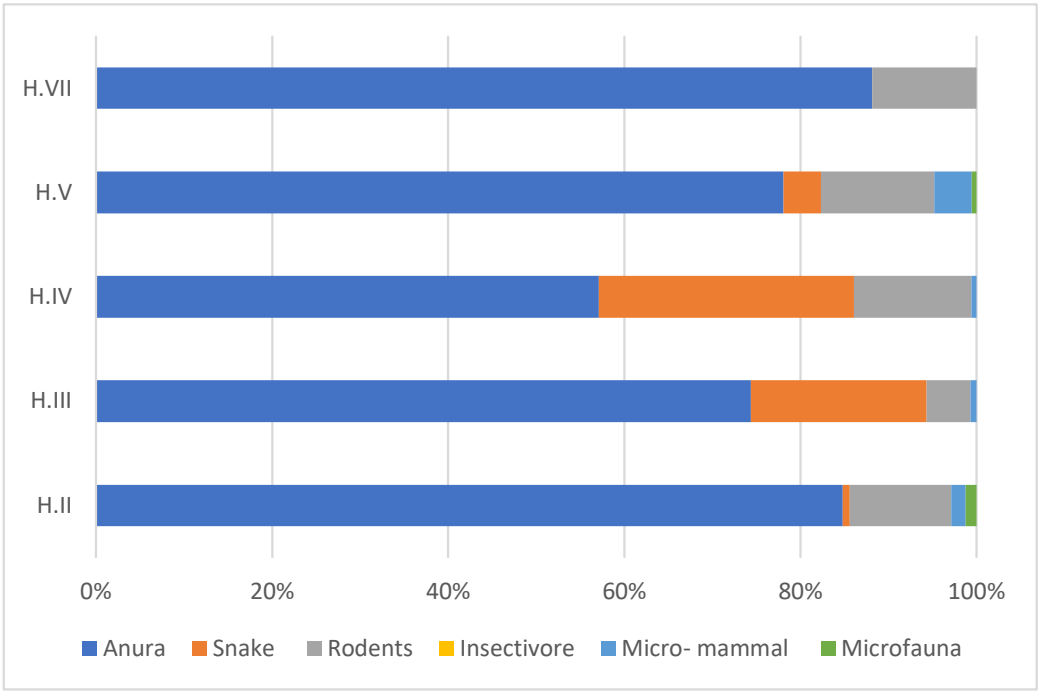

Figure 6.17 Higher taxonomic groups by phase for Area H

Taxa in Area K (Figure 6.18) were again dominated by anura. Phase K.III contained no other species, and phases K.IV and K.V had higher numbers of snake than other phases in this Area. Rodents were present in all phases, apart from K.III, and no insectivores were recorded in any phase in this Area.

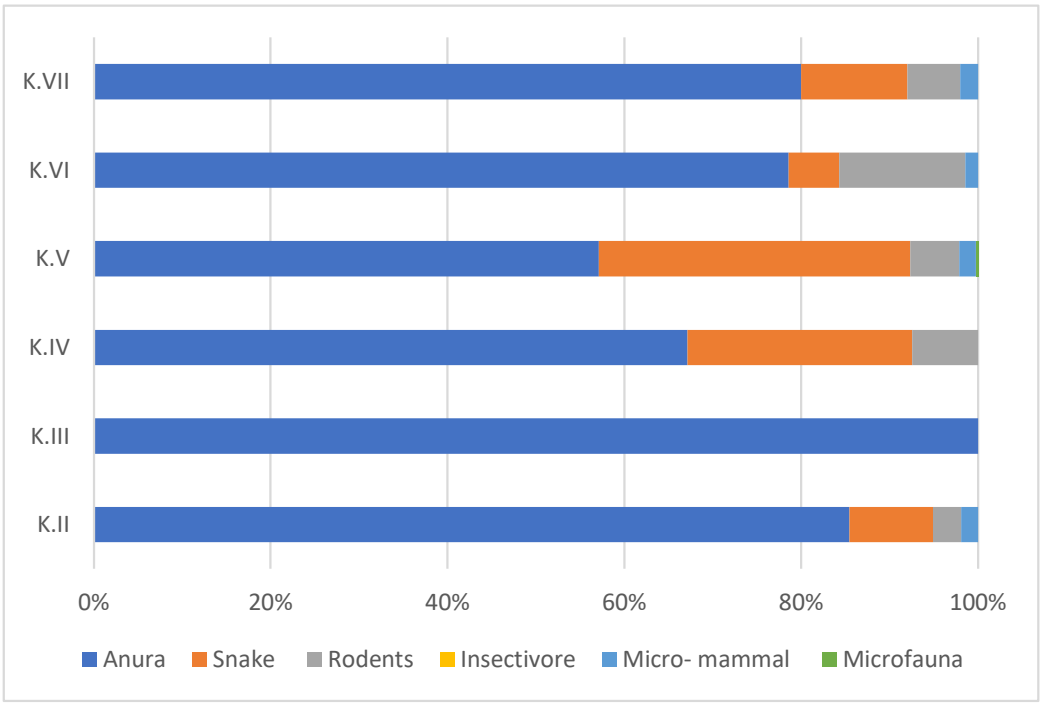

Figure 6.18 Higher taxonomic groups by phase for Area K

Taxa in Area M (Figure 6.19) were more variable, with anura dominating all phases with the exception of phase M.IX. Insectivores and rodents were present in all phases, with the latter taxa dominating phase M.IX. Snakes were also found in higher numbers in this phase, in comparison to other phases in this Area.

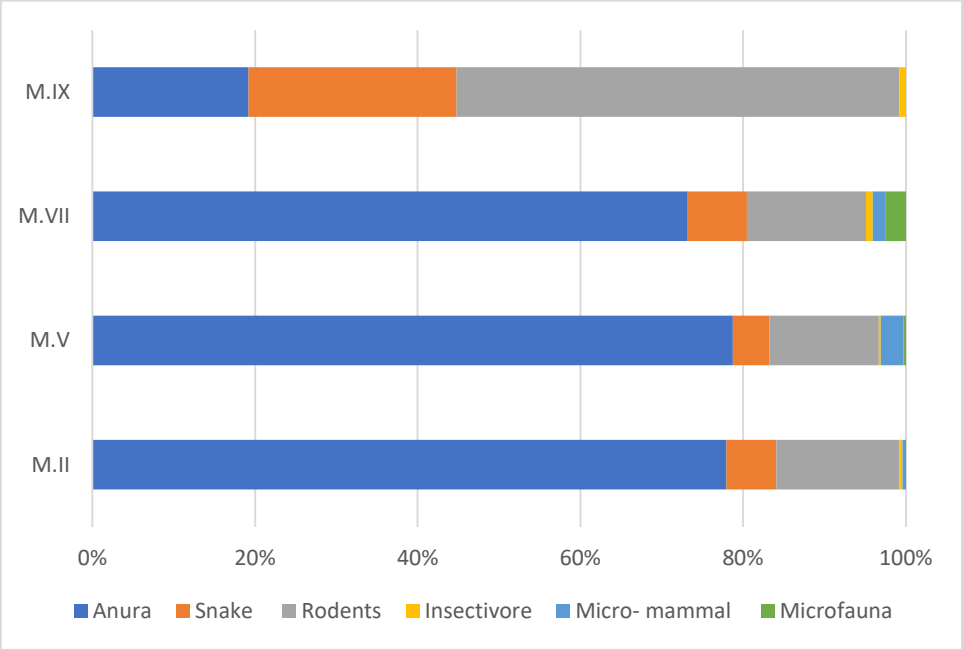

Figure 6.19 Higher taxonomic groups by phase for Area M

6.2.4 Microfauna by context interpretive category

Fill. In total 10 out of the 31 contexts analysed were interpreted as fills. This included burial fills, the fill of a vessel, hearth fills, a levelling fill, a pit fill and a post fill. This category has an average adjusted NISP per litre of 1.1. Microfauna from this category include anura, *Pelophylax* sp., *Arvicola amphibius*, arvicolinae, rodents, *Mus* sp., micromammals, snake, and specimens categorised as microfauna.

The *burial fill* sub-category consisted of four contexts; ZHH, ZHI, ZKJ, and ZKM, and had an average adjusted NISP per litre of 0.4. Taxa were again dominated by anura including *Pelophylax* sp., but the assemblage also included specimens identified to *A. amphibius*, rodent, *Mus* sp. and snake, all in much lower numbers than anura.

The *fill of a vessel*, context MEO, was again dominated by anura, with other specimens limited to micromammal and snake. This fill sub-category had a very high average adjusted NISP per litre of 23.

Two contexts were identified as *hearth fills*; KDD and KRK. This sub-category had an average adjusted NISP per litre of 1.8. Species represented in this sub-category included anura, with the highest NISP, as well as *Pelophylax* sp., *A. amphibius*, arvicolinae, rodent, micromammal, and snake

The *levelling fill* sub-category was also represented by a single context; KWV, which had an average adjusted NISP per litre of 2.6. The taxa were represented predominantly by anura, including *Pelophylax* sp., as well as *A. amphibius*, rodents, including *Mus* sp., micromammal, and snake.

The *pit fill* and *post fill* sub-categories were also represented by a single context each; HGG a pit fill, and KAZ a post fill. They had an average adjusted NISP per litre of 2.9 and 1.4 respectively. Taxa in the pit fill was dominated by anura including *Pelophylax* sp., but also *A. amphibius*, rodent, snake, and specimens only identified as microfauna. Taxa in post fill were represented by anura, rodent, and snake only.

Middens. Seven contexts were identified as midden deposits (HBG, HFG, HFW, MAL, MCW, MDC, and MNZ). Middens produced the largest microfaunal assemblage of all interpretive categories, with a NISP of 2,539, and an average adjusted NISP per litre of 3.7. This category also contained the highest number of taxa. Whilst still dominated by anura, the taxa in this category also included *Pelophylax* sp., *Pelophylax ridibundus,* toad, *A.amphibius*, arvicolinae, *Microtus guentheri*, rodent, *Crocidura suaveolens*, *Erinaceus concolor*, micromammal, snake, and specimens identified to microfauna.

Structural debris. Five contexts were analysed; HLD, KAN, KAR, KBB, and MCX. This category had an average adjusted NISP per litre of 1.4. Taxa were represented predominantly by anura, but also included *Pelophylax* sp., *P. ridibundus*, *Bufo viridis*, toad, *A. amphibius*, rodent, *C. suaveolens*, micromammal, and snake.

Floors. This category comprised two sub-categories; a floor surface, with three contexts, and floor contact, with two contexts. Floor surfaces contained contexts HEJ, KGV, and KJI, and had an average adjusted NISP per litre of 1.7. The floor surface sub-category taxa were comprised of anura, *Pelophylax* sp., *A. amphibius*, rodent, micromammal, and snake. The floor contact sub-category contained contexts HFO, and

KAJ, and had an average adjusted NISP per litre of 15.2. Taxa represented consisted of anura, *Pelophylax* sp., *A. amphibius*, arvicolinae, rodent, micromammal, snake, and specimens identified as microfauna.

Surface make-up in dirty area. This category was represented by two contexts; KWA, and KWT, and had an average adjusted NISP per litre of 1.4. Only 13 specimens were recorded, with only anura and *Pelophylax* sp. identified.

Arbitrary spit. This category contained a single context; HJW, which produced an average adjusted NISP per litre of 5.7. Taxa analysed in this category included anura, *Pelophylax* sp., toad, *A. amphibius*, rodent, including *Mus* sp., micromammal, snake, and specimens identified as microfauna.

Ash/Charcoal. This category was also represented by a single context; MDJ and had an average adjusted NISP per litre of 9.9. Taxa included anura, *Pelophylax* sp., *P. ridibundus,* toad, *A. amphibius*, arvicolinae, rodent, snake, and specimens identified as microfauna.

Data was also tabulated for all categories and sub-categories to explore the difference between context NISP and adjusted NISP per litre. Figure 6.20 shows category data by NISP, with Figure 6.21 showing the same categories and sub-categories with numbers based on adjusted NISP per litre.

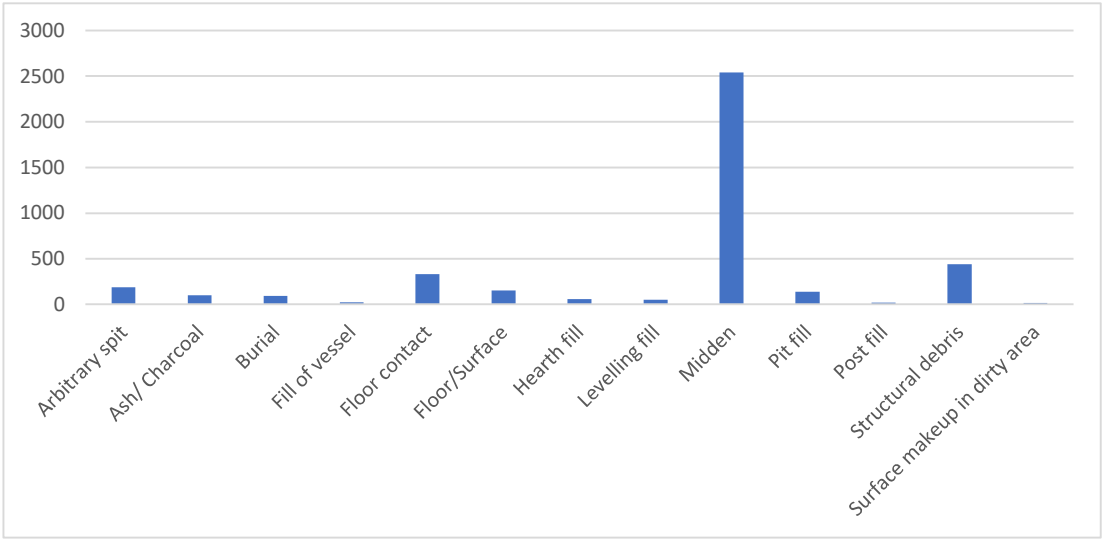

Figure 6.20 Context category by NISP at Boncuklu

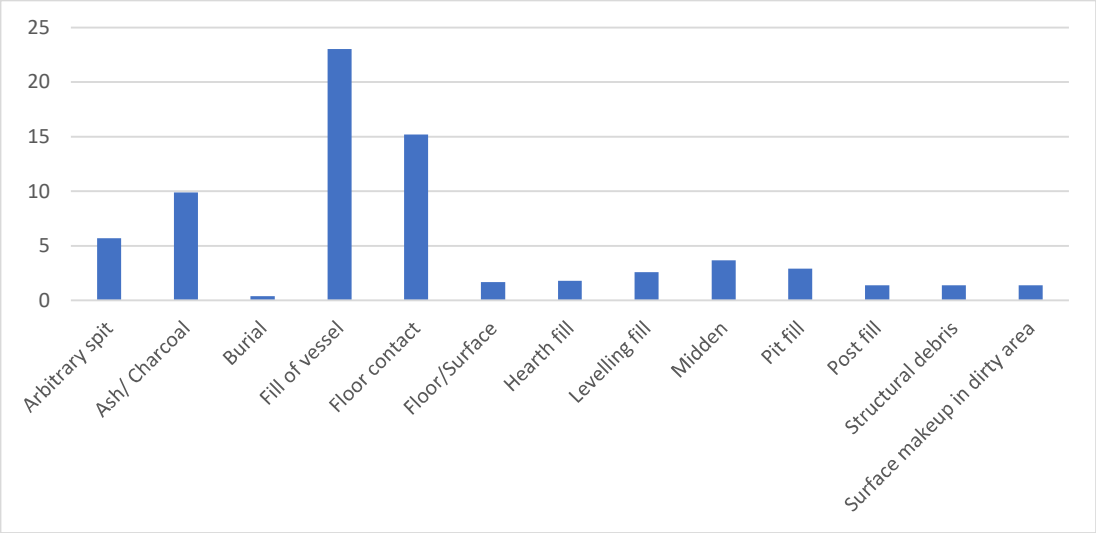

Figure 6.21 Context category by average adjusted NISP per litre at Boncuklu.

6.2.5 Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI)

Minimum Numbers of Elements (MNE) were calculated for all higher taxonomic groups and species by context, with 'micromammal, and 'microfauna' excluded, as several species could be represented within these general categories. Anura MNE calculations were limited to elements for which 'zones' were recorded (see Chapter 5), but excluded mandibles and maxilla due to the highly fragmentary nature of these elements. Skull elements were also taken into account as they were used for species determination.

Minimum Number of Individuals (MNI) was then calculated using the highest MNE for each species by context (Table 6.24). MNIs for species represented by low NISP may be over inflated, but are included in Table 6.27 to illustrate contexts from which these species were recovered.

Table 6.24 Minimum Number of Individuals (MNI) for Boncuklu

Context	NISP	Anuran	*Pelophylax sp.*	*Pelophylax ridibundus*	Toad	*Bufo viridis*	Rodent	*Arvicola amphibius*	Arvicolinae	*Microtus guentheri*	*Mus sp.*	*Crocidura suaveolens*	*Erinaceus concolor*	Snake
HBG	345	17	3				3	6						1
HEJ	134	13	4				1	2						1
HFG	223	14	3				1	3	2					1
HFO	22	3												1
HFW	484	40	5		1		3	1						1
HGG	138	10	3				1	4						1
HJW	187	12	3		1		2	3			1			1
HLD	105	9	1		2	1	2	1						
KAJ	380	11	1				1	1	1					1
KAN	38	4	1											1
KAR	70	4	3	1			1				1			1
KAZ	21	2					1							1
KBB	50	4	2					1						1
KDD	21	2	1				1	1						1
KGV	13	2	2					1						
KJI	7	1												
KRK	35	2					1	1	1					1
KWA	3	1												
KWT	10	2	1											
KWV	50	5	2				1	1			1			1
MAL	1294	51	13	1	2		3	7	4	1		1		1
MCW	26	3						1						1
MCX	177	7	4				2	3				1		1
MDC	42	4	4		1		1	2						1
MDJ	99	4	1	1	1			1	1					1
MEO	23	1	1											1
MNZ	125	5	1				3	8	4				1	1
ZHH	25	2	1				1	1						
ZHI	34	2	3				1				1			
ZKJ	12	1												1
ZKM	22	2	1					1						

6.2.6 Body Part Representation and Element Frequency

Body part representation was calculated for all contexts with a species and higher taxonomic MNI over 10. As with the methodology for Çatalhöyük, calculations were based on MNEs for major cranial and post-cranial elements that were then grouped into categories based on skeletal location.

As only anura had MNIs greater than 10, with the exception of *Pelophylax* sp. in context MAL, body part representation has only been calculated for this taxonomic group (Figure 6.22).

The expected percentage on the graph shows the distribution we would expect if complete animals had been incorporated into and recovered from the assemblage. All contexts analysed show a hindlimb bias. The forelimbs were the next most common

category, with the exception of context HFG, where the axial skeleton was better represented. For all contexts, the cranial body part category was under-represented. The axial category did match the expected frequencies for contexts HFG and HFW but was under-represented in all others.

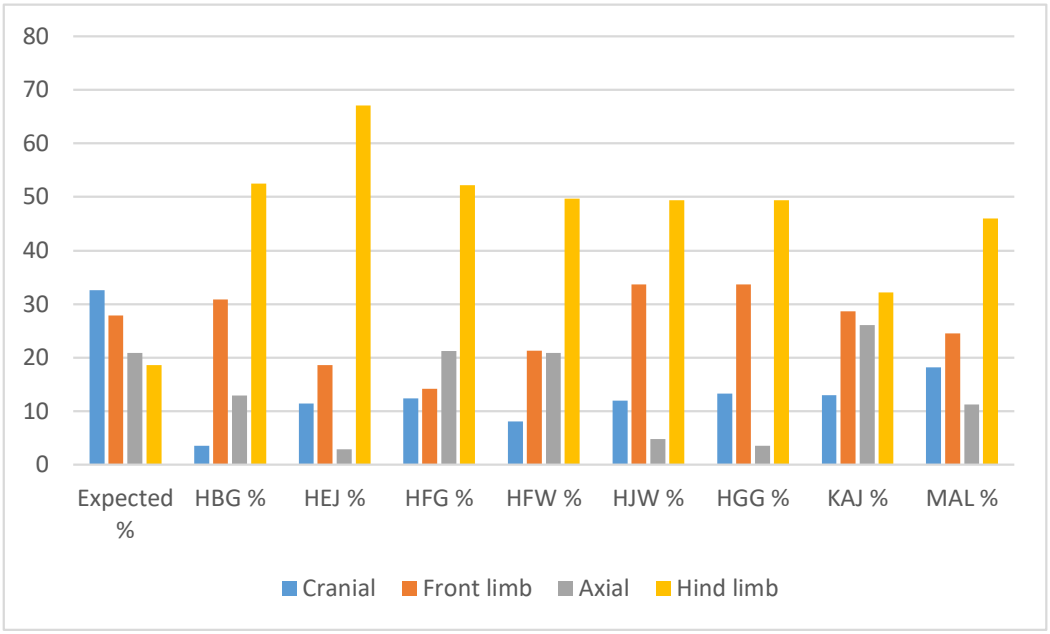

Figure 6.22 Body Part Representation for anura, for contexts with a MNI greater than 10 at Boncuklu.

Element frequency was calculated as a percentage for each element of observed against expected frequency, based on the MNI calculations for that species or taxonomic group. Again, only taxa with an MNI over 10 were analysed. Table 6.25 shows higher than expected percentages for sphenthmoid, humerus, urostyle, ilia, and tibio-fibula, with urostyle and ilia being very well represented, ranging from 45.5% to 100% and 70.8% to 100% respectively, however some of the contexts did have very small sample sizes.

Table 6.25 Percentage of element frequency for anura at Boncuklu based on observed over expected data for contexts with an MNI over 10.

Element	Skeletal frequency	HBG%	HEJ%	HFG%	HFW%	HJW%	HGG%	KAJ%	MAL%
Premaxilla	2				2.5	4.2		9.1	26.5
Frontoparietal	2			10.7	2.5	4.2	10	9.1	8.8
Parasphenoid	1			7.1		16.7			7.8
Sphenethmoid	1	5.9	15.4	35.7	30	16.7	60	63.6	19.6
Pterygoid	2	11.8		7.1	3.8	12.5		18.2	16.7
Scapula	2	17.6	19.2	7.1	10	4.2	15	27.3	7.8
Humerus	2	55.9	15.4	10.7	22.5	29.7	75	45.5	57.8
Radio-Ulna	2	8.8		10.7	3.8	45.8	5	27.3	19.6
Coracoid	2	26.5	11.5	10.7	28.8	4.2	25	18.2	11.8
Sacrum	1			35.7	30	8.3		27.3	29.4
Urostyle	1	100	61.5	71.4	60	100	70	45.5	52.9
Ilium	2	94.1	84.6	89.3	100	70.8	85	95.5	100
Ischium	1	5.9	7.7	7.1	5		10	27.3	5.9
Femur	2	11.8		14.3	12.5		5		1
Tibio-Fibula	2	47.1	38.5	57.1	30	41.7	65	31.8	36.3
Anura MNI		17	13	14	40	12	10	11	51

6.2.7 Fragmentation

Small mammals

Fragmentation was analysed to explore the nature of the assemblage as well as to aid in the identification of any predators that may have been responsible for assemblage accumulation. Post-cranial fragmentation includes both 'rodent' as well as 'microfauna' specimens and, due to the increase in species diversity at Boncuklu, may represent several different species within these taxonomic groupings.

The low numbers of micromammal species did not allow for an examination of fragmentation by context and so post-cranial fragmentation for the humerus, ulna, femur, tibia (Andrews 1990) were calculated for the whole assemblage. Insectivores were not included in this analysis, due to the low number of specimens. As at Çatalhöyük, fragmentation for these elements was recorded both for the portion of the element present (Table 6.26), as well as percentage completeness (Table 6.27). Rodent humeri were not well represented in the Boncuklu assemblage. The distal portion, shaft, and complete elements were present to the same percent, each at 30% of the assemblage, with the proximal portion under-represented at 10%. Rodent ulnae, despite being identifiable along nearly the entire length of the bone, were primarily represented by proximal fragments at 85.7%, with the other 14.3% being shaft fragments. All portions of femora were represented in the assemblage, with the majority being proximal fragments at 46.7%. Distal portions made up 26.7% of the fragmentation

assemblage, with the shaft and complete elements at 13.5% each. As stated above, tibiae, due to the unique shape of the bone, are identifiable along the entire length of the element. As such, it was the most identifiable, and hence, recorded of the post-cranial specimens. The shaft was the most represented, at 42.5% of specimens, with the distal end at 37.5%. Proximal portions made up 15%, with only 5% of elements complete.

Table 6.26 Post-cranial fragmentation in rodents, showing differential recovery of 'portions' of elements at Boncuklu.

Element	Rodent (Whole site)	
	N	%
Humerus		
Complete	3	30
Proximal	1	10
Shaft	3	30
Distal	3	30
Ulna		
Complete		
Proximal	6	85.7
Shaft	1	14.3
Distal		
Femur		
Complete	2	13.3
Proximal	7	46.7
Shaft	2	13.3
Distal	4	26.7
Tibia		
Complete	2	5
Proximal	6	15
Shaft	17	42.5
Distal	15	37.5

Rodent post-cranial fragmentation analysis by breakage category (Table 6.27) showed that three of the four elements were most frequently broken into the '1/3 to 2/3' category, with the exception of the femora, in which the 'less than 1/3' category was most prevalent.

Table 6.27 Rodent post-cranial fragmentation by percentage category

Element	Category	Rodent (Whole site)	
		N	%
Humerus	Less than 1/3	1	9.1
	1/3 - 2/3	6	54.5
	More than 2/3	1	9.1
	Complete	2	18.2
	Epiphysis	1	9.1
Ulna	Less than 1/3	1	14.3
	1/3 - 2/3	4	57.1
	More than 2/3	2	28.6
	Complete		
	Epiphysis		
Femur	Less than 1/3	6	40
	1/3 - 2/3	5	33.3
	More than 2/3		
	Complete	2	13.3
	Epiphysis	2	13.3
Tibia	Less than 1/3	10	25
	1/3 - 2/3	23	57.5
	More than 2/3	5	12.5
	Complete	2	5
	Epiphysis		

Maxillary and mandibular fragmentation for rodents includes all contexts, rather than just those with a NISP over 50, due to the limited number of these specimens recorded.

Maxillary breakage (Table 6.28) was exceptionally high with all maxillae recorded as highly fragmented. Due to the rodent assemblage being primarily comprised of arvicolins, rather than murins, maxillary breakage yielded more palate than maxilla fragments, due to the structure of the skull and teeth, which have large alveolar spaces which facilitate breakage along lines of weakness. Squamosal processes were also present, but for the majority of contexts these were in low numbers.

Table 6.28 Rodent maxillary breakage categories at Boncuklu.

Context	Complete, with zygomatic region		Broken with zygomatic intact		Maxilla fragment lacking the zygomatic process		Palate fragment		Squamosal process	
	N	%	N	%	N	%	N	%	N	%
HBG							3	100		
HEJ							2	66.7	1	33.3
HFG							2	100		
HFW							2	100		
HGG					1	33.3	2	66.7		
HJW							2	66.7	1	33.3
HLD							1	100		
ZHH							1	100		
KBB							1	100		
KDD									1	100
KWV									1	100
MAL							11	73.3	4	26.7
MCX					1	25	3	75		
MDC							2	100		
MDJ							1	100		
MNZ							10	100		

Mandibular breakage (Table 6.29) was much more variable as their structure makes them more durable than the maxillae. The majority of mandibles fell into the 'ascending ramus missing' category with the next most represented category being even more fragmented. Very few elements were complete. Many of the mandibles were from *Arvicola amphibius* and the breakage categories reflect the large size of these specimens, leading to other parts of the element being recovered, such as the symphysis and condyloid process.

Table 6.29 Rodent mandibular breakage categories

Context	Complete		Broken ascending ramus		Ascending ramus missing		Symphysis missing		Ascending ramus missing and inferior border broken		Symphysis only		Condyloid process only	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
HBG					4	50			4	50				
HEJ					1	50			1	50				
HFG					3	75			1	25				
HFW					3	50	1	16.7			1	16.7	1	16.7
HGG	1	11.1			4				2		1	11.1	1	11.1
HJW					2	66.7							1	33.3
HLD					1	100								
ZHH					1	100								
KAJ											4	75	1	25
KBB									1	100				
KGV							1	100						
KWV			1	50					1	50				
ZKM									1	100				
MAL					9	36			9	36	5	20	2	8
MCW					1	50			1	50				
MDJ			1	100										
MNZ	2	40			1	20			1	20	1	20		

Table 6.30 Loose and in-situ incisors and molars for arvicolids, by context

	Loose Incisors		In-situ incisors		Loose molars		In-situ molars	
Context	No.	%	No.	%	No.	%	No.	%
HBG	8	80	2	20	10	55.6	8	44.4
HEJ	1	50	1	50			2	100
HFG	4	66.7	2	33.3	2	28.6	5	71.2
HFW			2	100	3	33.3	6	66.7
HGG			4	100	1	16.7	5	83.3
HJW	7	87.5	1	12.5	7	63.6	4	36.4
HLD	2	66.7	1	33.3			2	100
KAJ	3	100			7	100		
KAR	1	100						
KBB			1	100				
KGV							2	100
KRK					3	100		
KWV			1	100				
MAL	19	73.1	7	26.9	73	83	15	17
MCW							3	100
MCX	3	42.9	4	57.1	9	52.9	8	47.1
MDJ	4	100			5	100		
MNZ	7	63.6	4	36.4	44	89.8	5	10.2
ZHH	1	50	1	50			1	100
ZKM							2	100

Loose and *in-situ* teeth analysis (Table 6.30) only included arvicolids, so a comparison between the Çatalhöyük data could be made. This was to determine if there was a difference between murine (Çatalhöyük) and arvicolid (Boncuklu) tooth retention. Tooth retention is much more variable with both loose and *in-situ* incisors and molars present in the Boncuklu assemblage; however, the sample size was low.

Anura

Fragmentation for amphibians includes all anura species, except those identified as toad or toad species as the different physiology, slight as it is, may have an impact on fragmentation. Also, species identification was based on certain identifiable elements, so by discounting the ilia, the data was biased because *Pelophylax* sp. humeri, radio-ulnae, urostyles, and tibio-fibulae are most likely included in the counts.

Rather than recording the 'portion' of the element, such as the proximal or distal end, anura elements were zoned (Figure 5.2). The tibio-fibula was not included in the fragmentation analysis due to the symmetrical nature of the element.

Table 6.31 shows fragmentation by zones that are represented on each specimen. For humeri both zones 1 and 3 are well represented, with zone 4, a much more fragile part of the element, being less well represented. A similar pattern occurs for other elements, with the harder parts of the elements, for example the articular surface of the ilia, or the proximal end of the radio-ulnae better represented than other zones.

When the specimens were analysed for completeness, the majority of elements were recorded as being 'less than 1/3' or '1/3 to 2/3' complete (Table 6.32). Very few elements were recorded as 'more than 2/3' (those specimens lacking the ends, however this doesn't count bones which are unfused), with the exception of the humeri, which did have more specimens in this category. Only a single humerus, and three radio-ulnae were complete.

Table 6.31 Anura post-cranial fragmentation by zone for Boncuklu.

		HBG		HEJ		HFG		HFW		HJW		HGG		HLD		KAJ		KAR		KBB		KWV		MAL		MCX		MDJ		Building 1		Building 3		Building 9		Building 4		Building 5	
Element	**Category**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus	Zone 1	19	35	4	33	1	14	12	24	9	39	15	34	8	23	10	35	2	29	2	22			46	31	5	36	3	27	6	27	1	33	5	33	23	29	13	22
	Zone 2	19	35	4	33	1	14	17	33	7	30	13	30	8	23	8	28	3	43	2	22			45	30	4	29	3	27	7	32	1	33	5	33	21	27	18	31
	Zone 3	14	26	4	33	3	43	18	35	6	26	12	27	15	43	9	31	2	29	4	44	2	67	50	34	5	36	3	27	8	36	1	33	4	27	27	34	22	37
	Zone 4	2	3.7			2	29	4	7.8	1	4.8	4	9.1	4	11	2	6.9			1	11	1	33	8	5.4			2	18	1	4.5			1	6.7	8	10	6	10
	Total	**54**		**12**		**7**		**51**		**23**		**44**		**35**		**29**		**7**		**9**		**3**		**149**		**14**		**11**		**22**		**3**		**15**		**79**		**59**	
Radio-ulna	Zone 1	3	33			3	27	2	25	9	27	1	33	2	18	5	39	1	50	2	40			17	32			1	50	4	33			3	30	3	21	5	26
	Zone 2	3	33			4	36	2	25	11	33	1	33	4	36	6	46	1	50	2	40			20	38			1	50	5	42			3	30	5	36	6	32
	Zone 3	3	33			4	36	3	38	10	30	1	33	4	36	2	15			1	20			12	23					3	25			3	30	5	36	7	37
	Zone 4							1	13	3	9.1			1	9.1									4	7.5									1	10	1	7.1	1	5.2
	Total	**9**		**0**		**11**		**8**		**33**		**3**		**11**		**13**		**2**		**5**		**0**		**53**		**0**		**2**		**12**		**0**		**10**		**14**		**19**	
Urostyle	Zone 1	16	27	8	29	10	23	24	26	12	27	7	32	4	25	5	56	2	33	1	25	1	20	27	33	7	32	4	27	4	29	1	50	3	38	11	29	35	25
	Zone 2	17	29	8	29	10	23	23	25	12	27	7	32	4	25	4	44	2	33	1	25	1	20	26	32	7	32	4	27	4	29	1	50	3	38	11	29	34	25
	Zone 3	10	17	6	21	8	19	19	21	10	22	3	14	4	25			1	17	1	25	1	20	16	20	4	18	3	20	3	21			1	13	7	18	27	20
	Zone 4	7	12	4	14	7	16	14	15	7	16	1	4.5	3	19			1	17	1	25	1	20	6	7.4	2	9.1	3	20	3	21			1	13	4	11	21	15
	Zone 5	9	15	2	7.1	8	19	11	12	4	8.9	4	18	1	6.3							1	20	6	7.4	2	9.1	1	6.7							5	13	21	15
	Zone 6																																						
	Total	**59**		**28**		**43**		**91**		**45**		**22**		**16**		**9**		**6**		**4**		**5**		**81**		**22**		**15**		**14**		**2**		**8**		**38**		**138**	
Ilium	Zone 1	6	13	10	15	4	6.6	17	10	4	9.3	4	9.1	4	15	1	2.1	1	4.5	4	14	2	7.1	24	7.9	4	7.3	3	12	5	7.7	2	6.7	2	8.7	8	11	23	9.6
	Zone 2	19	42	25	37	21	34	80	48	19	44	18	41	9	33	22	47	9	41	12	43	9	32	127	42	21	38	11	42	27	42	11	37	10	44	27	38	107	45
	Zone 3	5	11	6	9	3	4.9	3	1.8	2	4.7	2	4.5	2	7.4	4	8.5	5	23	4	14	5	18	29	9.6	10	18	2	7.7	11	17	3	10	3	13	4	5.6	6	2.5
	Zone 4	12	27	24	36	25	41	64	39	17	40	18	41	10	37	17	36	7	32	8	29	11	39	111	37	17	31	9	35	18	28	12	40	7	30	28	39	94	39
	Zone 5	3	6.7	2	3	8	13	2	1.2	1	2.3	2	4.5	2	7.4	3	6.4					1	3.6	12	4	3	5.5	1	3.8	4	6.2	2	6.7	1	4.3	4	5.6	10	4.2
	Total	**45**		**67**		**61**		**166**		**43**		**44**		**27**		**47**		**22**		**28**		**28**		**303**		**55**		**26**		**65**		**30**		**23**		**71**		**240**	

Table 6.32 Anura post-cranial fragmentation by percentage category for Boncuklu.

		HBG		HEJ		HFG		HFW		HJW		HGG		HLD		KAJ		KAR		KBB		KWV		MAL		MCX		MDJ		Building 1		Building 3		Building 9		Building 4		Building 5	
Element	**Category**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus	Less than 1/3	4	19			1	25	4	18	5	46	7	41			8	53	2	67	2	50			13	21	3	30			7	64			1	20	7	21	5	19
	1/3 - 2/3	15	71	4	100	3	75	17	77	5	46	9	53	15	94	6	40	1	33	2	50	2	100	46	73	5	50	1	33	4	36	4	100	3	60	24	73	21	78
	More than 2/3	2	9.5					1	4.5	1	9.1	1	5.9	1	6.3	1	6.7							4	6.3	2	20	2	67							2	6.1	1	3.7
	Complete																																	1	20				
	Total	**21**		**4**		**4**		**22**		**11**		**17**		**16**		**15**		**3**		**4**		**2**		**63**		**10**		**3**		**11**		**4**		**5**		**33**		**27**	
Radio-ulna	Less than 1/3					3	75									10	56			1	50			15	48			1	100	1	20			1	33			3	43
	1/3 - 2/3	3	100			1	25	3	100	9	82	1	100	4	100	8	44	1	100	1	50			14	45					2	40			1	33	5	100	4	57
	More than 2/3									1	9.1													2	6.5					1	20								
	Complete									1	9.1																			1	20			1	33				
	Total	**3**		**0**		**4**		**3**		**11**		**1**		**4**		**18**		**1**		**2**		**0**		**31**		**0**		**1**		**5**				**3**		**5**		**7**	
Urostyle	Less than 1/3	3	17	1	13	3	30	5	20							4	80	1	50					4	15	1	14	1	25	2	50	1	100	1	33			8	22
	1/3 - 2/3	15	83	7	88	7	70	18	72	12	100	6	86	4	100	1	20	1	50	1	100			22	82	6	86	3	75	2	50			2	67	10	91	27	73
	More than 2/3							2	8			1	14									1	100	1	3.7											1	9.1	2	5.4
	Complete																																						
	Total	**18**		**8**		**10**		**25**		**12**		**7**		**4**		**5**		**2**		**1**		**1**		**27**		**7**		**4**		**4**		**1**		**3**		**11**		**37**	
Ilium	Less than 1/3	15	37	5	16	19	54	45	48	5	24	17	63	5	39	19	68	6	50	8	62	6	40	68	44	19	68	8	62	18	55	7	47	4	36	22	55	66	49
	1/3 - 2/3	26	63	26	84	16	46	48	52	16	76	10	37	8	62	9	32	5	42	5	39	9	60	85	56	8	29	5	39	14	42	8	53	7	64	18	45	68	51
	More than 2/3																	1	8.3							1	3.6			1	3								
	Complete																																						
	Total	**41**		**31**		**35**		**93**		**21**		**27**		**13**		**28**		**12**		**13**		**15**		**153**		**28**		**13**		**33**		**15**		**11**		**40**		**134**	
Tibio-fibula	Less than 1/3	6	21			8	42	4	13			4	25	6	33	3	30	4	44	1	25			13	18	4	50	4	57	7	47	1	20	2	33	10	29	13	25
	1/3 - 2/3	21	75	15	100	8	42	28	88	17	90	12	75	10	56	7	70	4	44	3	75	3	60	58	82	4	50	3	43	7	47	4	80	4	67	22	65	37	70
	More than 2/3	1	3.6			3	16			2	11			2	11			1	11			2	40							1	6.7					2	5.9	3	5.7
	Complete																																						
	Total	**28**		**15**		**19**		**32**		**19**		**14**		**18**		**10**		**9**		**4**		**5**		**71**		**8**		**7**		**15**		**5**		**6**		**34**		**53**	

6.2.8 Burning

A total of 444 elements, across all three areas were recorded as affected by thermal alteration or burning. Taxa affected can be found in Table 6.33. Anura accounted for the majority of the burnt assemblage, with 67.8% of burnt specimens belonging to this taxonomic group. Mammals comprised 20.7% of the burnt assemblage. No burning was recorded on any specimens identified as 'insectivore'. Snake comprised 10.1% of the burnt assemblage.

Table 6.33 Burning by taxa at Boncuklu.

Taxa	Taxa NISP	Burnt NISP	% Burnt by taxa	% Burnt by site
Anuran	2892	301	10.4	67.8
Arvicola amphibius	266	45	16.9	10.1
Arvicolinae	28	12	42.8	2.7
(*Arvicola amphibius* + Arvicolinae)	295	57	19.3	12.8
Microtus guentheri	1	0	0	0
Bufo viridis	1	0	0	0
Crocidura suaveolens	4	0	0	0
Microfauna (smaller than rabbit)	12	0	0	0
Micromammal	71	15	21.1	3.4
Mus sp.	5	0	0	0
Erinaceus concolor	1	0	0	0
Pelophylax ridibundus	4	0	0	0
Pelophylax sp.	160	6	3.8	1.4
Rodent	189	20	10.6	4.5
Snake	572	45	7.9	10.1
Toad	9	0	0	0
Site Total	**4215**	**444**		**10.5**

The severity of burning, for example slight, partial, total surface burnt, or calcined, was also recorded (Table 6.34), with 91.9% of burnt specimens showing that the whole specimen was affected. Partially burnt specimens accounted for only 6.5% of the assemblage, with slightly burnt and calcined specimens only providing 1.4% and 0.2% of the burnt specimens respectively.

Table 6.34 Burning by type

Burn type	NISP	% Burn type
Slightly burnt	6	1.4
Partly burnt	29	6.5
Burnt	408	91.9
Partly calcined	1	0.2

Burn colour was also recorded to indicate temperatures to which the specimens had been exposed (Table 6.35). 32.9% of the burnt specimens were recorded as brown, and 28.2% were recorded as black. Grey was initially recorded as a single colour. However, a difference between light and dark grey was noted during analysis and, as the temperature these colours appear at is different, a decision was made to split that category. Generally, the percentage values decrease as potential temperatures increase. However, white specimens, associated with high temperatures or prolonged periods of burning, provided 6.5% of the burnt assemblage.

*Table 6.35 Burning by colour for Boncuklu. * Denotes elements recorded as grey before the colour was split into light and dark variants.*

Burnt colour	NISP	% burnt by colour
Brown	146	32.9
Black	125	28.2
Blue	49	11
Dark Grey	30	6.8
Grey*	37	8.3
Light grey	26	5.9
Blue to white	2	0.5
White	29	6.5

Burning was also analysed by taxa and context (Table 6.36) to determine any patterns. Area M contained the largest number of burnt specimens, with 66.4% of the burnt assemblage coming from this area. Area H produced the second highest number of burnt specimens, at 21.4%, with Area K accounting for 12.2% of the burnt assemblage. In all areas anura were the most commonly burnt taxa. In Area H, the percentages for burning by context for anura ranged from 2.4% to 20%, although some of the assemblages were small. Burnt specimens of other taxa were rare, with only 1-5 burnt specimens by context in this area.

Table 6.36 Burning by taxa and context, including by Area

	Anura			*Arvicola amphibius*			Arvicolinae			Micromammal			*Pelophylax sp.*			Rodent			Snake			Total		
	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%
HBG	189	17	9	21	3	14.3				2			8	1	12.5	25	1	4	100	5	5	345	27	7.8
HEJ	91	5	5.5	5	1	20				3			12			3			20			134	6	4.5
HFG	147	6	4.1	6			2	1	50	2			7			6			53	5	9.4	223	12	5.4
HFW	344	20	5.8	10	1	10				1			20			11			97	6	6.2	484	27	5.6
HGG	108	7	6.5	13									9			3			2	1	50	138	8	5.8
HJW	136	6	4.4	11						8			8			12	1	8.3	8	1	12.5	187	8	4.3
HLD	84	2	2.4	2						4			2			10						105	2	1.9
HFO	20																		2			22		
ZHH	20	4	20	2									1			2						25	4	16
ZHI	26	1	3.8										5			1						34	1	2.9
Area H	**1165**	**68**	**5.8**	**70**	**5**	**7.1**	**2**	**1**	**50**	**20**			**72**	**1**	**1.3**	**73**	**2**	**2.7**	**282**	**18**	**6.4**	**1697**	**95**	**5.7**
KAJ	216	20	9.3	8	1	12.5	1	1	100	7	2	28.6	1			12	3	25	134	2	1.5	380	29	7.6
KAR	50	7	14							3	1	33.3	7			2			6			70	8	11.4
KBB	39	3	7.7	2									6						3			50	3	6
KWV	36	2	5.6	1						1			4			1			6			50	2	4
KAN	30	2	6.7										2						6			38	2	5.2
KAZ	14	3	21.4													2			5			21	3	14.3
KDD	11			1									1			1	1	100	7			21	1	4.8
KGV	10	1	10	1									2									13	1	7.7
KJI	7																					7		
KRK	25	2	8	2			1			1						2			4			35	2	5.7
KWA	3																					3		
KWT	8												2									10		
ZKJ	7																		5			12		
ZKM	16	3	18.8	1									1			4						22	3	13.6
Area K	**472**	**43**	**9.1**	**16**	**1**	**6.3**	**2**	**1**	**50**	**12**	**3**	**25**	**26**			**24**	**4**	**16.7**	**176**	**2**	**1.2**	**732**	**54**	**7.4**
MAL	977	149	15.2	91	22	24.2	18	8	42.1	36	11	30.6	39	2	5.1	64	13	20.3	58	14	24.1	1294	219	16.9
MCX	123	23	18.7	20	5	25							13	2	15.4	10	1	10	10	4	40	177	35	19.8
MDJ	70	8	11.4	9	3	33.3	2						3	1	33.3	7			2			99	12	12.1
MNZ	23			54	7	13	4	2	50				1			10			32	5	15.6	125	14	11.2
MCW	20	4	20	2															4	1	25	26	5	19.2
MDC	29	4	13.8	4	2	50				1			5			1			1			42	6	14.3
MEO	13	2	15.4							2	1	50	1						7	1	14.3	23	4	17.4
Area M	**1255**	**190**	**15.1**	**180**	**39**	**21.7**	**24**	**10**	**41.7**	**39**	**12**	**30.8**	**62**	**5**	**8.1**	**92**	**14**	**15.2**	**114**	**25**	**21.9**	**1786**	**295**	**16.5**
Site Total	**2892**	**301**	**10.4**	**266**	**45**	**16.9**	**28**	**12**	**42.9**	**71**	**15**	**21.1**	**160**	**6**	**3.75**	**189**	**20**	**10.6**	**572**	**45**	**7.9**	**4215**	**444**	**10.5**

The snake assemblage contained higher numbers of burnt specimens, 18 out of 95, with a range of 5% to 50% of burnt specimens by context. Only one context in this Area (HFO) did not contain any burnt specimens. In Area K, five contexts out of 14 did not contain any burnt specimens of anura. For those that did, burning ranged from 5.6% to 21.4% by context. Other species were not well represented in the burnt assemblage for this area. In Area M, all but one of the seven contexts contained burnt specimens of anura, with percentages of burnt elements ranging from 11.4% to 20%. Specimens of *A. amphibius* were also burnt in higher numbers in this area, with percentages of burning by context ranging from 13% to 50%. Other species are better represented than others, but the numbers of burnt specimens by species, even for contexts in Area M, are still much lower than for anura.

Burning was also analysed by element for both anura and small rodents. In anura (Table 6.37), elements from all areas of the skeleton were represented in the burnt assemblage. The ilia were the most commonly affected element, comprising 34.2% of the burnt assemblage, and 20.1% of all ilia were burnt. Maxillary fragments, at 13.3% of the burnt assemblage, were the next most affected element. Humeri made up 11.6% of the burnt assemblage, with 15.5% of all anuran humeri burnt. Six specimens of *Pelophylax* sp. were burnt, and although species identification is limited to a few elements, all burnt specimens were ilia.

Table 6.37 Burning by element for Anura and Pelophylax sp. for Boncuklu.

	Anura				*Pelophylax sp.*			
Elements in anuran	NISP	N. Burnt	% Ele Burnt	% of Burnt elements	NISP	N. Burnt	% Ele Burnt	% of Burnt elements
Premaxilla	40	1	2.5	0.3				
Maxilla with teeth	322	40	12.4	13.3				
Mandible without teeth	235	14	6	4.7				
Frontoparietal	33	1	3	0.3	5			
Parasphenoid	15							
Sphenethmoid	74	10	13.5	3.3	28			
Pterygoid	68	6	8.8	2				
Squamosal	7							
Clavicle	1							
Sternum	20	1	5	0.3				
Scapula	74	3	4.1	1	43			
Humerus	226	35	15.4	11.6				
Radio-Ulna	87	8	9.2	2.7				
Coracoid	113	3	2.7	1				
Atlas	11	1	9.1	0.3				
Axis								
Vertebra	247	12	4.9	4				
Sacrum	53	7	13.2	2.3				
Urostyle	149	18	12.1	6				
Ilium	512	103	20.1	34.2	84	6	7.1	100
Ischium	17							
Femur	31							
Tibio-Fibula	293	19	6.4	6.3				
Tarsals	28							
Astragalus								
Metapodials	191	13	6.8	4.3				
Phalanges	45	6	13.3	2				
Total	2892	301		10.4	160	6		3.75

When body part category was analysed for burning in anura (Table 6.38), the hindlimbs were most frequently affected, making up 46.5% of the burnt assemblage. The cranial category, at 23.9% of the burnt assemblage, was the next most represented category, with the forelimb category at 16.6%. The axial skeleton and the foot bones provided 6.6% and 6.3% of the burnt anura bones respectively.

Table 6.38 Burning by body part category for Anura and Pelophylax sp. for Boncuklu.

	Anura				*Pelophylax sp.*			
	Site NISP	N. Burnt	% Burnt	% burnt assemblage	Site NISP	N. Burnt	% ele Burnt	% burnt assemblage
Cranial	794	72	9.1	23.9	33			
Forelimb	521	50	9.6	16.6	43			
Axial	311	20	6.4	6.6	N/A	N/A	N/A	
Hind limb	1002	140	14	46.5	84	6	7.1	100
Podials	264	19	7.2	6.3	N/A	N/A	N/A	
Total	**2892**	**301**		**10.4**	**160**	**6**		**3.8**

Burning by element in small mammals (Table 6.40) showed that *A. amphibius* made up 50.5% of the burnt small mammal assemblage, with rodent at 21.1%, micromammal at 15.8%, and Arvicolinae at 12.6%. No post-cranial specimens were recorded for *A. amphibius* or Arvicolinae, due to identification to genus or species reliant on cranial elements only. Post-cranial specimens were represented in the micromammal and rodent higher taxonomic categories, and burnt elements were represented in all areas of the body.

When body part categories were analysed for burning (Table 6.39), the cranial category was found to be most affected, with 66.3% of the burnt assemblage attributed to cranial elements in small mammals. The hind limb was the next most affected category, at 12.6% of the burnt assemblage.

Table 6.39 Burning by body part category for small rodents at Boncuklu. Number of burnt elements includes in-situ teeth.

	All small rodents			
	Site NISP	N. Burnt	% Element Burnt	% Burnt assemblage
Cranial	484	63	13	66.3
Forelimb	29	4	13.8	4.2
Axial	30	9	30	9.5
Hindlimb	62	12	19.4	12.6
Podials	46	7	15.2	7.4
Total	**651**	**95**	**10.4**	**14.6**

Table 6.40 Burning by element for small mammals (excluding insectivores) at Boncuklu. Calculations include in-situ molars and incisors.

	Arvicola amphibius				**Arvicolinae**				**Rodent**				**Micromammal**			
Elements in small mammals	**NISP**	**N. Burnt**	**% Ele Burnt**	**% Burnt assemblage**	**NISP**	**N. Burnt**	**% Ele Burnt**	**% Burnt assemblage**	**NISP**	**N. Burnt**	**% Ele Burnt**	**% Burnt assemblage**	**NISP**	**N. Burnt**	**% Ele Burnt**	**% Burnt assemblage**
Molar	220	30	13.6	62.5	12	2	16.7	16.7								
Incisor	34	2	5.9	4.2					64							
Skull fragments	3								11				2			
Premaxilla									4							
Maxilla	5															
Palate fragment	32	10	31.3	20.8	11	6	54.5	50								
Mandible	68	6	8.8	12.5	5	4	80	33.3	13	3	23.1	15				
Scapula									4	1	25	5				
Humerus									9	1	11.1	5	2			
Radius									5	1	20	5	2	1	50	6.7
Ulna									6				1			
Atlas													1			
Axis									1							
Vertebra									1				26	9	34.6	60
Rib													1			
Sacrum									1				1	1	100	6.7
Pelvis									4				1			
Femur									13	2	15.4	10	2	1	50	6.7
Tibia									38	8	21.1	40	2			
Astragulus									2	1	50	5	2	2	100	13.3
Calcaneus									6	2	33.3	10	1			
Metacarpal									2				3			
Metatarsals													1			
Metapodial									2	1	50	5	12	1	8.3	6.7
Phalanges									4				11			
Total	**362**	**48**		**13.3**	**28**	**12**		**41.3**	**190**	**20**		**10.5**	**71**	**15**		**21.1**

6.2.9 Gnawing

Gnawing was very limited in this assemblage with only two confirmed cases of carnivore gnawing (Table 6.41). A single anura tibio-fibula, from context HEJ, showed evidence of multiple puncture marks (Figure 6.23), and a *Pelophylax* sp. scapula, from context MNZ, showed evidence of an isolated puncture. All other puncture marks were only identified as potential gnawing, as they lacked the criteria to confirm that they were actually caused by a predator or scavenger.

Table 6.41 All recorded gnawing for the Boncuklu assemblage

Context	Taxa	Element	Gnawing type	Gnawing intensity	Puncture marks	NISP	Site NISP	% gnawed
KAR	*Mus sp.*	Mandible with teeth	?Carnivore			1	5	20
MAL	Snake	Vertebra	?Carnivore			3	572	0.5
MAL	Anuran	Ilium	?Carnivore			1	N/A	N/A
HEJ	Anuran	Amphibian tibio-fibula	Carnivore	Light	Multiple Puncture Marks	1 (2)	2892	0.07
MNZ	*Pelophylax sp.*	Scapula	Carnivore	Light	Isolated Puncture Marks	1	160	0.6

As such, gnawing on the anura assemblage only accounted for 0.07% of the specimens recorded, and 0.6 % on specimens identified as *Pelophylax* sp.

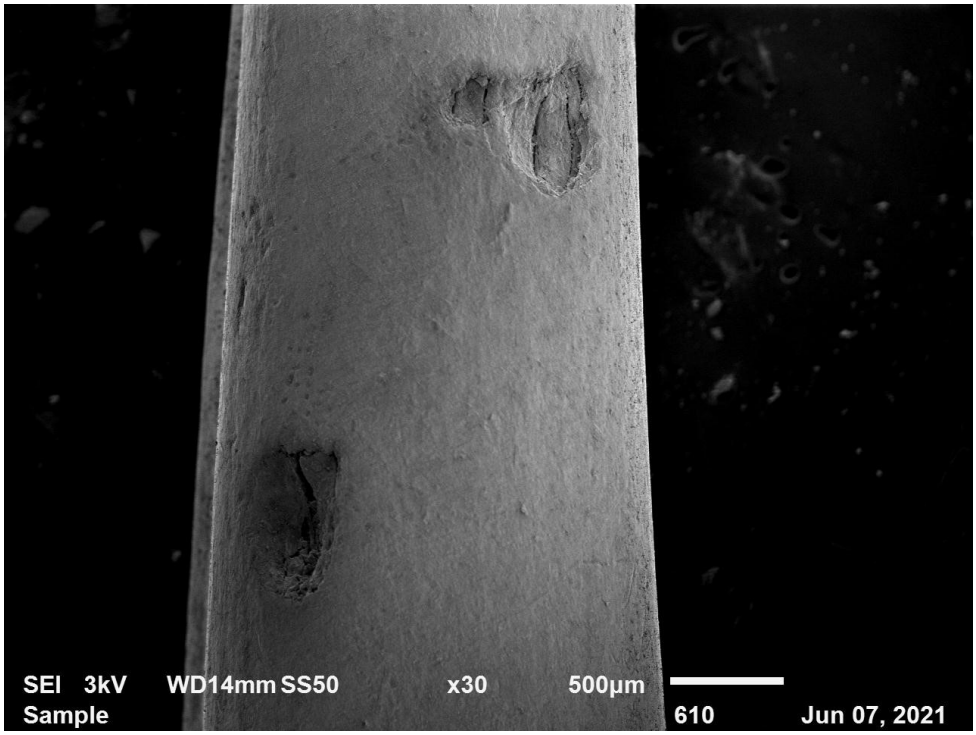

Figure 6.23 Multiple gnaw marks on an anura tibio-fibula

6.2.10 Digestion

Very few digested elements were identified at Boncuklu, and included specimens of small mammals, anura, and snakes.

Rodent digestion

Rates of digestion for the small mammal assemblage at Boncuklu were very low, at only 1.6%. Digestion was recorded for isolated and *in-situ* molars and incisors, distal humeri and proximal femora, following the methodology of Andrews (1990) and Fernandez-Jalvo and Andrews (1992). Only nine specimens showed evidence of digestion, with a further two specimens that may have been digested. The latter are included in Table 6.42 but not included in percentage calculations (Table 6.43).

Table 6.42 Digestion for small mammals

Context	Taxa	Element	Digestion	Loose Tooth type	Loose tooth class	Loose tooth number	NISP
HEJ	Rodent	Femur	Light				1
MAL	Micromammal	Femur	Light				1
HJW	Rodent	Humerus	Moderate				1
MNZ	*Arvicola amphibius*	Loose tooth	Moderate	Lower	Molar	1	1
MNZ	*Arvicola amphibius*	Loose tooth	Light	Lower	Molar	1	1
HBG	*Arvicola amphibius*	Loose tooth	Moderate	Indeterminate	Molar	Indeterminate	1
MAL	*Arvicola amphibius*	Loose tooth	Light	Upper	Molar	2	1
MCX	*Arvicola amphibius*	Loose tooth	Moderate	Indeterminate	Molar	Indeterminate	1
MAL	Arvicolinae	Loose tooth	Moderate	Upper	Molar	1	1
HJW	Micromammal	Humerus	?Digested				1
HBG	Rodent	Humerus	?Digested				1

The majority of the digested elements were molars, five of which were identified as *Arvicola amphibius*. *A. amphibius* accounted for 55.6% of the digested assemblage (Table 6.43), with rodent the next most affected taxa at 22.2% of the digested assemblage.

Table 6.43 Digestion categories by species

	Light	Moderate	Total	% digested assemblage
Arvicola amphibius	2	3	5	55.6
Arvicolinae		1	1	11.1
Micromammal	1	1	2	22.2
Rodent	1		1	11.1
Total	**4**	**5**	**9**	
% Category	**44.4**	**55.6**		**100**

Only light and moderate digestion categories were observed, with no specimens identified as having heavy or extreme digestion damage. 55.6% of the digested assemblage was recorded in the moderate category, with the remainder exhibiting light digestion. SEM micrographs showing digested elements of small mammals can be seen in Figure 6.24.

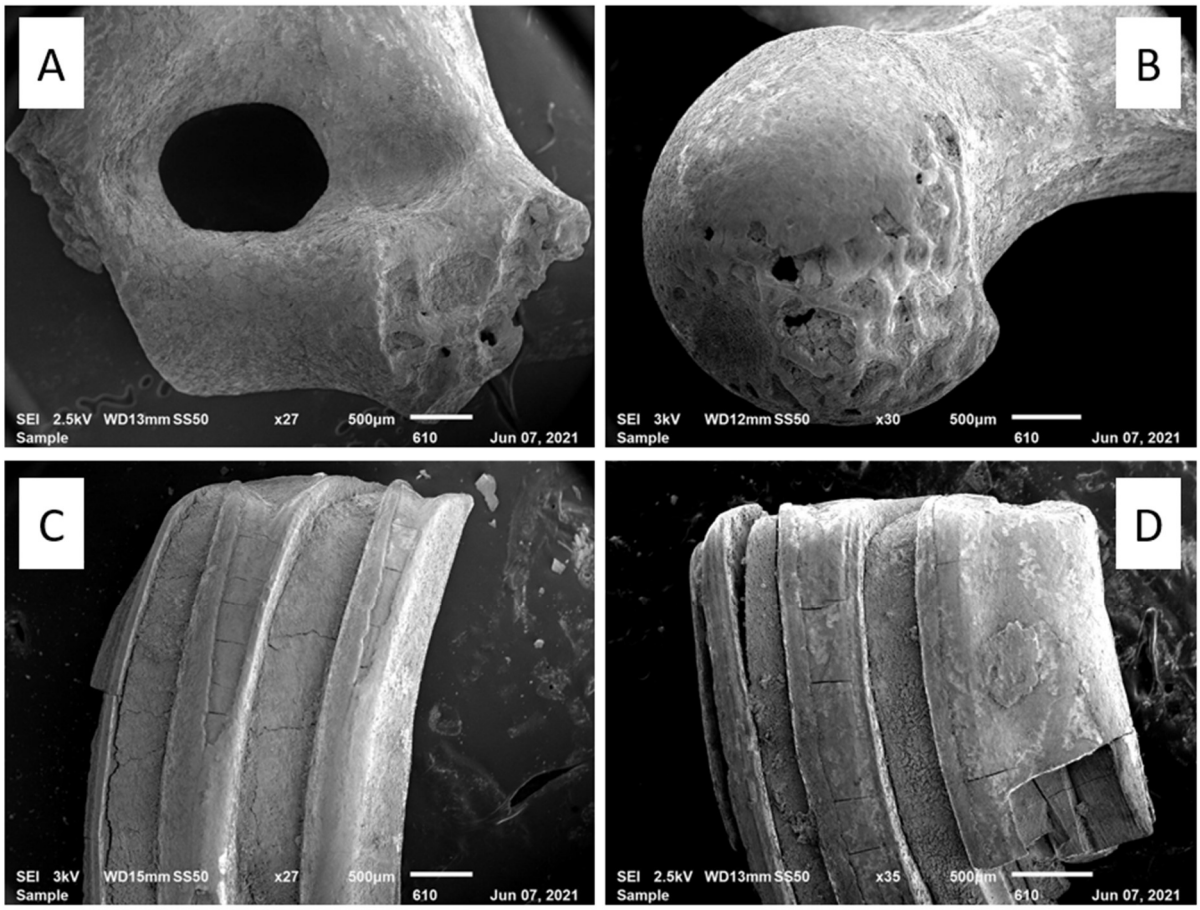

Figure 6.24 Digestion of small mammal specimens from Boncuklu. A. Moderate digestion of a distal humerus (HJW), B. Light digestion on a proximal femur (HEJ), C. Moderate digestion on a microtine molar (MCX), D. Moderate digestion on a microtine molar (MAL)

Snake digestion

Nine specimens identified as snake were identified as digested, all of which were vertebrae from context MAL. Bone loss was exhibited on the head of the vertebral body, resembling digestion of the proximal femur (Figure 6.25).

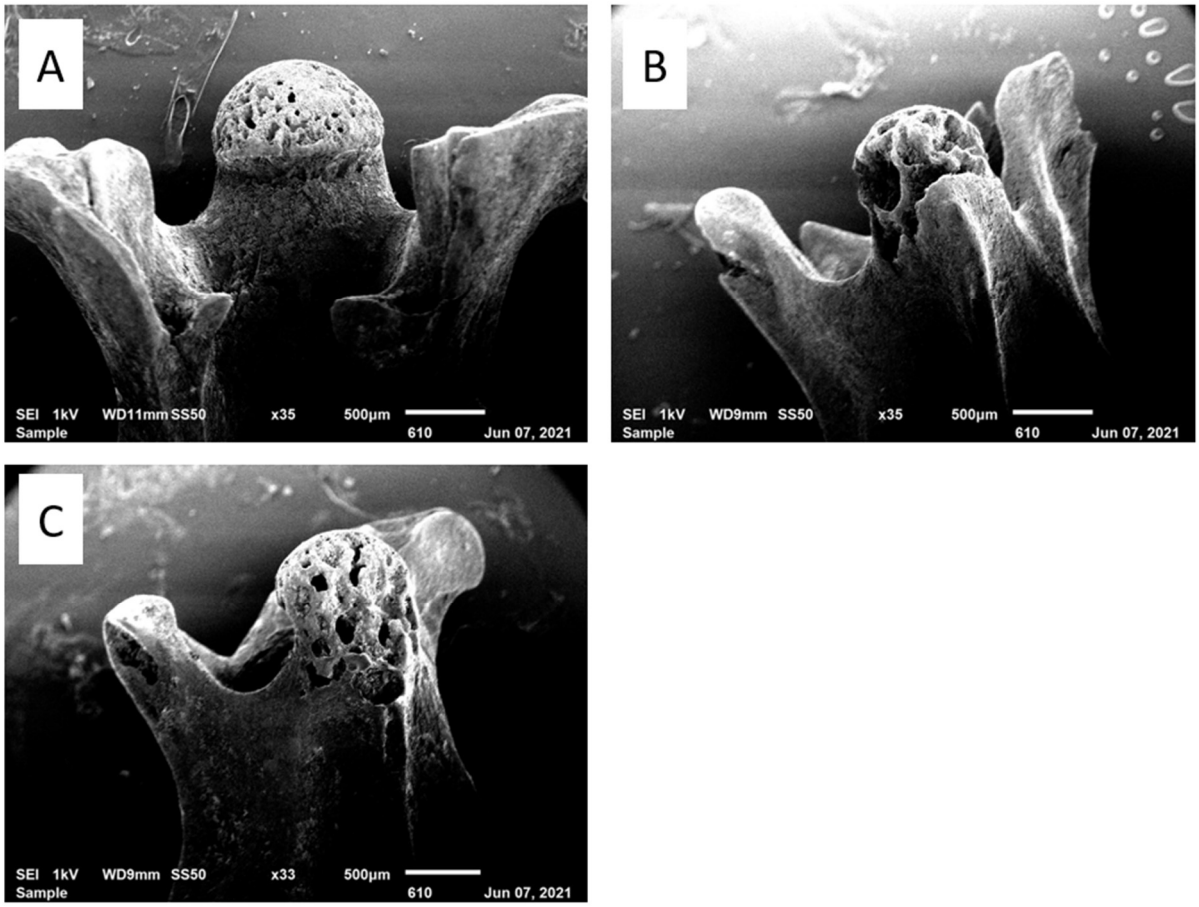

Figure 6.25 Digestion of the head of the vertebral body of snake specimens from Boncuklu.

Amphibian taphonomy

Taphonomic changes affecting amphibians were identified to the higher taxonomic category, anura, as well as *Pelophylax* sp., and toad (Table 6.47). Anura accounted for 91.5% of specimens affected by taphonomic modifications (as detailed in table 6.45), excluding fragmentation and burning. Of the 212 specimens exhibiting taphonomic changes, 17 were attributed to Pelophylax sp., forming 8% of the assemblage affected by taphonomic changes, with only a single specimen of toad, at 0.5%.

Table 6.44 Taphonomic modification by species at Boncuklu.

Taxa	N	%	NISP	%
Anuran	194	91.5	2892	6.5
Pelophylax sp.	17	8	160	5
Toad	1	0.5	9	11.1
Total	**212**	**6.9**	**4215**	**5**

Taphonomic modifications (Table 6.45) included articular digestion-bone loss which accounted for 50.5% of the taphonomic assemblage, with articular digestion-protruding edges accounting for an additional 30.2%. Other modifications including root-marking and flaking were recorded in much lower numbers.

Table 6.45 Amphibian taphonomic modifications by category at Boncuklu.

Amphibian Taphonomy	N	%
Articular digestion - bone loss	107	50.5
Articular digestion - polished ends	1	0.5
Articular digestion - protruding edges only	64	30.2
Flaking exfoliation edges	1	0.5
Flaking exfoliation other	14	6.6
Pitting	1	0.5
Rootmarks	10	4.7
Rounding whole bone surface	1	0.5
Splitting other	13	6.1
Total	**212**	**6.9**
Total anura site NISP (inc. toad, *B. viridis* etc.)	**3066**	

When examined by area (Table 6.46), 50% of the modified specimens came from Area M, an outside area containing various features. Area H, which also included midden deposits, accounted for 32.5% of the taphonomic assemblage, with Area K only accounting for 17.4%.

Table 6.46 Percentages of taphonomic modification by Area at Boncuklu.

	N	%
Area H	69	32.5
Area K	37	17.4
Area M	106	50

SEM micrographs showing examples of taphonomic modifications on specimens of anura can be seen in Figure 6.26.

Taphonomic modification categories were also analysed by element to determine whether there were any significant patterns in their relative frequency (Table 6.47). The most commonly affected elements were the humeri and the ilia, at 34.9% and 31.6% of the taphonomic assemblage, respectively. Elements in all four body categories were affected.

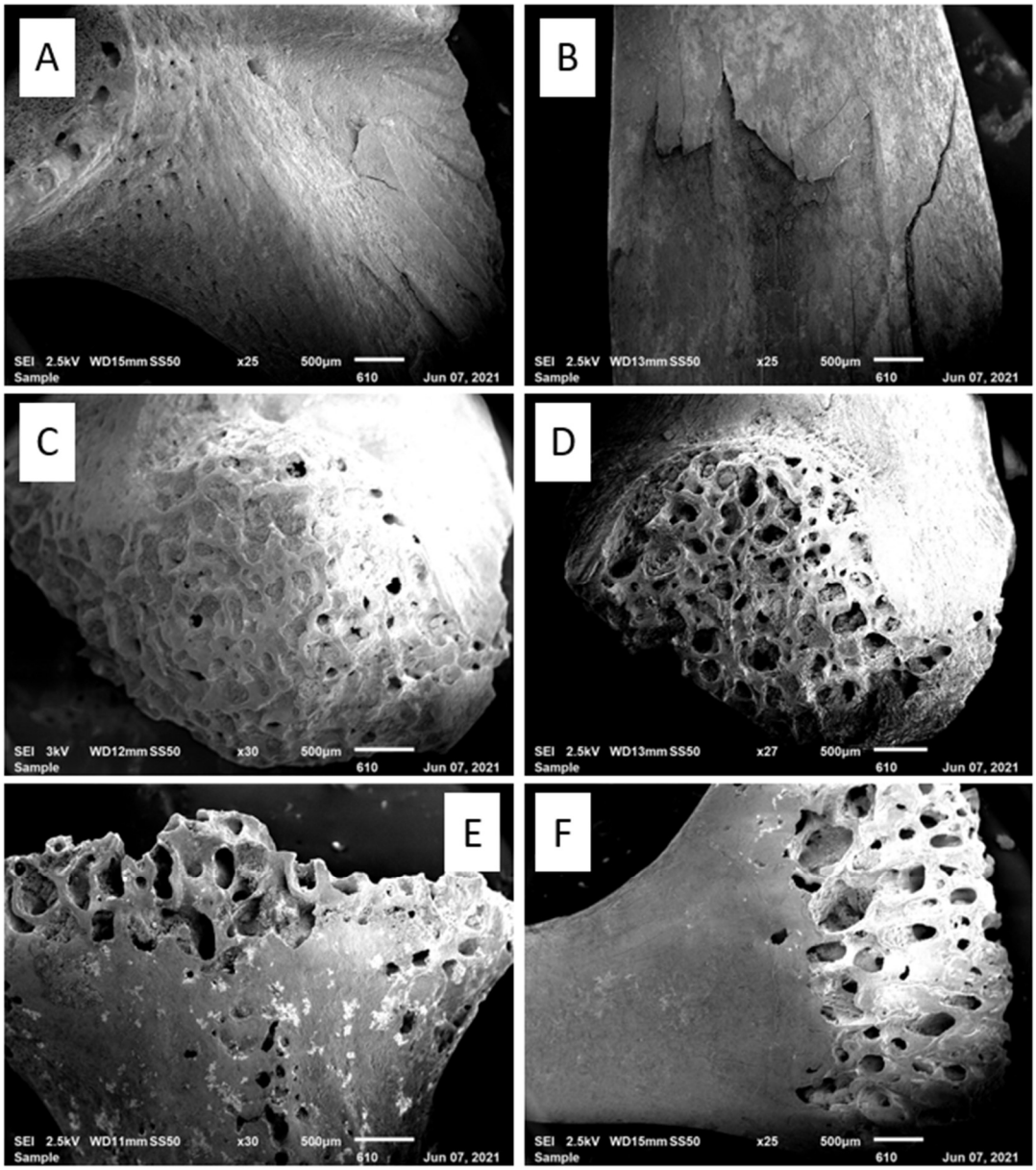

Figure 6.26 SEM microscopy of taphonomic modifications to anura at Boncuklu. A. Flaking on ilia specimen, B. Splitting on tibio-fibula specimen, C. and D. Articular digestion - bone loss to the distal humeri, E. Sphenethmoid showing articular digestion – protruding edges, and F. Coracoid showing articular digestion – bone loss.

Modifications to *Pelophylax* sp. were limited to the scapula and ilia, two of the four elements used to identify specimens to genus or species. The ilia accounted for 94.1% of modified specimens, making up 7.4% of the total taphonomic assemblage.

Taphonomic modifications in toad were limited to a single specimen of tibio-fibula, with accounted for 0.5% of the total taphonomic assemblage.

Table 6.47 Taphonomic modifications by element for anura, Pelophylax sp., and toad at Boncuklu.

	Anura												*Pelophylax sp.*								Toad				
	NISP	Articular digestion - bone loss	Articular digestion - protruding edges only	Flaking exfoliation edges	Flaking exfoliation other	Pitting	Rootmarks	Rounding whole bone surface	Splitting other	Total	% taphonomic assemblage	% by element	NISP	Articular digestion - bone loss	Articular digestion - polished ends	Articular digestion - protruding edges only	Rootmarks	Total	% taphonomic assemblage	% by element	NISP	Splitting other	Total	% taphonomic assemblage	% by element
Premaxilla	40																								
Maxilla	322																								
Mandible	235				2				1	**3**	**1.4**	**1.3**													
Frontoparietal	33												5												
Parasphenoid	15																								
Sphenethmoid	74		1					1		**2**	**0.9**	**2.7**	28								2				
Pterygoid	68								1	**1**	**0.5**	**1.5**													
Squamosal	7																								
Clavicle	1																								
Sternum	20																								
Scapula	74	1			1				1	**3**	**1.4**	**4.1**	43		1			**1**	**5.9**	**2.3**	1				
Humerus	226	70			2	1	1			**74**	**34.9**	**32.7**													
Radio-Ulna	87	4	13				2			**19**	**9**	**21.8**													
Coracoid	113	1			1		1			**3**	**1.4**	**2.7**													
Atlas	11																								
Axis																									
Vertebra	247	1								**1**	**0.5**	**0.4**													
Sacrum	53	4	1							**5**	**2.4**	**9.4**													
Urostyle	149				3		1		1	**5**	**2.4**	**3.4**													
Ilium	512	21	39	1	4		2			**67**	**31.6**	**13.1**	84	5		10	1	**16**	**94.1**	**19**	1				
Ischium	17																								
Femur	31																								
Tibio-Fibula	293				1		2		8	**11**	**5.2**	**3.8**									5	1	**1**	**11.1**	**20**
Tarsals	28																								
Metapodials	191																								
Phalanges	45																								
Total	**2892**	**102**	**54**	**1**	**14**	**1**	**9**	**1**	**12**	**194**	**6.7**		**160**	5	1	10	1	**17**	**10.6**		**9**	**1**	**1**	**11.1**	

6.2.11 Body size

During recording of the Boncuklu assemblage a decision was made to add body size categories for specimens. No solid parameters were put in place for the boundaries of each category, leading to subjectivity over whether the specimen was large or small (see Chapter 5).

The data holds value for micromammals, as it aids in the separation of the post-cranial specimens which cannot be identified to genus or species, separating elements into 'mouse-sized' species, such as smaller arvicolids and *Mus* sp., versus 'rat-sized', such as *Arvicola amphibius*. Table 6.48 shows that the majority of rodent specimens fall into the large body size category, most likely belonging to *A. amphibius*. However, 15.9% of the rodent specimens were from species with a smaller body size than *A. amphibius*.

Anura, including those identified to genus, were much more varied in body size. However, as mentioned above, what constituted the body size categories was subjective and therefore changed as exposure to the assemblage increased.

Table 6.48 Body size categories by species

	Small		Medium		Large		Total
	N	%	N	%	N	%	N
Anuran	418	27.3	689	44.9	426	27.8	1533
Pelophylax sp.	21	18.4	46	40.4	47	41.2	114
Pelophylax ridibundus					2	100	2
Bufo viridis	1	100					1
Toad	4	80			1	20	5
Rodent	20	15.9	1	0.8	105	83.3	126
Arvicola amphibius					167	100	167
Arvicolinae	2	12.5	4	25	10	62.5	16
Mus sp.	5	100					5
Micromammal	10	26.3			28	73.7	38
Erinaceus concolor					1	100	1
Snake	46	55.4			37	44.6	83

6.2.12 Interesting Specimens of Note

A large deposit of coprolites was found in Area M. These have been confirmed to be of human origin (Baird Pers comm.). Many of these coprolites contained small bone fragments. None of the coprolites from Area M form part of the analysis in this thesis.

Specimens of coprolites were also discovered in Area R, not an area analysed for this thesis, and due to their similarity to those found in Area M, it was concluded that they were also of human origin. A rapid assessment of the bone fragments from the coprolites was made during the 2018 excavation season, and are presented here as interesting specimens of note that will require additional analysis. It is important to note that anura specimens were identified in the coprolites, indicating that anura were being consumed by humans. Specimens from the cranium, axial skeleton, forelimb, and feet were represented (Figure 6.27). This discovery has implications for the determination of anura as being included in the human diet at Boncuklu.

Figure 6.27 Anura fragments from coprolites recovered from Area R. Left upper; squamosal fragment, Right upper; radio-ulna, Left lower; vertebral body, Right lower; phalanges.

6.3 Pınarbaşı

6.3.1 Site Details

A total of 2,522 specimens were recorded from 35 contexts, across three different phases of occupation at Pınarbaşı. The 7th millennium BCE occupation in Trench B produced 312 specimens, the 10th-9th millennium BCE occupation in Trenches A and D produced 616 specimens, and the Epipalaeolithic occupation produced 1,594 specimens. Details of the interpretive categories, as well as a brief description of each context can be found in Table 6.49.

The 7th millennium BCE (Late Neolithic) deposits consisted of contexts BBH, BDF, BFV, BHL, and BJY. Within the same trench Epipalaeolithic occupation was uncovered, beneath a large deposit of rock shatter and sediment. The Epipalaeolithic deposits consisted of contexts BIA, BIB, BIE, BIF, BIH, BIJ, BIK, BIL, BIP, ZBB, and ZBD. Approximately 100m southwest of Trench B is the small promontory on which the early Neolithic occupation was recovered from Trenches A and D. The contexts from this phase of occupation were ADJ, ADN, ADX, AER, AFA, AFC, AFI, AHA, ZAM, DCI, DCL, DFA, DFH, DFM, DGK, DGL, DGN, DGS, and DGT.

Table 6.49 Context details

Context	Interpretive Category	Area	Phase	Brief Description
ADJ	Cobble spread	A	10/9th MBCE	Context comprises angular cobbles. Amongst cobbles there is a large amount of animal bone including Aurochs, Equid and capro-ovid. Few bones are burnt.
ADN	General fill	A	10/9th MBCE	Arbitrary spit of 9thMM deposit from SW quadrant of trench A.
ADX	General fill	A	10/9th MBCE	Second 9th MM spit from NW Quadrant.
AER	Pit fill	A	10/9th MBCE	Pit forms an 'L' shape around two sides of cist burial cut. There are a small amount of chipped stone and bone artefacts.
AFA	General fill	A	10/9th MBCE	Spit of standard 9th MM deposit exc'd from NW quad
AFC	General fill	A	10/9th MBCE	Spit of standard 9th MM deposit exc'd from NW quad
AFI	General fill	A	10/9th MBCE	Spit of standard 9th MM deposit exc'd from NW quad
AHA	Midden	A	10/9th MBCE	Midden deposit
BBH	General fill	B	Neolithic E I	Clean up of the Neolithic section/baulk.
BDF	Dump	B	Neolithic F	The fill of a slightly irregular shaped pit, oval on plan view. Fill comprises mainly cobbles, stones and bone. Perhaps the defining characteristic of the loci is the number of small finds, encased in plaster.
BFV	Occuption deposit	B	Neolithic F	Occupation
BHL	Partly Natural - cliff erosion and some cultural material	B	Late Neolithic	Gravel deposits are characterised by gradual changes and differences. the differences are potentially mini-events within the mostly naturally derived gravels and so were excavated in spits.
BIA	General fill	B	Epiplaeolithic	Mix of occupation and rock face debris
BIB	General fill	B	Epiplaeolithic	Mix of occupation and rock face debris
BIE	General fill	B	Epiplaeolithic	Mix of occupation and rock face debris
BIF	General fill	B	Epiplaeolithic	Mix of occupation and rock face debris
BIH	General fill	B	Epiplaeolithic	Mix of occupation and rock face debris

Context	Interpretive Category	Area	Phase	Brief Description
BIJ	General fill	B	Epiplaeolithic	Mix of occupation and rock face debris
BIK	General fill	B	Epiplaeolithic	Mix of occupation and rock face debris
BIL	General fill	B	Epiplaeolithic	Mix of occupation and rock face debris
BIP	General fill	B	Epiplaeolithic	Possible hearth fill
BJY	Sediment dump	B	Late Neolithic	Fill of the structure/pit.
DCI	General fill	D	10/9th MBCE	Spit and plaster wall lining
DCL	General fill	D	10/9th MBCE	Spit taken from the area assumed to be the inside of the building (south of the vertical plaster). Even distribution of obsidian and bone throughout.
DFA	General fill	D	10/9th MBCE	DFA was the first clean area of 9th MM context encountered
DFH	Midden	D	10/9th MBCE	Midden deposit below Building 3
DFM	Midden	D	10/9th MBCE	Fill of a 9th MM pit. Rich in finds, especially broken animal bones and obsidian debitage.
DGK	Midden	D	10/9th MBCE	Midden preceding Building 3
DGL	Packing?	D	10/9th MBCE	Packing material with small amounts of stone, bone and obsidian. Sandwiched between two layers of wall plaster DGA and DGM
DGN	Midden	D	10/9th MBCE	Midden deposit below Building 3
DGS	General fill	D	10/9th MBCE	Spit overlaying a very thin red floor (DGU). The context also surrounds skeleton ZDS and comes down onto what may be a natural There is no apparent cut for the burial - but it must be later than red floor (DGU).
DGT	General fill	D	10/9th MBCE	Spit below DGS, east side. Arbitrary separated from DGS because of the presents of the cutless burial.
ZAM		Burial 6	10/9th MBCE	Fill of arbitrary grave cut around skeleton (ZAN). The percentage of stones appeared to be higher upon and beneath the skeleton. Numerous ground stones and obsidian flakes recovered. Animal bone was also recovered.
ZBB	Burial fill	B	Epiplaeolithic	Burial fill of Grave 13
ZBD	Burial fill	B	Epiplaeolithic	Burial fill of Grave

6.3.2 Number of Identified Specimens (NISP)

Numbers of Identified Specimens can be found in Table 6.50, with the NISP by taxa and context in Tables 6.51 and 6.52. Due to the separate phases of occupation being significantly different in date, contexts with a NISP over 50 were analysed further. However, each was analysed within the phase of occupation they pertained to, unless specified differently.

Table 6.50 Number of Identified Specimens (NISP) by context and corrected NISPs per litre

Context	NISP	Corrected NISP	Sample Volume (litres)	Nisp per Litre
ADJ	31	31	30	1.03
ADN	116	164	269	0.61
ADX	17	20	68	0.29
AER	25	25	52	0.48
AFA	73	73	72	1.01
AFC	23	23	49	0.47
AFI	25	25	57.5	0.43
AHA	29	29	73	0.4
BBH	4	4	76	0.05
BFV	2	2	10	0.2
BHL	26	26	50	0.52
BIA	143	143	136	1.05
BIB	122	122	45	2.71
BIE	308	320	73	4.38
BIF	81	99	47	2.11
BIH	556	819	180	4.55
BIJ	116	116	55	2.11
BIK	11	11	29	0.38
BIL	62	185	42	4.4
BIP	23	83	26	3.19
BJY	246	310	38	8.16
DCI	3	3	72	0.04
DCL	15	15	112	0.13
DFM	14	14	75	0.19
DGK	3	3	13	0.23
DGL	4	4	9	0.44
DGN	15	24	45	0.53
DGS	62	62	162.5	0.38
DGT	88	88	38.5	2.29
ZAM	23	23	73.5	0.31
ZBB	22	22	70	0.31

Table 6.51 Number of Identified Specimens (NISP) by taxa for each context; 7th millennium BCE and early Neolithic phases, including phase totals.

Context		Anura	*Pelophylax sp*	*Pelophylax ridibundus*	*Pelobates sp*	Rodent	*Arvicola amphibius*	Arvicolinae	*Microtus sp.*	*Microtus guentheri*	*Meriones sp.*	*Mesocricetus sp.*	*Cricetulus migratorius*	Murinae	*Mus sp.*	Spalacidae	*Crocidura sp.*	*Crocidura suaveolens*	Insectivora	*Pipistrellus sp.*	*Myotis myotis*	*Erinaceus concolor*	Snake	Micromammal	Microfauna	NISP
7th Millennium BCE	BBH	3																					1			**4**
	BDF	4				2		4						1									1	4		**16**
	BFV																					1		1		**2**
	BHL	11					2	3										1					24	3		**44**
	BJY	234	7			1									1								2	1		**246**
	Total	**252**	**7**			**3**	**2**	**7**						**1**	**1**			**1**				**1**	**28**	**9**		**312**
10th - 9th Millennium BCE	ADJ	14				1	1																38			**54**
	ADN	102	2			1	4	2															7	3		**121**
	ADX	13					1							1										2		**17**
	AER	22	2																				1			**25**
	AFA	62	2				3	2															2	2		**73**
	AFC	20						1															1	1		**23**
	AFI	21	2																			1	1	1		**26**
	AHA	28				1																				**29**
	ZAM	20	1			1		1																		**23**
	DCI	2																						1		**3**
	DCL	6			1	2																1	3	2		**15**
	DFA						1																			**1**
	DFH	2																								**2**
	DFM	17																					2	3		**22**
	DGK	2																						1		**3**
	DGL	4																								**4**
	DGN	14	1																							**15**
	DGS	66																					4	2		**72**
	DGT	80	1			1		2			1												2	1		**88**
	Total	**495**	**11**		**1**	**7**	**10**	**8**			**1**			**1**								**2**	**61**	**19**		**616**

Table 6.52 Number of Identified Specimens (NISP) by taxa for all contexts; Epipalaeolithic phase, and site totals for taxa.

Context		Anura	*Pelophylax sp*	*Pelophylax ridibundus*	*Pelobates sp*	Rodent	*Arvicola amphibius*	Arvicolinae	*Microtus sp.*	*Microtus guentheri*	*Meriones sp.*	*Mesocricetus sp.*	*Cricetulus migratorius*	Murinae	*Mus sp.*	Spalacidae	*Crocidura sp.*	*Crocidura suaveolens*	Insectivora	*Pipistrellus sp.*	*Myotis myotis*	*Erinaceus concolor*	Snake	Micromammal	Microfauna	NISP
14th - 12th Millennium BCE	BIA	61		1		8	6	7	1		1				1				1			1	38	15	2	**143**
	BIB	62	5	1		2		3															36	13		**122**
	BIE	66				23	7	25						1	1	1	1		1				198	78	3	**405**
	BIF	17				7	3	4						1		1							20	26	2	**81**
	BIH	23				39	6	32	5	4		1	1	2	1	1	5		2		1		370	61	2	**556**
	BIJ	1				6		8							1	1	2						72	25		**116**
	BIK	2																					8	1		**11**
	BIL	14				1	1	6						1									30	8	1	**62**
	BIP	1				2		3					1										11	5		**23**
	ZBB	1				3	1	11								1							5	14	1	**37**
	ZBD	2				1														1			28	6		**38**
	Total	**250**	**5**	**2**		**92**	**24**	**99**	**6**	**4**	**1**	**1**	**2**	**5**	**4**	**5**	**8**		**4**	**1**	**1**	**1**	**816**	**252**	**11**	**1594**
Site Total		**997**	**23**	**2**	**1**	**102**	**36**	**114**	**6**	**4**	**2**	**1**	**2**	**7**	**5**	**5**	**8**	**1**	**4**	**1**	**1**	**4**	**905**	**280**	**11**	**2522**

6.3.3 Species Composition

Species composition for the 7th millennium BCE deposits were dominated by anura, which formed 83% of the assemblage (Figure 7.28). Snake were the next most common taxon and were mainly represented by vertebrae. This is problematic for NISP counts because snakes can have over 200 vertebrae leading to inflated counts.

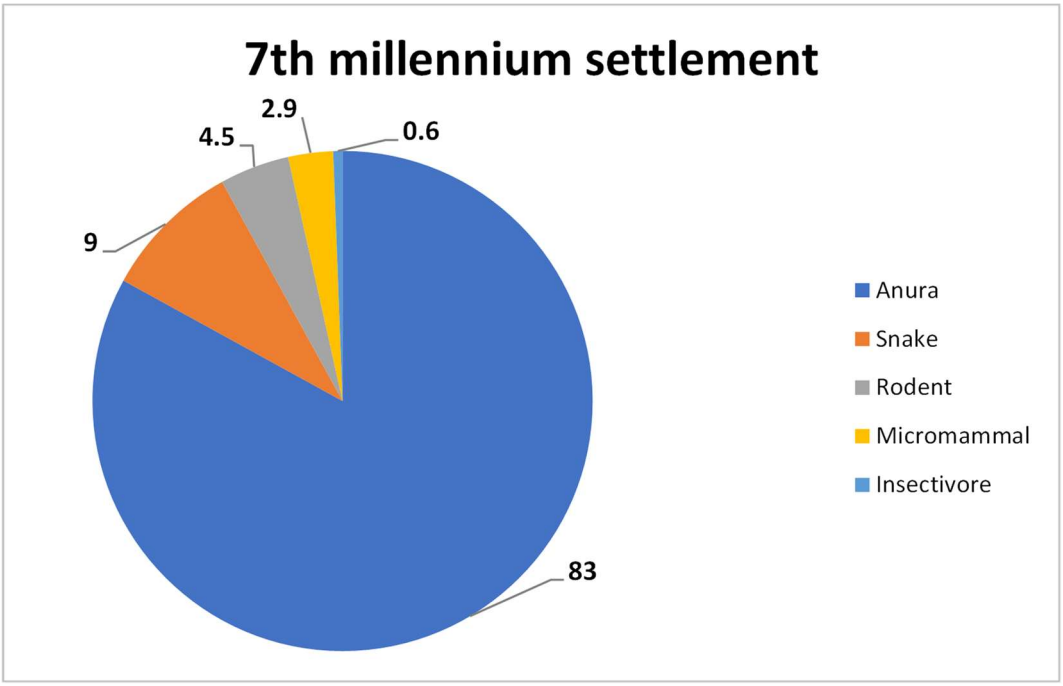

Figure 6.28 Percentages for taxonomic composition for the 7th millennium BCE settlement at Pınarbaşı. Higher classification groupings only by NISP. N=312.

Of the genera and species identified *Pelophylax* sp. represented 35% (Figure 6.29), with the other 65% made up of small mammals including *Erinaceus concolor*, *Crocidura suaveolens*, *Mus* sp., *Arvicola amphibius* and others. However, Arvicolinae are the most common forming 45% of the assemblage, including *A. amphibius* specimens. The NISP for each species for the 7th millennium BCE occupation phase can be found in Table 6.53.

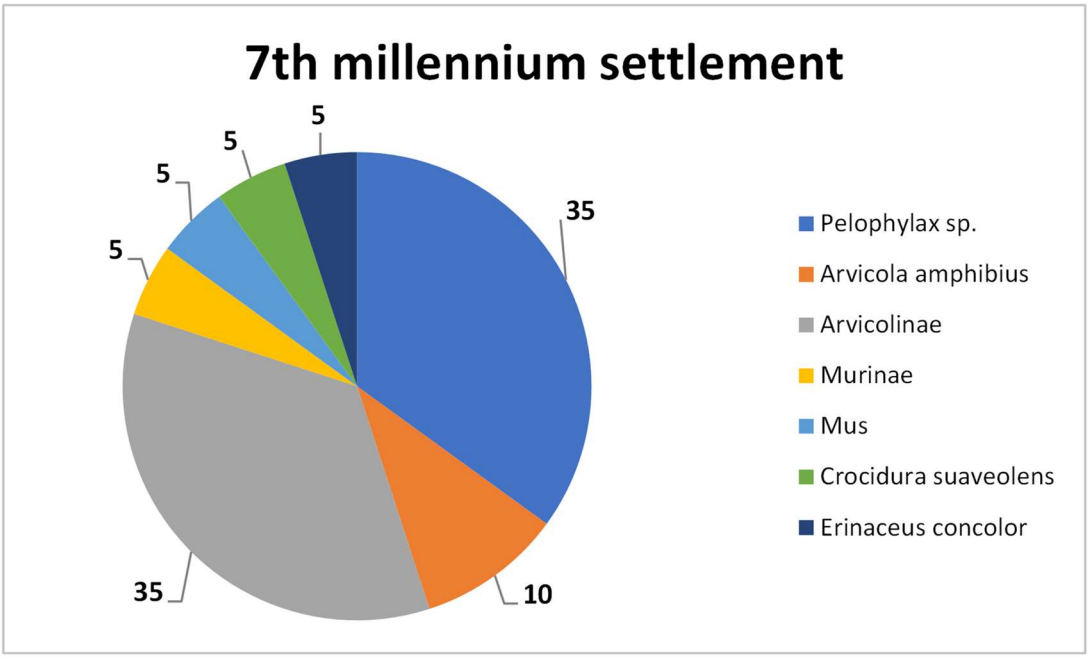

Figure 6.29 Percentages for taxonomic composition at genera and species level for the 7th millennium BCE settlement at Pınarbaşı, by NISP. N=100.

Table 6.53 NISP for taxa identified in the 7th millennium BCE deposits at Pınarbaşı.

7th millennium	
Taxa	**NISP**
Anuran	252
Pelophylax sp.	7
Rodent	3
Arvicola amphibius	2
Arvicolinae	7
Murinae	1
Mus sp.	1
Erinaceus concolor	1
Crocidura suaveolens	1
Micromammal	9
Snake	28
Total	**312**

The assemblage from the10th-9th millennium BCE (early Neolithic) occupation phases, is dominated by anura (82.3%), followed by snake (9.9%). Insectivores were represented only by *Erinaceus concolor* in both trenches (Figure 6.30).

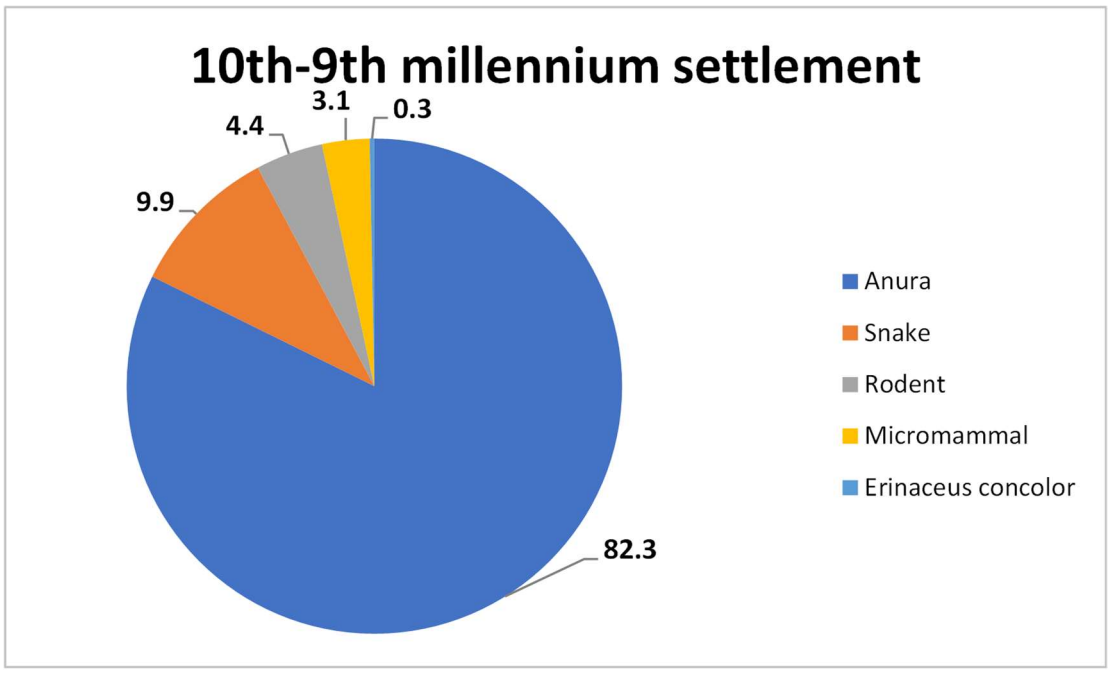

Figure 6.30 Percentages for taxonomic composition for the 10th-9th millennium BCE settlement at Pınarbaşı by NISP. N=616. Higher classification groupings only

The species found in the 10th-9th millennium phases are slightly more varied than in the 7th millennium phase (Figure 6.31), with additional species present such as *Pelobates* sp, and *Meriones* sp. However, the numbers of specimens identified to species level remain low (Table 6.54). Arvicolinae, including *A. amphibius*, dominate, forming 52.9% of the species assemblage, with *Pelophylax* sp. the next most common.

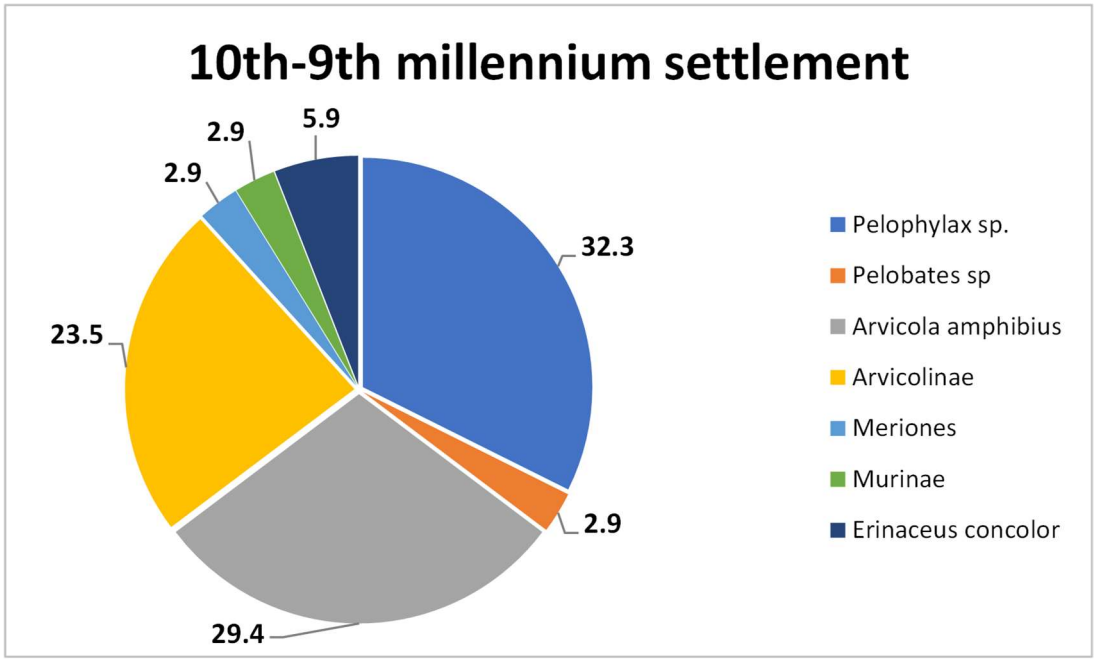

Figure 6.31 Percentages for taxonomic composition at genera and species level for the 10th-9th millennium BCE settlement at Pınarbaşı by NISP. N=34

Table 6.54 NISP for taxa identified in the 10th-9th millennium BCE deposits

10th-9th millennium			
Taxa (Trench A)	**NISP**	**Taxa (Trench D)**	**NISP**
Anuran	302	Anuran	193
Pelophylax sp.	9	*Pelophylax sp.*	2
		Pelobates sp.	1
Rodent	4	Rodent	3
Arvicola amphibius	9	*Arvicola amphibius*	1
Arvicolinae	6	Arvicolinae	2
Murinae	1	*Meriones sp.*	1
Erinaceus concolor	1	*Erinaceus concolor*	1
Micromammal	9	Micromammal	10
Snake	50	Snake	11
Total	**391**		**225**

The 14th-12th millennium BCE (Epipalaeolithic) phase, has a different microfaunal assemblage with the NISP dominated by snake (Figure 6.32). As mentioned above, due to the predominance of vertebrae in a snake skeleton, this taxon is most likely over-represented, although its dominance is still interesting.

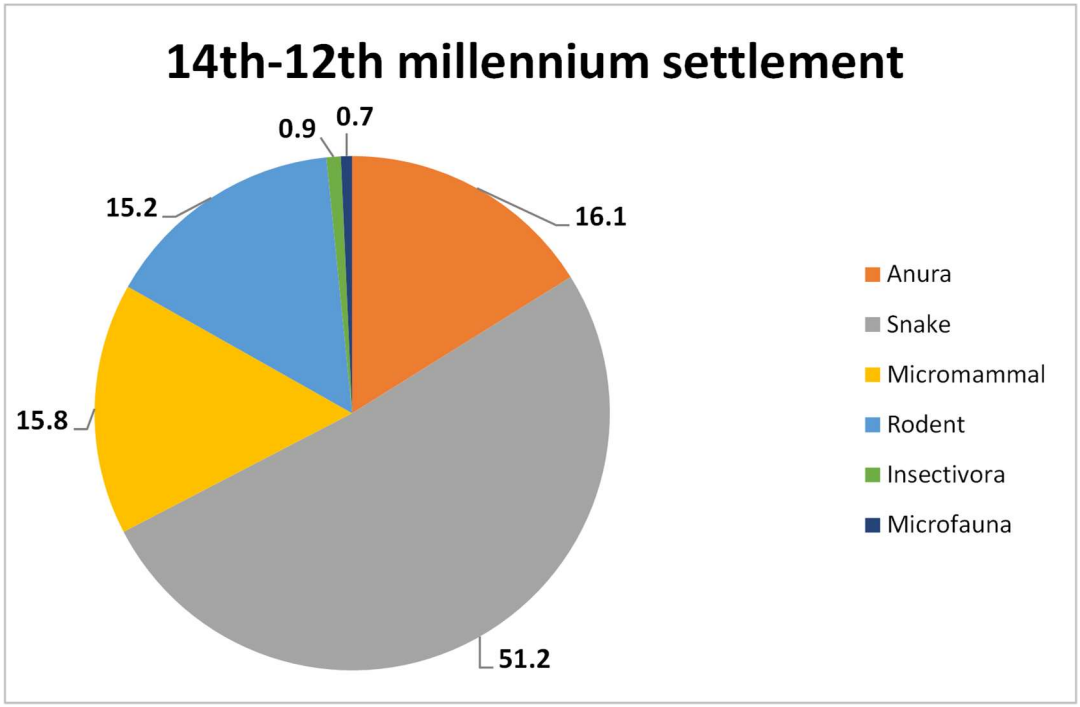

Figure 6.32 Percentages for taxonomic composition for the 14th-12th millennium BCE settlement at Pınarbaşı by NISP. N=1594. Higher classification groupings only

The Epipalaeolithic phase of occupation produced a much wider variety of microfauna, especially small mammals, although these are still dominated by Arvicolinae, which

form 78.8% of the identified species (Figure 6.33). Microfauna included gerbils/jirds, hamsters, mice, hedgehogs, and two species of bats, although all were present only in low numbers. The NISP for each species can be found in Table 6.55.

Several *Microtus* sp. specimens were identified as *Microtus guentheri*, but a single *Microtus* specimen (from BIH) appeared to belong to *M. levis* (formerly *M. rossiameridonalis*). However, no reference material was available to confirm the identification, so it was left as *Microtus* sp. Accordingly, the assumption that all *Microtus* sp. were *M. guentheri* was not made.

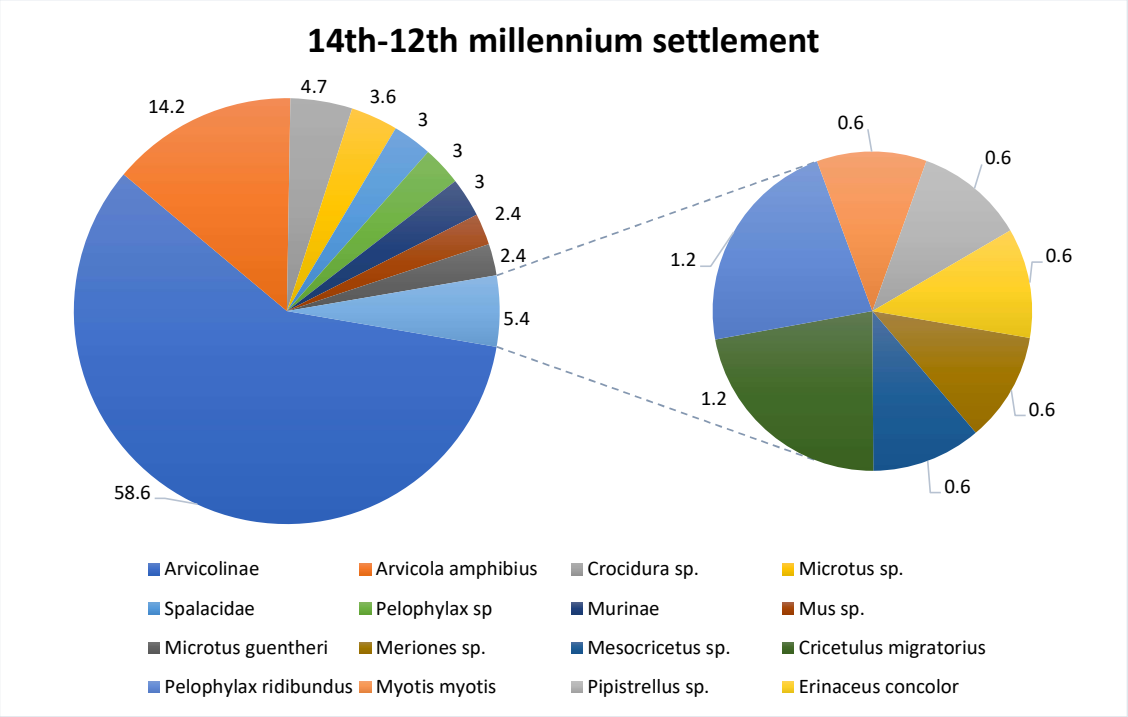

Figure 6.33 Percentages for taxonomic composition at genera and species level for the 14th-12th millennium BCE settlement at Pınarbaşı by NISP. N=169

Table 6.55 NISP for taxa identified in the 14th-12th millennium BCE deposits at Pınarbaşı.

14th-12th millennium	
Taxa	**NISP**
Anuran	250
Pelophylax sp.	5
Pelophylax ridibundus	2
Rodent	92
Arvicola amphibius	24
Arvicolinae	99
Microtus sp.	6
Microtus guentheri	4
Meriones sp.	1
Mesocricetus sp.	1
Cricetulus migratorius	2
Murinae	5
Mus sp.	4
Spalacidae	5
Crocidura sp.	8
Insectivora	4
Pipistrellus sp.	1
Myotis myotis	1
Erinaceus concolor	1
Snake	816
Micromammal	252
Microfauna	11
Total	**1594**

6.3.4 Microfauna by context interpretive category

As was the case for the assemblages from the other sites, an adjusted NISP per litre was calculated based on the sample percentage and volume of samples processed (Table 6.50). NISPs for each taxa by context can be found in Tables 6.51 and 6.52.

The 7th millennium BCE occupation

Only five contexts were analysed from this phase of occupation, each with different interpretive categories, except for BDF and BJY, which were both interpreted as dumps. Unfortunately, flotation information for BDF was unavailable and so no NISP per litre could be calculated. Microfauna occurred at generally low levels throughout the contexts, with NISP per litre values ranging from 0.05 to 8.16. The lowest NISP per litre value was from general fill, BBH. However, as this sample was obtained from cleaning of the section, it is possible that the sample is unrepresentative of the whole context and why the density value is so low. This category contained only anura and a single specimen of snake. The highest value is from sediment dump, BJY, also

described as the fill of a pit. Elements consisted primarily of anura, with low numbers of micromammals, including *Mus* sp., and snake. Occupation deposit, BFV, had a NISP per litre of 0.2 and its assemblage consisted of a single specimen of *Erinaceus concolor* and a micromammal. BHL, interpreted as cliff erosion material with occupational debris, had a NISP per litre of 0.52 which was predominantly made up of snake and anura remains, with low numbers of small mammals.

The 10th-9th millennium BCE occupation

For this phase of occupation, 19 contexts were analysed across both Trenches A and D. The largest interpretive category was general fill, with 10 contexts belonging to this group; ADN, ADX, AFA, AFC, AFI, DCI. DCL, DFA, DGS, and DGT. The NISP per litre ranged from 0.04 to 2.29, and had an average adjusted NISP per litre of 0.53. Unfortunately, there was no flotation information available for context DFA, and so this context was not included in these calculations. The assemblage consisted mostly of anura, including *Pelophylax* sp., as well as *Pelobates* sp. The micromammal assemblage mostly comprised Arvicolinae, although a single specimen of *Meriones* sp. was also recovered, as well as a specimen of Murinae. *Erinaceus concolor* was also represented, as well as snake.

Five contexts were interpreted as middens (AHA, DFH, DFM, DGK, and DGN). The NISP per litre for this category ranged from 0.19 to 0.53 and had an average adjusted NISP per litre of 0.34. The microfaunal assemblage was made up primarily of anura including *Pelophylax* sp., with very low numbers of snake and micromammals, none of which were identified to species or genera.

ADJ was interpreted as a cobble spread, with bone material recovered from between the cobbles. It had an adjusted NISP per litre of 1.03. This context contained a high number of snake specimens, followed by anura, with very few small mammal remains. A single specimen of *Arvicola amphibius* was identified. AER was interpreted as pit fill, with an adjusted NISP per litre of 0.48. Again, this context was dominated by anura, including *Pelophylax* sp., plus a single specimen of snake. ZAM was a burial fill and had an adjusted NISP per litre of 0.31. The microfaunal assemblage consisted of anura, including *Pelophylax* sp. and a very low number of rodents, including a single specimen identified as Arvicolinae. DGL was identified as packing material from between two

layers of wall plaster. It had an adjusted NISP per litre of 0.44 and produced four specimens of anura only.

The 14th-12th millennium BCE occupation

The Epipalaeolithic phase of occupation was represented by thin lenses of occupation debris and rock shelter collapse. The majority of contexts were given the interpretive category of general fill, as each context was likely to represent periods of human occupation as well as abandonment. These contexts were BIA, BIB, BIE, BIF, BIH, BIJ, BIK, BIL, and BIP. The NISP per litre from these contexts ranged from 0.38 to 4.55, with an adjusted NISP per litre of 2.9. Context BIP, as well as being interpreted as general fill, was specifically noted as being the fill of a hearth and it produced a NISP per litre of 3.19. The microfaunal assemblage from the general fills in the Epipalaeolithic levels was much more diverse than in other phases and was dominated by snake, followed by micromammals, and then anura. The micromammal assemblage included *Arvicola amphibius*, *Microtus* sp., *Microtus guentheri*, *Meriones* sp., *Mesocricetus* sp., *Cricetulus migratorius*, *Mus* sp., *Crocidura* sp., *Crocidura suaveolens*, *Erinaceus concolor*, Spalacidae, as well as a species of bat, *Myotis myotis*. The anuran assemblage included *Pelophylax ridibundus*, as well as *Pelophylax* sp.

Two additional contexts, ZBB and ZBD were burial fills. Unfortunately, no flotation information was available for ZBD so there is no NISP per litre for this context, ZBB had an NISP per litre of 0.31. The fill of these two contexts contained approximately equal numbers of snake and small mammals, as well as low numbers of anura. The small mammals included *Arvicola amphibius*, other Arvicolinae, Spalacidae, and a single species of bat, *Pipistrellus* sp.

6.3.5 Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI)

MNEs were calculated for each context based on species, element, side of element and the numbers of zones present. Anura MNEs were limited to cranial and zoned elements, excluding the mandible and maxilla due to the high levels of fragmentation of these elements. MNIs were then calculated based on the highest MNE for each group, excluding the 'micromammals' or 'microfauna' categories (Table 6.56).

Table 6.56 Minimum Numbers of Individuals (MNI) for all contexts at Pınarbaşı. Contexts separated into phases with 7th millennium at top to Epipalaeolithic at bottom of table.

Context	Anura	*Pelophylax sp*	*Pelophylax ridibundus*	*Pelobates sp*	Rodent	*Arvicola amphibius*	Arvicolinae	*Microtus sp.*	*Microtus guentheri*	*Meriones sp.*	*Mesocricetus sp.*	*Cricetulus migratorius*	Murinae	*Mus sp.*	Spalacidae	*Crocidura sp.*	*Crocidura suaveolens*	Insectivora	*Pipistrellus sp.*	*Myotis myotis*	*Erinaceus concolor*	Snake	NISP
BBH	1																					1	4
BDF	1				1		1						1									1	16
BFV																					1		2
BHL	1					1	2										1					1	44
BJY	11	4			1									1								1	246
ADJ	1				1	1																1	54
ADN	14	1			1	2	1															1	121
ADX	1					1							1										17
AER	3	2																				1	25
AFA	7	2				1	1															1	73
AFC	1						1															1	23
AFI	4	1																			1	1	26
AHA	2				1																		29
ZAM	3	1			1		1																23
DCI	1																						3
DCL	2			1	1																1	1	15
DFA						1																	1
DFH	1																						2
DFM	3																					1	22
DGK	1																						3
DGL	2																						4
DGN	2																					1	15
DGS	7																					1	72
DGT	8	1			1		1			1												1	88
BIA	4		1		1	1	2	1		1				1				1			1	1	143
BIB	4	3	1		1		1															1	122
BIE	4				3	1	4						1	1	1	1		1				1	405
BIF	2				2	1	1						1		1							1	81
BIH	3				5	1	7	2	1		1	1	1	1	1	1		1		1		2	556
BIJ	1				1		2							1	1	2						1	116
BIK	1																					1	11
BIL	1				1	1	1						1									1	62
BIP	1				1		2					1										1	23
ZBB	1				1	1	6								1							1	37
ZBD	1				1														1			1	38

MNI counts for species represented by only a single, or a few elements per context may be inflated, but they have been included to show where they occur. Also, specimens identified in the higher taxonomic grouping, such as anura or rodent, may have belonged to the same animals identified to species level, and so these numbers have not been amalgamated

6.3.6 Body Part Representation

Body part representation, as analysed for Çatalhöyük and Boncuklu was not possible for the assemblage from Pınarbaşı, due to the low MNIs for all contexts and taxa across the site (Table 6.56). Only two contexts had an MNI greater than 10 for any species which were anura in both cases. BJY had an MNI of 11, and ADN had an MNI of 14. These contexts came from different phases, so the decision was made not to carry out body part analyses by MNE for this site.

Instead, calculations for anura only, were made based on NISP (Figure 6.34). Although this is a less accurate way of calculating body part representation, due to the potential for breakage leading to higher numbers for some elements, it does allow for comparison between phases which should be subject to the same, or similar, environmental processes.

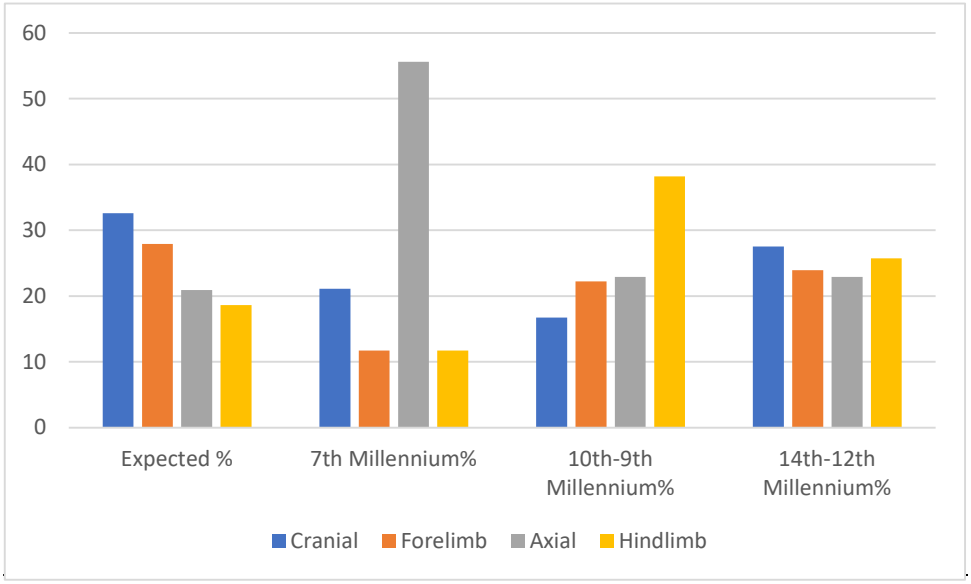

Figure 6.34 Body Part Representation for anura (excluding toad), for all contexts by phase at Pınarbaşı.

Percentages for the different body categories for each phase shows a hindlimb bias in the 10th-9th Millennium phase, as well as a higher-than-expected value for the 14th-12th Millennium phase.

6.3.7 Fragmentation

Levels of fragmentation were analysed to assess the overall state of the assemblage and to potentially aid in predator identification. Fragmentation was analysed for the humeri, ulnae, femora, and tibiae in rodents, and the humeri, radio-ulnae, urostyle, ilia, and tibio-fibulae in anurans. Both the extent to which the specimens were fragmented, as well as the portion of the bone that survived were recorded, for example less than 1/3 versus complete, and proximal or distal. In the case of anura, zones rather than proximal versus distal were analysed to establish which areas of the bones were represented.

Due to the small number of micromammals in other phases of occupation, fragmentation was only analysed for the Epipalaeolithic levels (excluding insectivores) and the contexts were combined. This is therefore a broad analysis of fragmentation encompassing the whole of the Epipalaeolithic assemblage, rather than a more detailed context-based analysis.

Table 6.57 Post-cranial fragmentation in rodents examining the differential recovery of parts of each specimen at Pınarbaşı.

Rodents (14th-12th millennium)		
Element	**N**	**%**
Humerus		
Complete	2	3.2
Proximal	10	16.1
Shaft only	21	33.9
Distal	29	46.8
Ulna		
Complete		
Proximal	9	81.8
Shaft only	2	18.2
Distal		
Femur		
Complete		
Proximal	30	57.7
Shaft only	7	13.5
Distal	15	28.8
Tibia		
Complete		
Proximal	2	9.1
Shaft only	8	36.4
Distal	12	54.5

The 'portion' of the bone best represented for each element is generally the one which fuses first. Despite long bone fusion not being related to age in micromammals, the distal humerus epiphysis appears to fuse in advance of the proximal epiphysis. In contrast, the proximal femoral epiphysis generally fuses before the distal epiphysis, leading to an increase in the diagnostic features from this structurally stronger part of the element. For the Epipalaeolithic (Table 6.57), rodent humeri are best represented by the distal end, followed by shaft, with numbers decreasing towards the proximal end. For the femora the reverse is true, with higher numbers of proximal ends, few shafts, which are difficult to identify, and half the number of distal ends compared to proximal. The ulnae are represented predominately by proximal ends, which have diagnostic features making them easy to identify, with no distal ends recorded. The tibiae are represented mostly by distal ends followed by shaft fragments, which are highly identifiable throughout their length.

Table 6.58 Post-cranial fragmentation for rodents examining the percentage category of each specimen at Pınarbaşı.

Rodents (14th-12th millennium)			
Element	**Category**	**N**	**%**
Humerus	Less than 1/3	13	21
NISP: 62	1/3 - 2/3	35	56.5
	More than 2/3	4	6.5
	Complete	2	3.2
	Epiphysis	8	12.9
Ulna	Less than 1/3	3	27.3
NISP: 11	1/3 - 2/3	8	72.7
	More than 2/3		
	Complete		
	Epiphysis		
Femur	Less than 1/3	16	30.8
NISP: 52	1/3 - 2/3	19	36.5
	More than 2/3	3	5.8
	Complete		
	Epiphysis	14	26.9
Tibia	Less than 1/3	5	22.7
NISP: 22	1/3 - 2/3	15	68.2
	More than 2/3		
	Complete		
	Epiphysis	2	9.1

Only two complete post-cranial elements were recorded (Table 6.58), with none recorded for ulnae, femora, or tibiae. The 1/3 to 2/3 size category was the best represented for each of the elements, with few examples assigned to the more than 2/3 category. Proximal humeri and distal femoral epiphyses were also present, both being robust parts of elements even before fusion, as well as being easily identifiable. The less than 1/3 size category was relatively high with between 21% and 30% of specimens falling into this category.

Table 6.59 Maxillary breakage for all contexts with rodent maxilla present at Pınarbaşı (Insectivores not included)

	Complete, with zygomatic region		**Broken with zygomatic intact**		**Maxilla fragment lacking the zygomatic process**		**Palate fragment**	
Context	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
BDF					1	100		
BHL					1	50	1	50
ADJ							1	100
BIH					2	50	2	50
BIL							1	100

Due to the low numbers of maxilla and mandibles, cranial breakage was calculated from the overall totals from all contexts. Levels of maxillary breakage was high (Table 6.59), with all maxillae being heavily fragmented. All palate fragments were identified as Arvicolinae, and these were recovered more often than maxillae, most likely due to the nature of arvicoline teeth and the lack of a robust bone structure around the alveolar spaces. The patterns of maxillary breakage remain the same through all phases of occupation, although sample sizes for each phase are small, with two contexts from the 7th millennium BCE phase, BDF and BHL; one context from the 10th-9th millennium BCE phase, ADJ; and two from the Epipalaeolithic phase, contexts BIH and BIL.

Mandibular breakage is more varied than maxillary breakage due to the more robust nature of the element. For the majority of contexts, breakage levels were high, with most mandibles being heavily fragmented with the ascending ramus missing and the inferior border broken (Table 6.60). Numbers of mandibles represented only by symphyses were also high.

The 7th millennium BCE phase was represented by only three contexts, none of which produced any complete elements. Although both BDF and BJY had broken elements, BHL had a higher degree of breakage, and numbers of mandibles in this phase were low.

The 10th-9th millennium BCE phase had more mandibles than maxillae, with seven contexts containing these elements. This phase included the only complete mandible from Trench D. Breakage was still high, with the majority of mandibles being heavily fragmented.

The Epipalaeolithic phase showed a more variable degree of fragmentation, although the majority of mandibles were still heavily fragmented. They also included a number of broken symphyses, again indicating high levels of breakage. Four mandibles were recorded as missing the ascending ramus, and three consisting only of the ascending ramus were recovered.

Table 6.60 Mandibular breakage for all contexts containing rodent mandibles at Pınarbaşı (insectivores not included)

	Complete		Broken ascending ramus		Ascending ramus missing		Ascending ramus missing and inferior border broken		Symphysis only		Ascending ramus only	
Context	N	%	N	%	N	%	N	%	N	%	N	%
BDF			1	100								
BHL							2	100				
BJY					1	100						
ADN									1	100		
ADX			1	100								
AFA							2	100				
AFC							1	100				
AHA											1	100
ZAM							1	100				
DFA	1	100										
BIA							2	66.7	1	33.3		
BIB							1	100				
BIE					1	12.5			6	75	1	12.5
BIF			1	16.7			2	33.3	1	16.7	2	33.3
BIH			1	6.3	2	12.5	7	43.8	6	37.5		
BIJ					1	50	1	50				
BIL			1	100								
ZBB							1	50	1	50		

Post-cranial breakage in anura is high with most bones in the majority of contexts having breakage levels in the 1/3 to 2/3 category, with very few complete elements. Fragments that were less than 1/3 complete were the next highest category, and in some contexts for certain elements specimens of this small size outnumbered the 1/3 to 2/3 category (Table 6.61).

The 7th millennium BCE anura breakage levels were based on a single context, BJY, which contained the only complete element. This assemblage was less fragmented than the others as it also had elements in the more than 2/3 category, not seen in the rest of the assemblage.

Table 6.61 Post-cranial fragmentation categories for anura, for all contexts with a NISP over 50 at Pınarbaşı.

		7th Millennium		10th - 9th Millennium								14th - 12th Millennium									
		BJY		ADN		AFA		DGS		DGT		BIA		BIB		BIE		BIF		BIH	
Element	Category	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Humerus	Less than 1/3			2	25	4	36.4	1	20	2	50	1	100	1	33.3	1	100			1	100
	1/3 - 2/3	2	40	6	75	7	63.6	4	80	2	50			2	66.7			2	100		
	More than 2/3	2	40																		
	Complete	1	20																		
Radio-ulna	Less than 1/3			2	100					1	50	1	50	3	37.5						
	1/3 - 2/3	1	50			2	100			1	50	1	50	5	62.5	2	100	1	100	1	100
	More than 2/3	1	50																		
	Complete																				
Urostyle	Less than 1/3							1	20	4	80			3	100						
	1/3 - 2/3	3	100	4	100	3	100	4	80	1	20	4	100			2	100	1	100	1	100
	More than 2/3																				
	Complete																				
Ilium	Less than 1/3			8	30.8	2	16.7	5	33.3	7	70	6	100	4	100	8	66.7	2	66.7	2	50
	1/3 - 2/3	5	100	18	69.2	10	83.3	10	66.7	3	30					4	33.3	1	33.3	2	50
	More than 2/3																				
	Complete																				
Tibio-fibula	Less than 1/3					1	50	1	50	2	66.7	1	50			1	25			2	66.7
	1/3 - 2/3	6	100	2	100	1	50	1	50	1	33.3	1	50			3	75			1	33.3
	More than 2/3																				
	Complete																				

Table 6.62 Post-cranial fragmentation categories based on zones for anura, for all contexts with a NISP over 50 at Pınarbaşı.

		7th Millennium		10th - 9th Millennium								14th - 12th Millennium									
		BJY		ADN		AFA		DGS		DGT		BIA		BIB		BIE		BIF		BIH	
Element	Category	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Humerus	Zone 1	5	27.8	6	37.5	9	32.1	5	45.5	4	50	1	50	2	28.6			2	33.3		
	Zone 2	5	27.8	3	18.8	8	28.6	3	27.3	3	37.5	1	50	3	42.9			2	33.3		
	Zone 3	5	27.8	6	37.5	7	25	3	27.3	1	12.5			2	28.6	1	100	2	33.3	1	100
	Zone 4	3	16.7	1	6.3	4	14.3														
Radio-ulna	Zone 1	2	28.6	2	50	2	33.3			2	40	2	40	8	38.1	1	33.3	1	33.3	1	33.3
	Zone 2	2	28.6	2	50	2	33.3			2	40	2	40	8	38.1	1	33.3	1	33.3	1	33.3
	Zone 3	2	28.6			2	33.3			1	20	1	20	5	23.8	1	33.3	1	33.3	1	33.3
	Zone 4	1	14.3																		
Urostyle	Zone 1	3	27.3	4	36.4	3	42.9	4	33.3	4	36.4	3	42.9	3	60	2	40	1	25	1	50
	Zone 2	3	27.3	4	36.4	3	42.9	5	41.7	4	36.4	4	57.1	2	40	2	40	1	25	1	50
	Zone 3	3	27.3	1	9.1			2	16.7	2	18.2					1	20	1	25		
	Zone 4	2	18.2	1	9.1			1	8.3	1	9.1							1	25		
	Zone 5			1	9.1	1	14.3														
	Zone 6																				
Ilium	Zone 1	4	21.1	1	2.6	2	8.3	3	13	1	8.3					4	23.5				
	Zone 2	5	26.3	23	59	12	50	13	56.5	10	83.3			4	40	7	41.2	1	25	3	50
	Zone 3	5	26.3	1	2.6	2	8.3							3	30						
	Zone 4	5	26.3	13	33.3	8	33.3	7	30.4	1	8.3			3	30	6	35.3	3	75	2	33.3
	Zone 5			1	2.6															1	16.7

Breakage data from the 10th-9th millennium BCE phase were derived from four contexts, with the majority of specimens falling into the 1/3 to 2/3 category. The assemblage from DGT was more fragmentary, containing higher percentages of the less than 1/3 category.

The Epipalaeolithic anuran assemblage was also fragmentary, with no elements more than 2/3 complete. Some elements, such as the ilia and humeri were more fragmented than in other phases, but the radio-ulna and urostyle had patterns of breakage similar to those in the early Neolithic phases.

When anuran bone breakage was analysed by zone (Table 6.62), the pattern reflects the bias towards the survival of the most robust and diagnostic parts of the elements. For reasons discussed previously, the tibio-fibulae were not included. The distal end of the humerus is much more robust than the proximal end, being one of the few elements to have a bony, rather than cartilaginous end. Accordingly, the distal end of this element is more abundant than the proximal, a pattern seen in all phases of occupation. In addition to being robust it is also highly recognisable, making its recovery from flotation more likely. The same bias can be seen for the proximal radio-ulnae, another element with a bony end, whereas the distal end is cartilaginous. The anterior aspect of the urostyle, is also well represented. Variations between the numbers of zones per element suggest an increase in fragmentation in the earlier phases. The 7th millennium BCE phase, represented by BJY, has a less fragmentary anuran assemblage as indicated by a more even representation of the different zones of the elements. Conversely, the greater disparity of zones of the elements in the 10th-9th millennium BCE anuran assemblage reflects a more fragmentary assemblage. The Epipalaeolithic assemblage consists of very few specimens which limits any patterns emerging from the zoning data, other than the likelihood of survival increased for robust parts of elements.

6.3.8 Burning

A total of 147 elements across all phases of occupation were recorded as burnt, with taxa affected listed in Table 6.63. Anurans constituted 78.2% of the burnt assemblage, with micromammals and snakes forming 8.8% and 8.2% of the burnt remains respectively. Other taxa that exhibited burning contributed between 0.7% and 2.0% of the burnt elements. No burning was recorded for any insectivores, or any small mammal identified to species.

Table 6.63 Burning by taxa for all phases of occupation of the site

Taxa	Taxa NISP	Burnt NISP	% Burnt by taxa	% Burnt assemblage
Anuran	997	115	11.5	78.2
Pelophylax sp	23	1	4.3	0.7
Rodent	102	3	2.9	2
Arvicolinae	114	3	2.6	2
Micromammal	280	13	4.6	8.8
Snake	905	12	1.3	8.2
Site Total	**2522**	**147**		**5.8**

Both the type of burning and the colour of the burnt elements were recorded and the data can be seen in Tables 6.64 and 6.65 respectively. With regards to the burning type, 89.1% were recorded as having been burnt throughout the whole bone. No elements were recorded as calcined.

Table 6.64 Burn type for all phases of occupation of the site

Burn type	NISP	% Burn type
Slightly burnt	1	0.7
Partly burnt	15	10.2
Burnt	131	89.1
Partly calcined	0	0

The colour range of the burnt elements was recorded to indicate temperatures to which the elements have been exposed. The colour range of the burnt elements was more varied, with black the predominant colour at 45.6%, followed by brown at 24.5%. As the colours move from blue to white, suggesting an increase in temperature, the percentage of each category decreased.

Table 6.65 Burning by colour for phases of occupation of the site

Burnt colour	NISP	% burnt by colour
Brown	36	24.5
Black	67	45.6
Blue	17	11.6
Dark Grey	14	9.5
Light grey	7	4.8
White	6	4.1

The NISP and percentage of burnt specimens by taxa and context were also analysed. Only two specimens (one anuran and one micromammal) from 7th millennium BCE contexts were burnt, giving a percentage of burnt specimens for this phase of 0.6% (Table 6.66). The bones from the Epipalaeolithic levels show a higher level of burning than those in the later Neolithic levels, but the numbers are still quite low at 3.5% (Table 6.66). Anura bones exhibit the most burning in the Epipalaeolithic deposits. 12.8% of their elements were burnt, with percentages in individual contexts ranging from 5.9% to 16.7%. 3.3% of the rodent bones were also burnt followed by micromammals (2.8%), Arvicolinae (2.0%), and snake (1.3%). The 10th-9th millennium BCE phase had the largest burnt assemblage, with 90 specimens, representing 14.6% of the taxa from this phase (Table 6.67).

Anura provided the highest NISP of burnt specimens, but micromammals had the highest percentage (26.3%) by taxonomic group. Percentages of burnt bones in the *Pelophylax* sp., micromammal, Arvicolinae, and snake assemblages were all high, ranging from 1.6% to 26.3%, but some of these are based on very small samples. Burning frequencies for anura ranges from 7.1% to 50.0% in the different contexts, although some of these assemblages are also small.

Table 6.66 Burning by taxa and context for the 7th millennium BCE phase and the Epipalaeolithic phase at Pınarbaşı

	Anura			*Pelophylax* sp			Micromammal			Arvicolinae			Rodent			Snake			Context Total		
	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%
BBH	3																		4	0	0
BDF	4						4	1	25										16	1	6.3
BFV							1												2	0	0
BHL	11						3												44	0	0
BJY	234	1	0.4				1												246	1	0.4
7th Mil.	**252**	**1**	**0.4**				**9**	**1**	**11.1**										**312**	**2**	**0.6**
BIA	61	8	13.1				15			7	2	28.6	8			38			143	10	7
BIB	62	10	16.1				13			3			2			36	1	2.8	122	11	9
BIE	66	11	16.7				78	1	1.3	25			23	1	4.3	198	5	2.5	405	18	4.4
BIF	17	1	5.9				26	3	11.5	4			7	1	14.3	20			81	5	6.2
BIH	23	2	8.7				61	1	1.6	32			39			370	3	0.8	556	6	1.1
BIJ	1						25	1	4	8			6			72	2	2.8	116	3	2.6
BIK	2						1									8			11	0	0
BIL	14						8			6			1			30			62	0	0
BIP	1						4			3			2			11			23	0	0
ZBB	1						14	1	7.1	11			3	1	33.3	5			37	2	5.4
ZBD	2						6						1			28			38	0	0
14th-12th Mil.	**250**	**32**	**12.8**				**251**	**7**	**2.8**	**99**	**2**	**2**	**92**	**3**	**3.3**	**816**	**11**	**1.3**	**1594**	**55**	**3.5**

Table 6.67 Burning by taxa and context for the 10th-9th millennium BCE phase at Pınarbaşı

	Anura			*Pelophylax* sp			Micromammal			Arvicolinae			Rodent			Snake			Context Total		
	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%	NISP	N	%
ADJ	14	1	7.1													38			54	1	1.9
ADN	102	38	37.3	2	1	50	3	1	33.3	2						7	1	14.3	121	41	33.8
ADX	13	1	7.7				2												17	1	5.9
AER	22	2	9.1	2												1			25	2	8
AFA	62	8	12.9	2			2	1	33.3	2						2			73	9	12.3
AFC	20	3	15				1			1						1			23	3	13
AFI	21	2	9.5	2			1									1			26	2	7.7
AHA	28	2	7.1																29	2	6.9
ZAM	20	5	25	1						1									23	5	20
DCI	2	1	50				1	1	100										3	2	66.6
DCL	6						2	1	50							3			15	1	6.7
DFA																			1	0	0
DFH	2	1	50																2	1	50
DFM	17						3	1	33.3							2			22	1	4.5
DGK	2						1												3	0	0
DGL	4	1	25																4	1	25
DGN	14	1	7.1	1															15	1	6.7
DGS	66	6	9.1				2									4			72	6	8.3
DGT	80	10	12.5	1			1			2	1	50				2			88	11	12.5
10th-9th Mil.	**495**	**82**	**16.6**	**11**	**1**	**9.1**	**19**	**5**	**26.3**	**8**	**1**	**12.5**				**61**	**1**	**1.6**	**616**	**90**	**14.6**

Anura elements were further examined in order to determine whether there were variations in burning frequencies between different elements (Table 6.68). Elements from all areas of the body were represented in the burnt assemblage. Ilia were the most commonly burnt of all elements, making up 25.2% of the burnt assemblage, with 22.1% of all ilia being burnt, but by percentage of burnt elements by element type, the sphenethmoid, was the element most affected, with 32.4% of all sphenethmoids showing evidence of burning, although this element only made up 9.6% of the burnt assemblage. Only a single ilium of Pelophylax sp. was recorded as burnt.

Table 6.68 Burning by element for anura and Pelophylax sp., for the whole assemblage at Pınarbaşı (occipital (NISP=2) and exoccipital (NISP=24) elements)*

	Anura				Pelophylax sp			
Elements in anuran	NISP	N. Burnt	% Ele Burnt	% of Burnt elements	NISP	N. Burnt	% Ele Burnt	% of Burnt elements
Premaxilla	6	1	16.6	0.9				
Maxilla with teeth	51	10	16.6	8.7				
Mandible without teeth	42	6	14.2	5.2				
Frontoparietal	7	2	28.6	1.7				
Parasphenoid								
Sphenethmoid	34	11	32.4	9.6	3			
Pterygoid	13				1			
Squamosal	11							
Skull*	26	1	3.8	0.9				
Clavicle								
Sternum	8							
Scapula	32	1	3.1	0.9	9			
Humerus	57	4	7	3.5				
Radio-Ulna	31	1	3.2	0.9				
Coracoid	31	2	6.5	1.7				
Atlas	12							
Axis	1							
Vertebra	195	5	2.5	4.3				
Sacrum	37	2	5.4	1.7				
Urostyle	34	3	8.8	2.6				
Ilium	131	29	22.1	25.2	10	1	10	100
Ischium	8							
Femur	18	2	11.1	1.7				
Tibio-Fibula	42	4	9.5	3.5				
Tarsals	24							
Astragalus								
Metapodials	88	18	20.5	15.7				
Phalanges	58	13	22.4	11.3				
Total	**997**	**115**		**11.5**	**23**	**1**		**4.3**

The hindlimbs were found to be the most commonly affected elements (33%) by burning in anura, (Table 6.69). Cranial and podial elements were the next most affected

at 27% each. The forelimb and axial skeletal categories were not well represented, at 7% and 6.1% respectively. Despite hindlimbs being the most affected category in the burnt assemblage, only 16.3% of hindlimb elements were burnt.

Table 6.69 Burning by body part categories for anura and Pelophylax sp. at Pınarbaşı

	Anura				Pelophylax sp			
	Site NISP	N. Burnt	% Burnt category	% burnt assemblage	Site NISP	N. Burnt	% Burnt category	% burnt assemblage
Cranial	190	31	16.3	27	4	0	0	
Forelimb	159	8	5	7	9	0	0	
Axial	245	7	2.9	6.1	N/A	N/A	N/A	
Hind limb	233	38	16.3	33	10	1	10	100
Podials	170	31	18.2	27	N/A	N/A	N/A	
Total	**997**	**115**		**11.5**	**23**	**1**		**4.3**

Rodents make up only 12.9% of the burnt assemblage including specimens identified as Arvicolinae, rodent, and micromammal, and the majority of burnt specimens were micromammals (Table 6.63). Burning by element was analysed to see if there were variations in burning frequencies in small mammal (Table 6.70). Two of the three burnt *Arvicolinae* elements were molars and there were also two burnt rodent cranial elements and a burnt rodent femur. Micromammal taxa represented the majority of the post-cranial burnt assemblage, with tibiae and phalanges being the most affected elements, both making up 23.1% each of the burnt assemblage, with 17.6% of all tibiae and 9.7% of all phalanges burnt.

Table 6.70 Burning by element for small mammals, excluding insectivores, at Pınarbaşı.

Elements in small mammals	Arvicolinae				Rodent				Micromammal			
	NISP	N. Burnt	% Ele Burnt	% Burnt assemblage	NISP	N. Burnt	% Ele Burnt	% Burnt assemblage	NISP	N. Burnt	% Ele Burnt	% Burnt assemblage
Molar	66	2	3	66.7								
Incisor					47	1	2.1	33.3	1			
Skull fragments					8				1			
Premaxilla					1							
Maxilla	4											
Palate fragment	21	1	4.8	33.3								
Mandible	31				3	1	33.3	33.3	5	1	20	7.7
Scapula					2				4			
Humerus					21				43	1	2.3	7.7
Radius									3			
Ulna					1				11			
Atlas												
Axis												
Vertebra					1				62	2	3.2	15.4
Rib												
Sacrum									6			
Pelvis					2				7			
Femur					7	1	14.3	33.3	48	1	2.1	7.7
Tibia					8				17	3	17.6	23.1
Astragulus					1				7			
Calcaneus									11	1	9.1	7.7
Metacarpal									7			
Metatarsals									6			
Metapodial					1				10	1	10	7.7
Phalanges									31	3	9.7	23.1
Total	**122**	**3**		**2.5**	**103**	**3**		**2.9**	**280**	**13**		**4.6**

When body part categories were analysed (Table 6.71) cranial elements were found to be the most commonly burnt at 31.6% of the burnt small mammal assemblage. Hindlimbs and podials were the next most affected categories at 26.3% each, with podials being the most-frequently burnt category, with 6.8% of all podials burnt. Forelimbs were the least affected by burning, as only 5.3% of them were burnt.

Table 6.71 Burning by body part categories for small mammals, excluding insectivores, at Pınarbaşı.

	Small mammals			
	Site NISP	N. Burnt	% Element Burnt	% Category burned
Cranial	188	6	3.1	31.6
Forelimb	85	1	1.2	5.3
Axial	63	2	3.2	10.5
Hind limb	95	5	5.3	26.3
Podials	74	5	6.8	26.3
Total	**505**	**19**		**3.8**

6.3.9 Gnawing

Only a single element showed evidence of suspected gnawing and this was a micromammal femur from the Epipalaeolithic context BIA. The element showed possible evidence of an isolated carnivore tooth puncture mark. Only 0.04% of the assemblage was gnawed.

6.3.10 Digestion

Rodent digestion

The small mammal digested assemblage for Pınarbaşı as a whole was comprised of 34 specimens, 32 of which were identified as rodent, and two as *Crocidura* sp. Digestion was recorded on both loose and *in-situ* incisors and molars, as well as proximal femora and distal humeri, and included all small mammal species, however *Crocidura* sp. and insectivores were excluded from the analysis.

Levels of small mammal digestion at Pınarbaşı were very low, with only 1.3% of the whole assemblage digested. Evidence of digestion on rodents was only recorded in Area B, in two contexts from the 7th millennium, BDF and BHL, and seven contexts from the Epipalaeolithic. No digestion was recorded on bones from any contexts from the 10th-9th millennium occupation levels in Areas A and D.

Table 6.72 Categories for rodent digestion by context at Pınarbaşı.

Context	Category	Incisor		Molar		Humerus		Femur	
		N	%	N	%	N	%	N	%
BDF	Light								
	Moderate			1	33.3				
	Heavy								
	Extreme								
BHL	Light			1	33.3				
	Moderate								
	Heavy								
	Extreme								
BIA	Light	1	100	3	30				
	Moderate								
	Heavy								
	Extreme								
BIB	Light							2	40
	Moderate					1	100		
	Heavy								
	Extreme								
BIE	Light					1	7.1		
	Moderate								
	Heavy								
	Extreme								
BIF	Light	1	25			1	33.3		
	Moderate								
	Heavy								
	Extreme								
BIH	Light	1	5	2	6.9	1	5		
	Moderate								
	Heavy	2	10						
	Extreme	2	10	1	3.4				
BIJ	Light					3	27.3		
	Moderate	4	66.7			1	9.1	1	33.3
	Heavy								
	Extreme								
BIP	Light								
	Moderate	1	100	1	25				
	Heavy								
	Extreme								

Incisors were most affected by digestion, making up 37.5% of the digested assemblage, and represented in every category of digestion. Digestion damage on molars and humeri were at similar levels, at 28.1% and 25.0% respectively. Femora provided only 9.4% of the digested assemblage. SEM micrographs showing examples of digested elements of small mammals can be seen in Figure 6.35.

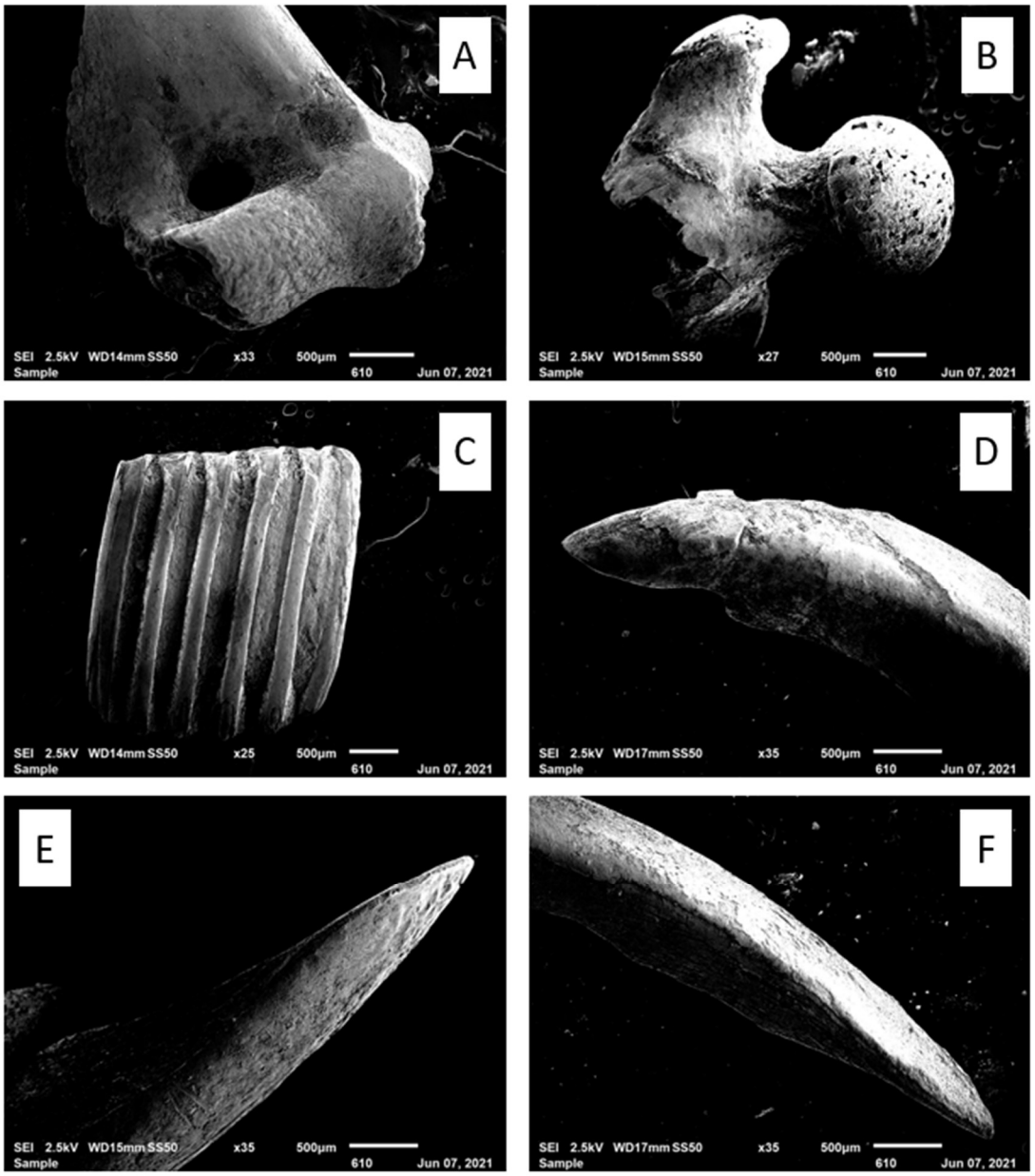

Figure 6.35 SEM micrographs showing elements affected by digestion. A. Distal humerus with light digestion, B. Proximal femur with light digestion, C. Microtine molar with light digestion, D, Maxillary Mus sp. incisor with moderate digestion, E. & F. Mandibular incisors showing moderate digestion

Table 6.73 Digestion categories by species

	Light	Moderate	Heavy	Extreme	Total	% digested by species
A. amphibius	3				3	9.4
Arvicolinae	1	3		1	5	15.6
Microtus sp.	1				1	3.1
Meriones sp.	1				1	3.1
Mus sp.		1			1	3.1
Rodent	2	5	2	2	11	34.4
Micromammal	8	2			10	31.5
Total	16	11	2	3	32	
% by category	50	34.4	6.3	9.4		1.3

50% of specimens affected exhibited light digestion. Few specimens were recorded with heavy or extreme digestion (Table 6.73).

Levels of digestion on rodent specimens ranged from as low as 3.4% to 100% for some elements by context (Table 6.72), but some of the highest percentages are based on very small samples.

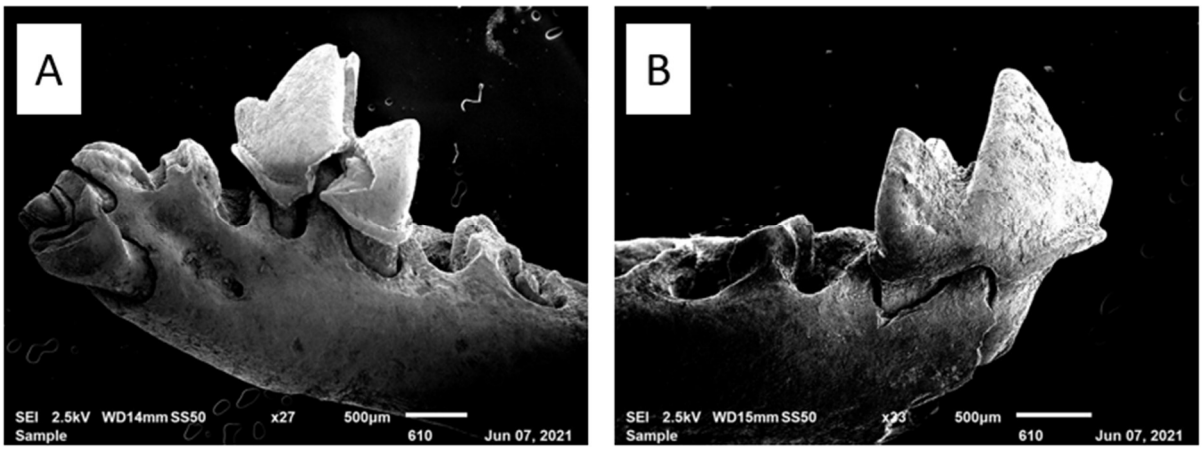

Figure 6.36 SEM micrographs of digestion on Crocidura sp. A. Mandibular molar (broken) showing light digestion shown by the stippling of enamel on the tooth B, Mandibular molar with moderate digestion, showing a greater degree of stippling on the tooth.

Only two specimens of Crocidura showed evidence of digestion, one exhibiting light digestion, and the other moderate (Figure 6.36).

Amphibian taphonomy

Only 42 out of 997 anuran specimens showed taphonomic modification other than fragmentation and burning (Table 6.74).

Articular digestion – bone loss, was the most common category, accounting for 40.5% of the taphonomically modified assemblage. The next most common category was flaking exfoliation at 23.8%, although this modification can also be indicative of weathering. Other modifications, such as root marks were not well represented in the assemblage (Table 6.74).

Table 6.74 Amphibian taphonomic modifications by category and taxonomic group at Pınarbaşı

Amphibian Taphonomy	Anuran		*Pelophylax* sp		*P. ridibundus*	
	N	%	N	%	N	%
Articular digestion - bone loss	17	40.5				
Articular digestion - protruding edges only	8	19			1	100
Flaking exfoliation other	10	23.8	1	100		
Rootmarks	3	7.1				
Rounding broken ends	1	2.4				
Rounding other	2	4.8				
Splitting other	1	2.4				
Taphonomy total	42	4.2	1	4.3	1	50
Site total	**997**		**23**		**2**	

When examined by occupation phase (Table 6.75), very little taphonomic modification was seen in the 7th millennium assemblage, with only a single specimen coming from this phase. The 10th-9th millennium phase provided 38.6% of the taphonomically modified anuran specimens, whereas 59.1% came from the Epipalaeolithic phase.

Table 6.75 Percentages of taphonomic modification by occupation phase for anura and species of anura at Pınarbaşı

	N	%
7th millennium	1	2.3
10th-9th millennium	17	38.6
14th-12th millennium	26	59.1
Total	**44**	**1.7**

Taphonomic modifications for anura, including other 'frog' species, were also examined by element, to determine whether some skeletal elements were more commonly affected than others. If so, this could be indicative of the predator responsible for assemblage accumulation, or other depositional pathways. Table 6.76 includes anura, *Pelophylax* sp., and *P. ridibundus*, but does not contain any specimens identified as 'toad'. The most commonly affected elements were the humeri and ilia, both making up 22.7% of the modified assemblage. Elements from every area of the body exhibited taphonomic modifications, although they were rarely recorded for podials and the axial skeleton.

Table 6.76 Taphonomic modifications by element for anura at Pınarbaşı. Sphenethmoid indicates a specimen identified to P. ridibundus, and Ilium* indicated one specimen identified as Pelophylax sp.*

	NISP for Anura (not inc. Pelobates)	Articular digestion - bone loss	Articular digestion - protruding edges only	Flaking exfoliation other	Rootmarks	Rounding broken ends	Rounding other	Splitting other	Total	% element affected by taphonomy	% of taphonomic elements
Premaxilla	6										
Maxilla	51										
Mandible	42			2	1				**3**	**6.8**	**7.1**
Frontoparietal	7										
Parasphenoid											
Sphenethmoid	38	1	2*						**3**	**6.8**	**7.9**
Pterygoid	14										
Squamosal	11										
Skull	26										
Clavicle											
Sternum	8										
Scapula	42	2	1	1					**4**	**9.1**	**9.5**
Humerus	57	8		2					**10**	**22.7**	**17.5**
Radio-Ulna	31	2	3	2				1	**8**	**18.2**	**25.8**
Coracoid	31										
Atlas	12						1		**1**	**2.3**	**8.3**
Axis	1										
Vertebra	195										
Sacrum	37										
Urostyle	34			1		1			**2**	**4.5**	**5.9**
Ilium	141	4	3	2*	1				**10**	**22.7**	**7.1**
Ischium	8										
Femur	18				1				**1**	**2.3**	**5.6**
Tibio-Fibula	42						1		**1**	**2.3**	**2.4**
Tarsals	24										
Metapodials	88										
Phalanges	58			1					**1**	**2.3**	**1.7**
Total	**1022**	**17**	**9**	**11**	**3**	**1**	**2**	**1**	**44**		**4.2**

6.3.11 Body Size

As discussed with regards to Boncuklu, the assignment of body size categories at Pınarbaşı was subjective with no solid parameters in place for the boundaries of each category. The data are still of value for micromammals, as it may aid in the separation of the post-cranial specimens in arvicolids, as the large post-cranial elements are likely to have been from *Arvicola amphibius*. Table 6.77 shows bones that were characterised as 'mouse-sized' versus bones that were 'rat-sized', such as *Arvicola amphibius*. Very few specimens of small mammals fell into the 'medium' body size category, with the exception of a few fragmentary specimens. The majority of specimens identified as rodent fell into the 'small' category, with post-cranial elements most likely to belong to *A. amphibius*, being recorded as 'large'.

Specimens of anura, including those identified to genus or species, were much more varied in size, although recording of the body size categories changed as exposure to the assemblage increased.

Table 6.77 Body size categories by species

	Small		Medium		Large		Total
	N	%	N	%	N	%	N
Anuran	297	54.7	173	31.9	73	13.4	543
Pelophylax sp	8	42.1	3	15.8	8	42.1	19
Pelobates sp.	1	100					1
Rodent	69	81.2			16	18.8	85
Arvicola amphibius					26	100	26
Arvicolinae	87	87	6	6	7	7	100
Microtus sp.	6	100					6
Microtus guentheri	4	100					4
Murinae	6	85.7			1	14.3	7
Mus sp.	4	100					4
Meriones sp.					1	100	1
Cricetulus migratorius	2	100					2
Spalacidae					4	100	4
Crocidura sp.	8	100					8
Crocidura suaveolens	1	100					1
Insectivora	3	75			1	25	4
Pipistrellus sp.	1	100					1
Micromammal	185	73.7	4	1.6	62	24.7	251
Erinaceus concolor					4	100	3
Snake	219	99.5			1	0.5	220

6.4 Geometric Morphometrics (GMM)

Six mandibular 1st molars, identified as Mus sp., were analysed using geometric morphometrics in an attempt to obtain a species identification. Five specimens came from Boncuklu with only a single specimen from the 7th millennium occupation at Pınarbaşı (Table 6.78).

Table 6.78 Details of specimens used for geometric morphometric analysis for species identification

Sample no.	Image #	Magnification	Site	Context
1	Sp 1.tif	x20	Boncuklu	ZHI
2	Sp 2.tif	x20	Boncuklu	HJW
3	Sp 3.tif	x20	Boncuklu	KAR
4	Sp 4.tif	x20	Boncuklu	KWV
5	Sp 5.tif	x20	Boncuklu	KNL
6	Sp 6.tif	x20	Pınarbaşı	BJY

Specimens were photographed by the author, and the GMM analysis was undertaken by Dr. Katerina Papayiannis, University of Athens (see Appendix A). Microscopy photographs provided to Dr. Papayiannis for the analysis can be seen in Figure 6.37. The outcome of the 2D shape analysis can be found in Figures 6.38 and 6.39.

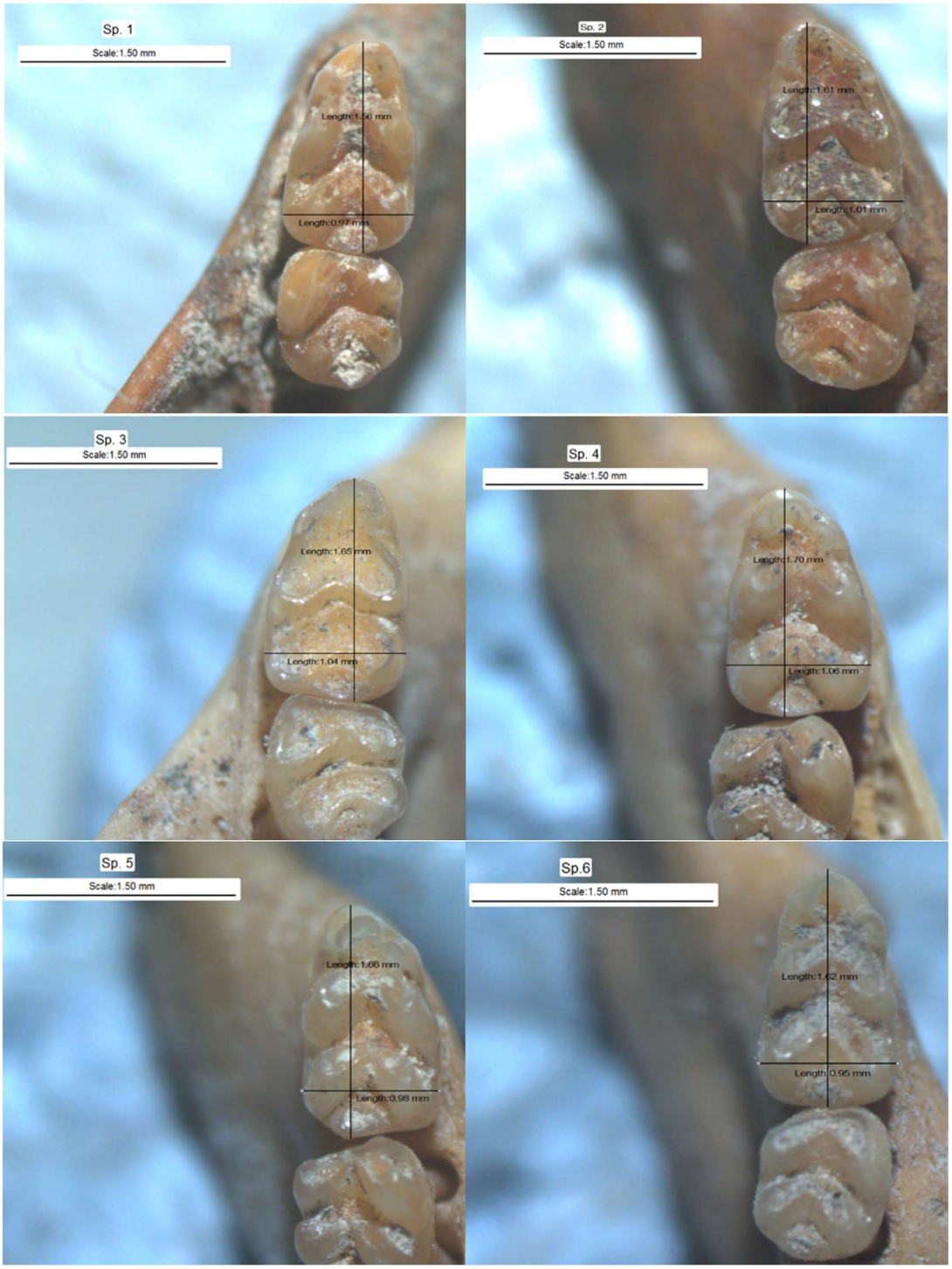

Figure 6.37 Specimens for geometric morphometric analysis on mandibular M1 from Boncuklu and Pınarbaşı

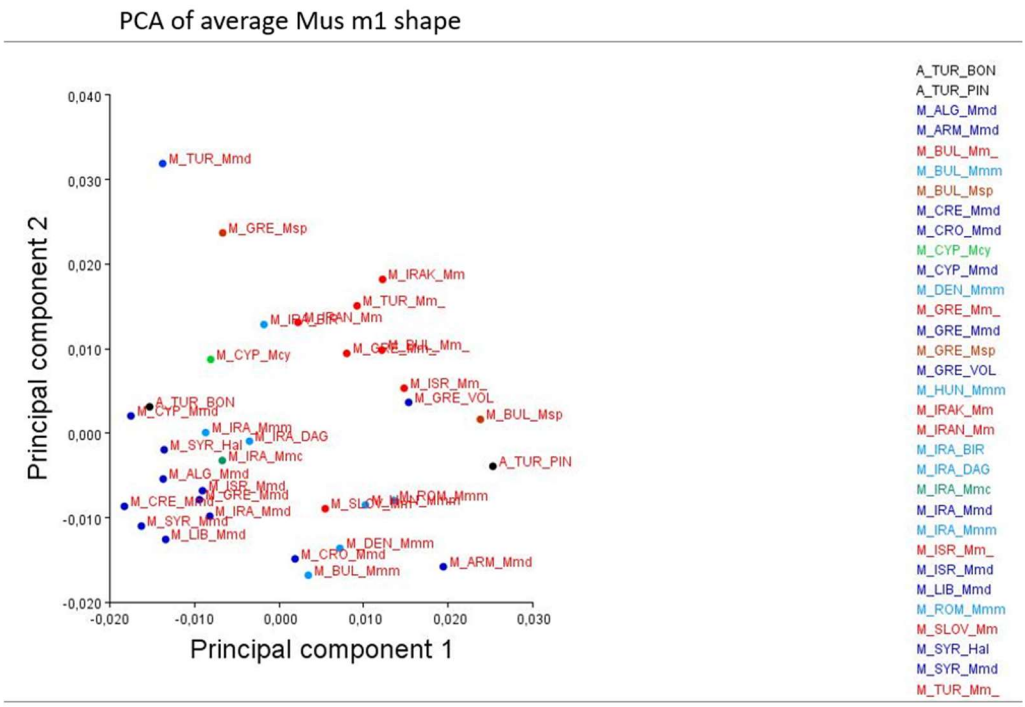

Figure 6.38 Principal component analysis (PCA) for the Boncuklu and Pınarbaşı Mus sp. teeth showing groupings of known species by locations (GMM analysis courtesy of Dr. Katerina Papayiannis, University of Athens)

The PCA of the shape analysis has shown that the Boncuklu *Mus* sp. cluster with known specimens of *Mus musculus domesticus* provided by Dr Thomas Cucchi, whereas the single specimen from Pınarbaşı clusters with known specimens of *Mus macedonicus* (Figure 6.38). These results were based on a very limited sample of specimens.

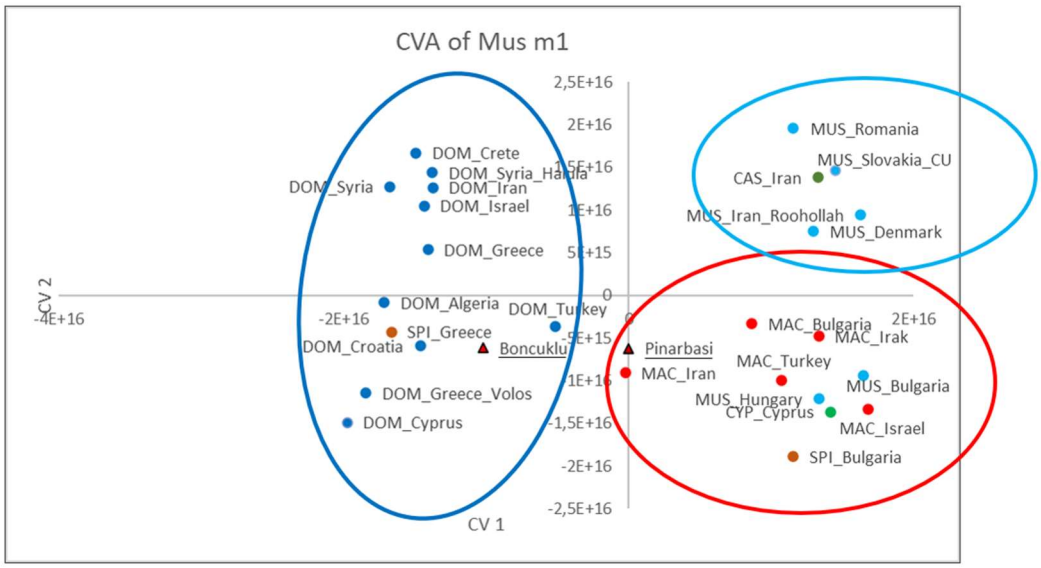

Figure 6.39 Plot of known species showing groupings by species, and where the specimens from Boncuklu and Pınarbaşı specimens fall within the known range (GMM analysis courtesy of Dr. Katerina Papayiannis, University of Athens)

This chapter has presented the results of the data analysis for Çatalhöyük, Boncuklu, and Pınarbaşı. The next chapter will discuss the results more fully, as they relate to each site, as well as the aims of this thesis and place the data into context for palaeoenvironmental reconstruction, broad-spectrum economy, ritual use, and anthrodependancy and sedentism.

7. Discussion

This chapter explores what microfaunal analysis of each assemblage brings to archaeology, and places the microfauna in their full environmental and economic context. Part 1 of this chapter will explore the interpretation of the results by site. Part 2 will revisit the aims of this thesis and how microfauna can be used as an interpretive tool for past human lifeways.

7.1. Part 1

7.1.1. Çatalhöyük

Figure 7.1 Çatalhöyük North shelter showing the distribution of the rooms and the plastered walls (Photo: M. Feider 2018)

In summary, a total of 8342 specimens were recorded from 26 contexts, primarily taken from the priority contexts at Çatalhöyük (Figure 7.1). These were contexts that were noted for being of particular interest for research, and therefore flagged to researchers. Many priority contexts contained microfauna but time constraints meant that not all were analysed. Contexts were selected from some of the early levels on the site,

through to the end of occupation on the East mound, however most of the contexts analysed for this thesis were from levels dated to the early and middle temporal groupings, 7100-6500 cal. BCE.

7.1.1.1. Quantification and Taxonomy

NISP

The Number of Identified Specimens (NISP) and adjusted NISP per litre were calculated for each context, so that contexts could be compared regardless of soil sample size. Of the 26 contexts analysed, 18 had an adjusted NISP per litre of less than one, showing a low background level of microfauna across the site. This was also found to be the case in previous microfaunal studies at Çatalhöyük (Jenkins 2005; 2009; 2012b; Jenkins and Yeomans 2013). Where microfauna was recorded in higher numbers, the adjusted NISP per litre calculations ranged from 3.3 to 205.7.

Table 7.1 shows the adjusted NISP per litre and interpretive category for each of the contexts with a NISP per litre over one highlighted. With the exception of the fill between walls (19802), which could contain midden material along with accidental inclusions, these contexts are all primarily anthropogenic in nature, with three of the seven being linked to oven features, one from the North Area, (21573), and two in the South, (21849) and (32632).

Due to the contexts selected, a phased analysis of Çatalhöyük microfauna was not possible for this thesis, as many of the contexts belonged to the same phase within the North and South Areas. However, concentrating analysis on a single phase has revealed some interesting spatial variation which would benefit from further analysis. Of the seven contexts with an adjusted NISP per litre of more than one, five of them are from the South.J phase, and are split between two buildings that are adjacent to each other, B.17 and B.161 (Table 7.1). These contexts will be discussed in greater detail later in this sub-chapter.

When analysed by data/interpretive category, the majority of contexts with high adjusted NISP per litre were recorded as fills, all in internal spaces, with the exception of a fill between buildings. The two that were not fills were interpreted as construction/make up/ packing material, and were both recorded as oven superstructures.

Table 7.1 Summary of adjusted NISP per litre by temporal groupings at Çatalhöyük. Figures in bold are to highlight those with an adjusted NISP per litre greater than 1

Context	Hodder Level	Temporal Grouping	Cal BCE	Building or Space	Data Category	Interpretive category	Adjusted NISP	NISP per litre
23215	South.?I	Early	7100-6700 BCE	Space 620	Floor (use)	Oven base	1	0.4
21810	South.J	Early		B.17	Fill	Burial infill	80	0.27
21814	South.J	Early			Fill	Burial infill	228	0.48
21842	South.J	Early			Fill	Niche infill	423	**15.67**
21849	South.J	Early			Fill	Oven debris	264	**11**
22512	South.J	Early			Fill	Burial pit fill	19	0.09
22513	South.J	Early			Fill	Burial pit fill	13	0.24
22515	South.J	Early			Fill	Burial pit fill	9	0.06
32611	South.J	Early		B.161	Fill	Arbitrary infill of burial	1416	**13.44**
32616	South.J	Early			Fill	Primary room infill	1265	**31.63**
32632	South.J	Early			Construction/make up/ packing	Oven superstructure	5142	**205.68**
32403	South.K	Early		B.162	Fill	Burial infill	24	0.09
30543	North.?G	Middle	6700-6500 BCE	B.102	Floor (use)	Dirty floor	2	0.5
30554	North.?G	Middle			Floor (use)	Dirty floor	10	0.37
21573	North.F	Middle		B.119	Construction/make up/ packing	Oven superstructure	79	**3.3**
30591	North.F	Middle		B.132	Floor (use)	Occupational surface	2	0.06
32717	North.F	Middle			Fill	Burial infill	15	0.54
32782	North.F	Middle			Floor (use)	Dirty floor	88	0.4
32793	North.F	Middle			Floor (use)	Occupational sediment	10	0.1
32334	North.G	Middle		B.131	Fill	Basin fill	3	0.43
18523	South.O	Middle		B.79	Construction/make up/ packing	Burnt collapse	4	0.17
18578	South.O	Middle		B.80	Fill	Dump roomfill	3	0.13
19802	South.O	Middle		B.76/B.80	Fill	Fill between walls	231	**3.92**
30217	TPC.N	Late	6500-6300 BCE	B.110	Fill	Infill layer	2	0.05
30269	TPC.N	Late			Fill	Infill	1	0.04

Species composition

The assemblage from Çatalhöyük is dominated by rodents, accounting for 61% of the assemblage by NISP. Micromammals are the next largest group, accounting for a further 36.6%, and including all elements that cannot be identified more specifically, such as vertebrae. When higher taxonomic groupings are removed, *Mus musculus domesticus* accounts for 97.7% of species, with a further nine species making up the other 2.3% of the Çatalhöyük microfauna. With species identification reliant on cranial elements only, it would not be unreasonable to assume that the majority of specimens identified to rodent, which consist primarily of post-cranial specimens, or mandibular incisors, which lack the diagnostic features of the maxillary incisors, and micromammal, are also those of *M. m. domesticus*. Therefore, the Çatalhöyük assemblage shows extremely low taxonomic diversity, even in the early levels, with South.J levels being some of the largest analysed for this assemblage, dating to 7100 to 6700 cal. BCE. This suggests that house mice were able to adapt quickly to exploit the human created niches that allowed these small mammals to out-compete its sympatric competitors.

Other small mammal species recovered from Çatalhöyük include *Apodemus* sp., including *A. mystacinus*, and *Microtus* sp., *Meriones* sp., and *Crocidura* sp. Several species of anura were also identified and included *Pelophylax ridibundus*, *Bufo viridis*, and *Pelobates* sp. However, the low numbers in which these species were recovered, would suggest that they are not indicative of the immediate habitat. Both *Crocidura* sp., and anura may be classed as commensal, attracted to the increased insect activity surrounding middens.

MNI

Minimum Numbers of Individuals, as with NISP, were heavily skewed to both *Mus* sp. and rodents. Every other species recovered from Çatalhöyük had an MNI of 1, with the exception of *Crocidura* sp. in context (32632), which had an MNI of 6, against 250 for *Mus* sp., and 192 for rodent (Table 6.4). There is the potential for a single individual to be incorporated into more than one context, which would mean the MNIs represented here would be artificially inflated if added together, but given the phasing and locations of those recovered, and the taphonomic pathways for large portions of this assemblage it is unlikely.

Body Part Representation

Body part representation was analysed to see whether any particular body 'portion' of the *Mus* sp./ rodent assemblage was over- or under-represented, which may indicate a curation or use of the animal. This was done for all contexts with a *Mus* sp./rodent MNI of 10 and above. When compared with what would be expected should whole animals have been incorporated into the assemblage, cranial elements are over-represented in the majority of contexts analysed, with the exception of (21842), which was primarily represented by the axial skeleton (Figure 6.3). Bone loss is evident in the assemblage. However, whether this is due to loss at the point of deposition, for example some elements being more affected by digestive corrosion than others and not recovered in pellets or scats, or due to dispersal or destruction over time, is unknown. There is also the potential for recovery bias, with some bones routinely missed by those doing the sorting. At Çatalhöyük, however, this seems unlikely. The heavy residue was sorted by local women who have been trained in picking out 'shaped bone', and who return season after season. The unsorted portion of the heavy residue has also been checked afterwards by a microfaunal specialist (Assoc. Prof. E Jenkins), with nothing of significance found. The fact that nearly all types of bone are represented in the assemblage, albeit in different proportions, would also suggest that these elements would be spotted if they were present. Damage during sampling and sieving is another possible cause of bone loss, however the previous argument also works against this.

Element frequency also looked at individual elements, rather than body part categories, in order to see if there was any pattern in bone survivability or recoverability. With regards to cranial specimens, the frequency of those identified as rodent was quite low. This is due to the fact that many of these elements, including maxillary incisors and molars are all identifiable to genus, so only those that were broken, or missing diagnostic elements were included in the rodent higher taxonomic group. Mandibular incisors are not identifiable to genus, and the frequency for this element ranges from 54.9% to 98.8% in rodents (Table 6.5). Conversely, only incisors found *in-situ* in mandibles with molars that allowed for species identification are found in the *Mus* sp. counts, and accordingly are very low in number, ranging from 7.1% to 16%. Some of the frequencies may be artificially high due to a small sample size, which is why this analysis was limited to those contexts with a MNI of over 10 (Tables 6.5 and 6.6).

Whilst element frequency shows that tibiae are the most common long bone, ranging from 10% to 95.5%, humeri have higher frequencies than those of femora, suggesting that the high numbers of tibiae are not due to a hindlimb bias, which may have lent weight to a suggestion that *Mus* sp. were being utilised by people for food. Radii have very low frequencies and were not recovered from all contexts, which is probably due to recoverability, as these elements are very slender and may go through a 2mm sieve, whereas the larger ulnae have much higher frequencies and are present in more contexts (Table 6.5).

7.1.1.2. Taphonomy

Taphonomic analysis of the assemblage focused on fragmentation, digestion, gnawing, and burning, in order to aid with the interpretation of how the microfaunal assemblages were deposited on the sites. In many instances microfauna are assumed to be incidental to the occupation of an archaeological site, and their importance as bio-artefacts excluded from study or limited to palaeoenvironmental reconstruction. In order to fully understand how microfauna may have been using the site, or were being used or affected by people, their depositional pathways need to be understood.

Predator induced modification

Levels of fragmentation for this microfaunal assemblage varied by element. Maxillary breakage was exceptionally high, with all maxillae recovered falling into the highest breakage category (Table 6.7). Breakage of this element for this analysis was higher than in previously analysed assemblages. This is evident when we consider that prior analysis was able to use the difference between the malar process and the zygomatic in order to distinguish *M. m. domesticus* from *M. macedonicus*. (Harrison and Bates 1991; Jenkins 2009) which was not possible in this analysis due to the high level of breakage. No complete mandibles were recorded, but mandibular breakage was not as extreme as maxillary breakage, and several specimens were recorded as only having a broken ascending ramus (Table 6.8). This element is quite robust; whereas fragmentation of the cranium may be more severely affected by mastication by a predator, which would affect maxillary region more than the mandible region.

Loose versus *in-situ* molars and incisors were also recorded and the analysis showed that incisors were much more likely to be loose than *in-situ*, with some contexts showing 100% incisor loss from the maxilla or mandible. The majority of molars,

however, were *in-situ* rather than loose (Table 6.9). Several factors could affect this, with different breakage levels of the mandibles and crania, being one. With high levels of breakage, the incisors are unlikely to remain *in-situ*, as the mandible loses the inferior border, and the maxilla is separated from the premaxilla. Mandibles with and without incisors, and loose incisors were bagged separately for analysis following a preliminary sort of bones from each context, and it was noted that after a period of time there were many loose incisors in with the mandibles. Incisor loss is therefore based on a number of factors and many of the incisors may have been *in-situ* at time of recovery and subsequently became separated following sampling, sorting, and bagging. Molars, especially those of small murines such as mice, are very small and are unlikely to be recovered unless a 1mm sieve size is routinely used and those doing the sorting are equipped with a microscope. The occlusal surface of *M. m. domesticus* mandibular first molars is approximately 1.6-1.7 mm in length, with third molar occlusal surface being approximately 0.5-0.6 mm in diameter, so potential for recovery and identification is low.

Post-cranial breakage analysis showed that few complete elements were recovered, and the majority of specimens were either proximal or distal ends with associated shafts, which are the most diagnostic. The exception for this were tibiae, because, as previously stated, the whole length of the bone is identifiable due to its unique shape. Therefore, tibia shaft fragments (which were defined as those not attached to either proximal or distal ends), were higher than those for other elements (Table 6.11). Proximal or distal end survivability and identification did appear to relate to fusion of those ends. For example, distal humeri were more frequently observed than proximal, and proximal femora were more frequently observed than distal. Epiphyseal fusion in rodents does not occur at skeletal maturity, as it is not linked to age, and therefore can last into old age for any particular individual (Mehta *et al*. 2002, Roach *et al.* 2003). Age profiles for rodents such as mice often rely on tooth wear based on maxillary and mandibular first molars (Lidicker 1996, Valenzuela-Lamas *et al*. 2011). Therefore, the lack of these unfused ends may be more down to recovery and/or identification bias. Analysis of percentage completeness for each of these elements shows that the assemblage is highly fragmentary with the majority of post-crania bones less than 50% complete (Table 6.10). The 'less than ¼' category is not as well represented as would be expected based on a visual inspection of the fragmentary nature of this assemblage. However, very small fragments of bone may pose identification issues, both by those

selecting ‘shaped’ bone from the heavy residue samples prior to analysis, and for those doing the analysis.

Digestion on teeth was low, with only 2.6% of molars, and 3.8% of incisors showing evidence of digestion. Percentage digestion by context was more variable, with incisors ranging from 0.4% to 13.6% digested, and molars from 0.5% to 40% by context. For some of these contexts, small sample size has inflated the percentage (Table 6.18).

Post-cranial digestion was much more variable with 16.5% of humeri having evidence of digestion compared with femora at only 3.8% (Table 6.19). As femoral digestion is analysed based on how it affects the femoral head, the late age of proximal fusion may have been an impacting factor for this element, as digestion may have been missed on an unfused end or the damage attributed to breakage rather than high levels of digestion. Levels of digestion by combining all elements for the contexts give a higher proportion of digestion, with contexts ranging from 1.6% to 17.1% (Table 6.19).

Although Fernadez-Jalvo *et al* (2016) suggested that evidence of gnawing on microfaunal bones was rare, this was not the case at Çatalhöyük. Percentage of gnawing by context, for assemblages with a NISP of over 50, ranged from 2.4% to 8.1%, with up to 14 different elements affected (Table 6.15). The size of the puncture marks measured from 0.15 mm to 0.74 mm in width and 0.17 to 0.57 mm in length, ruling out a lot of the potential predators due to the size of their teeth (Table 6.17). Although many measurements for predator teeth take into account the size at the base of canines, teeth can make smaller puncture marks if only the tip of the teeth are utilised. However, in this case the size of the puncture marks is so consistently small that it is unlikely that a larger predator, such as a large mustelid like a badger, or a canid could be responsible for the predatory derived deposits.

Tooth marks were consistently observed on the lateral aspect of mandibles, in the region of the masseteric ridge, as well as on distal humeri and proximal femora. This could suggest a hunting technique used by the small carnivore. However, weasels, the smallest of the mustelids, kill with a bite to the back of the neck rather than on the jaw (King and Powell 2006). The repeated occurrence, however, would suggest that the species of predator at work at Çatalhöyük, is consistent throughout the assemblage.

With evidence of both gnawing and digestion in many of the larger contexts in the assemblage, it is clear that the majority of microfauna analysed were from small mammalian carnivore scats. However, this presents a problem, as small mammalian carnivores are considered Category 5 predators under the methodology devised by Andrews (1990), but the low incidence and the predominance of light levels of digestion for this assemblage would suggest a Category 1 predator, i.e., a barn owl. The presence of gnaw marks, however, clearly indicates that the predator was a mammal rather than a bird of prey.

Fragmentation also makes determining the predator more difficult as the portions of bones, e.g., proximal, distal etc., recovered during this analysis do not match the results previously determined in Andrews' (1990) research. In his analysis of breakage of major skeletal elements created by different predators, Andrews found that the scats from mammalian carnivores did not include any distal tibiae, and that the most common portion was the proximal, with 82% recovered from scats of pine martens. In context (32632), the largest assemblage recorded during this analysis, 79% of the tibiae (N=305) recorded were from the distal end, with only 4.7% (N=18) being proximal (Table 6.11). The mammalian carnivores in Andrews (1990) data were much more limited in number than the avian predators, and perhaps this is the reason for the data not matching, or perhaps the predator present at Çatalhöyük was not a species analysed as part of Andrews research. It may also be worth noting that the predators' scats in Andrews' sample were collected from the wild in the UK where the main prey items of small predators are voles. These have a slightly larger body size than mice, and therefore may require more chewing, altering the fragmentation and effects of digestion on splintered bone in the stomach. However, it is clear that more research on modern samples is needed in order to pin down which predators were operating in antiquity.

Due to the challenges in recognising the taphonomic signatures for categorising predators at Çatalhöyük, both for this analysis, and for those undertaken previously, the identity of the predator responsible for producing the scats remains unknown.

The lack of evidence of gnawing on anura or insectivores at Çatalhöyük lends weight to the theory that they were present on site as commensals. However, they were seemingly present in such low numbers that it is unlikely they would have been hunted when there was a plentiful supply of mice for the small carnivores. Lack of gnaw marks or other

taphonomy associated with predation also leads to the conclusion that they were present on site rather than brought in as scats after being consumed offsite. Although taphonomic markers associated with predation is low overall, this may just be a consequence of the extremely low numbers of these species recovered.

If the main taphonomic pathway for the microfauna was via predator deposition, then there is a high predator selection bias with regards to the prey taken. With *M. m. domesticus* representing 97.7% of the taxa identified to species, it is clear that small mammalian carnivores were taking advantage of the presumably high house mouse numbers found in this anthropogenic niche. The patterning of gnaw marks, especially on the lateral aspect of the mandibles, would suggest that the species predating on the mice at Çatalhöyük were consistent over time, as the placement of the gnaw marks may relate to a hunting strategy. The domination of the assemblage by a single species would also suggest that nearly all hunting was being done onsite with little need to supplement diet elsewhere.

Burning

Although it could be said that burning is a predator induced modification when prey species are being cooked for consumption, burning has been considered separately, so that avian and small mammalian carnivore predation can be analysed independently from any potential human modification.

Evidence of burning at Çatalhöyük was exceptionally low, accounting for only 0.2% of the assemblage, with more than 50% of the burnt elements being that of anura, despite their very low numbers across the site (Table 6.13). The numbers of anura at Çatalhöyük are so low that it is unlikely they were eaten by humans. The burning is more likely to be accidental burning of individual bones, rather than deliberate burning or cooking of carcasses. Elements of *Mus* sp., rodent, and micromammals had a burn rate of 0.05%, 0.09%, and 0.07% respectively (Table 6.13).

The assemblage from one context, (32334) was burnt in its entirety but it only consisted of three specimens, and the context was described as the fill of a bin. This context contained *M. m. domesticus*, as well as specimens identified as insectivore, and micromammal. This is not the first time that burnt mice bones have been recovered from inside bins used as food storage. In Building 52, burnt mouse bones, as well as

their faecal pellets, were recovered along with food found *in-situ* in the storage bins, providing evidence of a mouse infestation in areas used to store food (Twiss *et al*. 2009; Bogaard *et al*. 2010

7.1.1.3. Anthropogenic contexts

Nearly all of the larger assemblages were from anthropogenic contexts, rather than ones that could be accounted for by incidental inclusions, such as midden deposits. Of the five contexts with an adjusted NISP per litre over one in the early temporal grouping of the site, three of them were from within the same building, B.161, and two from an adjacent building, B.17 (Figure 7.2).

Figure 7.2 Level South.J phase plan showing the locations of Building 161 and Building 17 (plan: Camilla Mazzucato)

B.161

The three largest assemblages came from B.161. Context (32632) from Phase 1.3 of occupation, and (32611) and (32616) from Phase 2, abandonment.

Context (32632)

The majority of specimens from this context came from a discreet, high-density cluster of microfauna, with a sample volume of a single litre and a NISP of 4296. It was initially interpreted as a commemoration offering by the excavators, due to it being in association with a large scapula, and a collection of shells (Feider and Jenkins 2021; Çatalhöyük Research Project Database).

Evidence of both digestion and gnawing in the assemblage identified it as having been a predatory-derived deposit. Due to the size of the tooth marks in the small mammal bones, the most likely predator was a small mustelid, however as already discussed, taphonomic analyses have not been able to confirm the identification of the predator.

Weasels have small stomachs, and as such are unable to eat more than one prey item at once, even though they may kill many more. They do have extremely fast metabolisms, and a meal can traverse the length of the gut in 2-4 hours (Short 1961; King and Powell 2007) and it has been recorded that they defecate up to 19 times a day. A feeding experiment undertaken by capture, tagging, and releasing wild weasels found that male weasels caught on average 5.1 prey items, with females catching 1.5 prey items in a 24-hour period (Erlinge 1975). However, (32632) has a *M. m. domesticus* MNI of 192, and a rodent MNI of 250. How long would it take a small mammalian carnivore to create such an assemblage? If we assume that the predators on site are catching six prey items every 24 hours, and all the faeces are collected, then it would take over 41 days to produce the assemblage in (32632). The oven is in the northeast corner of the building (Figure 7.2), and would be expected to be used by humans regularly when in use. The microfaunal cluster was recovered from the space between the dome of the oven and the walls to the north and east, which was packed with clay/scats, possibly to add strength to the structure. However, the inclusion of macrofaunal scapula and shells, lend weight to the argument that it was associated with a commemoration offering. As the microfauna had obviously traversed the length of a predator's digestive system, we can conclude that bodies of whole animals were not packed into this space, either intentionally or as pitfall victims. However, why scats were used rather than the typical building material is unclear.

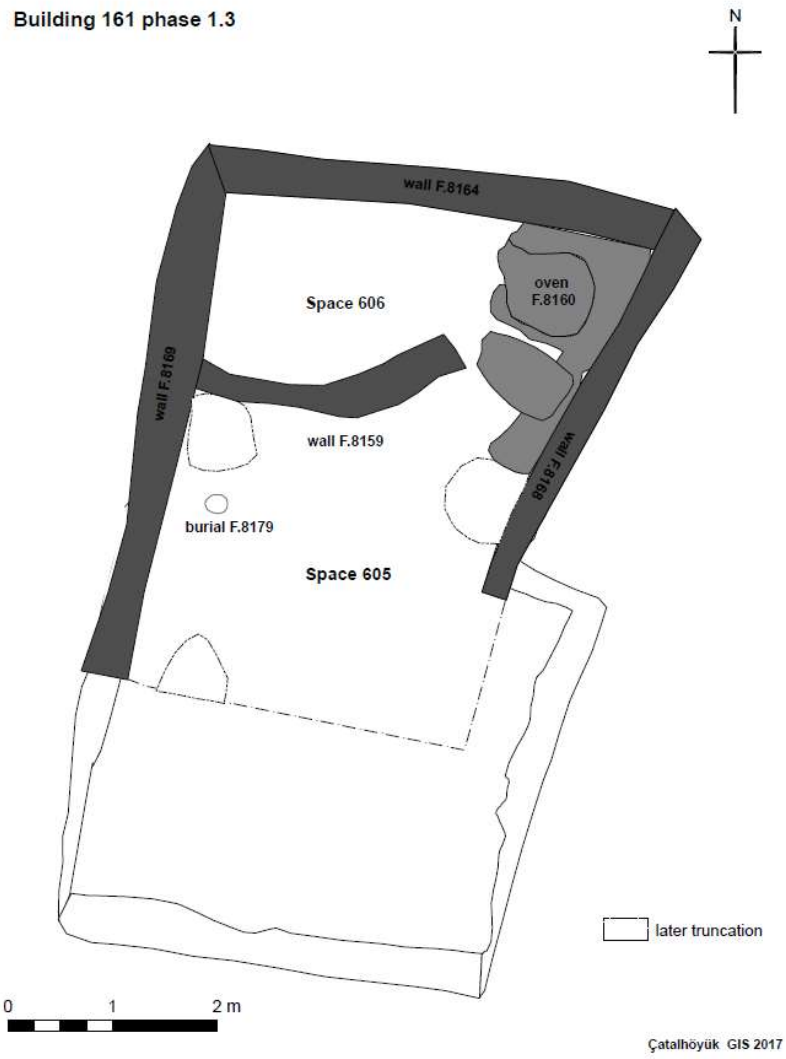

Figure 7.3 GIS building plan of Phase 1.3 of B.161, showing location of oven F.8160 in the north east corner which contained (32632) (plan: Camilla Mazzucato; Feider and Jenkins 2021:212)

The incorporation of small mammal scats into construction/make up/ packing material does not appear to have been a common practice at Çatalhöyük, as other contexts of this type of material previously analysed did not show a NISP per litre higher than five (Jenkins 2005; 2009), which is higher than the low background frequency of microfauna, but nowhere near as high as this cluster. The lower parts of many structures at Çatalhöyük are found intact due to the way the inhabitants 'closed' unused or old buildings, and the sampling strategy would have picked up a higher number of microfauna if this was routinely the case. Bone has been used to temper clay in the past to add strength, however the bone is usually ground into a powder, rather than incorporated as small fragments or complete small elements (Stilborg 2001; Feider and Jenkins 2021). Botanical tempers, such as barley straw, are more often used (Jenkins et al. 2017). The practice in B.161 is therefore uncommon, so perhaps the addition of the

scats has more to do with commemorative offering than just structural support (Feider and Jenkins 2021).

Context 32616

This context was related to the abandonment of the building and was noted by the excavators as being primary room infill, composed of collapsed material, roof, bricks, mortar, and oven superstructure (Feider and Jenkins 2021; Catalhoyuk Research Project Database).

This fill was related to Space 605 (Figure 7.3), with the deposit sloping from the south, down towards the northern partition. The fill contained a high density of microfauna, with an adjusted NISP per litre of 31.6, with a *M. m. domesticus* MNI of 70, and a rodent MNI of 101 (Table 6.4). There appears to have been a hiatus of the room infilling, following abandonment but before the human remains were incorporated into the fill (discussed further under context (32611)), although how long this hiatus lasted is unknown. It is interesting to note that the fill contains oven superstructure, and has a high NISP per litre of microfauna, suggesting that the oven superstructure could be the source of the microfauna, given the high levels of microfauna found in oven structures elsewhere in this building (32632). It is more likely however, given that this building was abandoned, that small mammalian carnivores used it as a latrinal area during the hiatus of the filling.

Context 32611

This context was the fill from around the remains of a young adult male (32608) recovered within the primary room infill of B.161 (Figure 7.4). The 'burial' was not typical of those usually found at Çatalhöyük, which took place in pits dug into the raised platforms within the houses. In this instance, the human skeletal remains showed evidence of perimortem injury to the mandible; the only injury of this type so far discovered at Çatalhöyük. There is also evidence for the binding of the hands and feet, with the body then either thrown or placed in the abandoned building (Taylor 2021). There was no discernible cut, so an arbitrary cut was assigned to separate the fill immediately adjacent to the body, from the wider room fill. The body was positioned with the head downslope, abutting the interior partition wall (Figure 7.5), leading to the belief it had been thrown in rather than carefully placed.

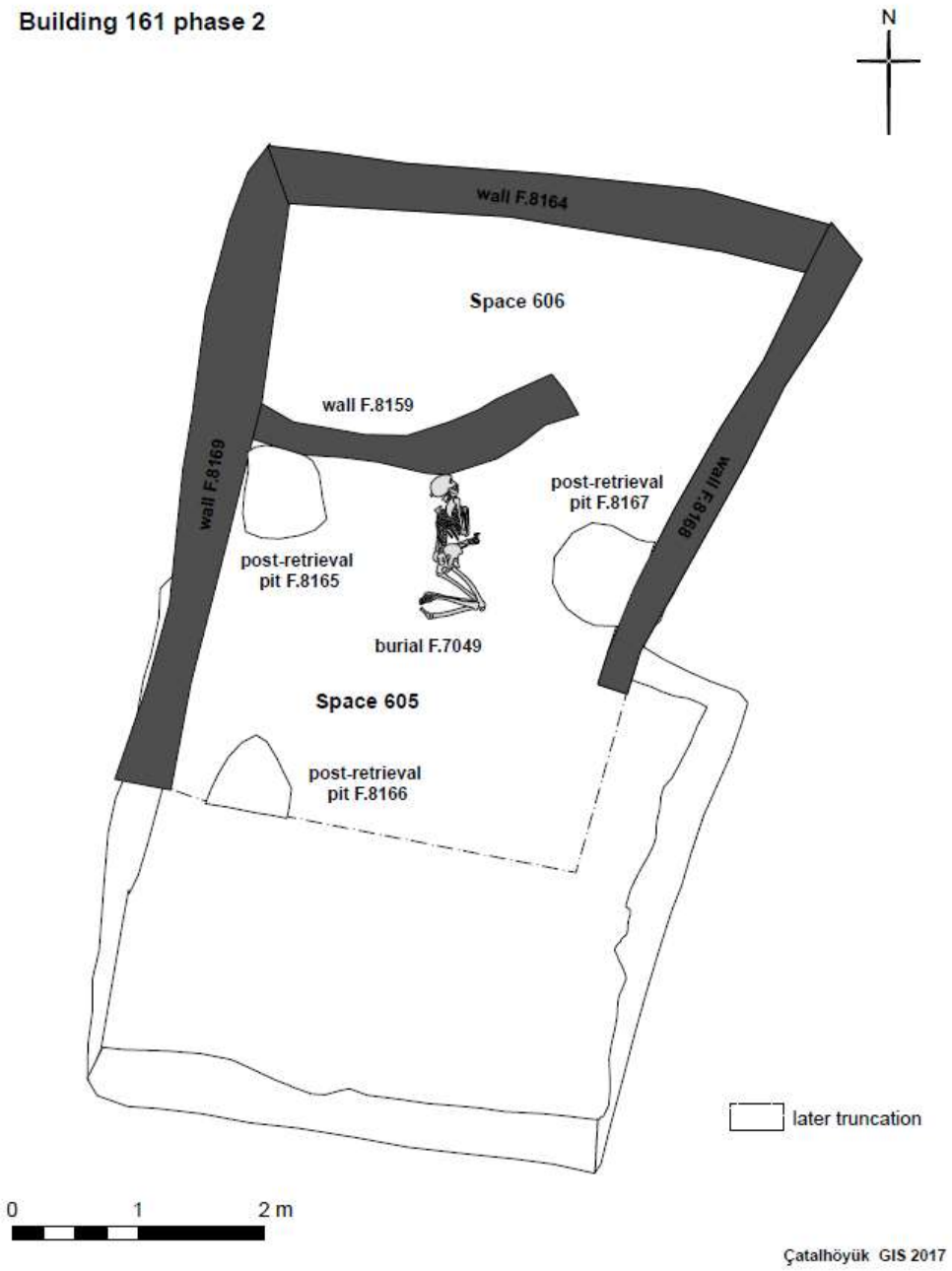

Figure 7.4 GIS building plane of phase 2 of building 161, showing location of human remains associated with (32611) and (32616) (plan: Camilla Mazzucato; Feider and Jenkins 2021, 214)

This context had an adjusted NISP per litre of 13.44, with a *Mus* sp. MNI of 43, and a rodent MNI of 61 (Table 6.4). The excavators noted that the fill around the body appeared to be the same as the wider fill, which supported the suggestion that the body was thrown in, rather than carefully buried here. Microfauna was observed at the time of excavation; however, they were also noted in the general fill outside of the arbitrary cut. Unfortunately, samples from the fill above the skeleton were not taken, so no comparison could be made. The context below the skeleton, however, has a higher adjusted NISP per litre than that of the adjacent fill, suggesting the inclusion of

microfauna around these human remains was not related to the burial practices observed in burials from previous research (Jenkins 2005, 2012a), and is more likely to be incidental to the siting of the body and related to the abandonment of the building being used as a latrine.

Figure 7.5 Human skeletal remains Sk.32608 found with microfauna in underlying and surrounding contexts (Feider and Jenkins 2021, 215)

B.17

Building 17 is the earliest building in this location in the South Area. Below B.17 there was evidence of open areas used as middens (Space 628), which gave way to open areas used for penning (Space 620). B.17 foundations were then laid, and subsequent buildings used a similar footprint.

The earliest context in this area is (23215), which relates to an oven feature in Space 620, prior to the areas use for penning. This feature contained a single microfaunal specimen, with an exceptionally low adjusted NISP per litre of 0.09. This may also be due to its outside location, with both small predators and prey staying away from human and animal activity in open areas.

Context (21842), a niche infill, relates to a rectangular niche located on the west face of the eastern wall of B.17, which abuts the western wall of B.161 (Figure 7.2). Unfortunately, no phasing data was available for this context, which means it is difficult to determine whether the material used to fill the niche was temporally connected to any of the deposits in B.161 where obvious small mammalian carnivore scat material was used. This context had an adjusted NISP per litre of 15.67, although the MNI for both *Mus* sp. and rodents is much lower than in B.161, at 6 and 11 respectively. The function of the niche, or the reasons for filling it with scat material, is unknown, but the excavator did note small inclusions of red ochre, which may suggest a more symbolic meaning for the niche.

7.1.1.4. Summary

The microfaunal assemblage at Çatalhöyük is dominated by mice, which would have eaten and fouled human food, and could have had a negative association for an early agricultural community. The fact that mice were found in the early levels in such high numbers meant that they quickly adapted to this human-created niche, and subsequently became prey for small predators also able to adapt to this environment. Evidence of gnawing and digestion in many contexts, although low in incidence, suggests that the majority of contexts analysed came from predatory derived deposits. The low average adjusted NISP per litre suggests a low background presence of microfauna across the site, but with 'hotspots' of activity related to human curation of small carnivore scats. These scats, as well as being incorporated in burials, were also incorporated into what we would consider utilitarian structures, such as ovens and niche infills. These may have been votive or foundational, as in the case of the oven superstructure, which was also found in association with large animal bones and shells. Understanding the importance of the scat is difficult, as its use is not common across the site. Whether the remains within the scat, the animal that produced them, or the scat itself was important to a subsection of the inhabitants of Çatalhöyük remains unknown.

7.1.2. Boncuklu

Figure 7.6 Excavations at Boncuklu under the protection of the canvas tents. The mound at Boncuklu is much smaller than at Çatalhöyük (Photo: M. Feider 2018)

In summary, a total of 4215 specimens were recovered from 31 contexts at this site, and included some of the earliest contexts, dating to approximately 8300 cal. BCE. Ten contexts were analysed from Area H, which was a mixture of buildings and middens, and 14 contexts from Area K, which was a sequence of six consecutive buildings. A further seven contexts were analysed from Area M, which was a mixed area with non-standard structures, and a single 'conventional' building, but which consisted mostly of outside space comprised of midden deposits, fire pits, and cooking areas.

7.1.2.1. Quantification and Taxonomy

NISP

The average adjusted NISP per litre for all contexts was much higher than at Çatalhöyük, with only nine of the 31 contexts having an adjusted NISP per litre of less than one. Four of these smaller contexts were burial fills. The average adjusted NISP per litre by area was Area H: 2.5; Area K: 2; Area M: 4.4 (Table 6.21).

Species composition

Also in contrast to the Çatalhöyük microfaunal assemblage, the species composition at Boncuklu was dominated by anura, with 72.7% of the assemblage represented primarily by frogs. Snake were the next most abundant taxa, at 13.6% of the assemblage, however this could be inflated by the number of elements (i.e., vertebrae) within a single animal (van Wijngaarden-Bakker and Troostheide 2003), and this may be borne out with each context containing snake specimens only ever having an MNI of one. The vertebrae recovered appeared most likely to belong to *Natrix* sp., as depicted in the literature (Ratnikov 2000). However, without a more extensive reference collection, and because of the inability to travel to one during the Covid-19 lockdown (Appendix A), these specimens were only allocated to the higher taxonomic classification of snake. Vertebrae were not the only elements of snake recorded; cranial elements were also recovered but in much lower numbers.

Only a small number of anura elements are identifiable to species, so the majority of elements were attributed to order, only. In addition to the order, specimens recorded included *Pelophylax* sp., *Pelophylax ridibundus*, and *Bufo viridis*. Toads can be toxic to humans but are known to be used in medicine and rituals around the world, although, as with the insectivores, they may also be attracted to any significant insect activity in midden deposits. This hypothesis is supported by the fact that no toad remains were recovered from Area K, which did not contain any midden deposits. Due to the limited number of anura elements that can be identified to species, when the higher taxonomic groups were removed *Arvicola amphibius* was the most abundant species at 55%, with *Pelophylax* sp. accounting for 33.4% of the assemblage (Figure 6.15). This is misleading as anura dominate this assemblage as a whole. Diagnostically identifiable elements of anura were low in number due to the fragmentary nature of the assemblage and *A. amphibius* only contributed to 6.3% of the assemblage.

Rodents together comprise 11.6% of the assemblage with the majority being *A. amphibius*, which formed 88.7% of the rodent elements. Specimens of *Mus* sp. were very limited in number, at only 1.7% of the rodent samples and 0.01% of the assemblage as a whole. This taxon was restricted to Areas H and K, with no *Mus* sp. specimens recovered from Area M. They are more likely to be anthrodependent, exploiting the habitat created with permanent occupation of the site.

Despite extensive burrowing activity of ground squirrels at Boncuklu, contamination of contexts leading to the inclusion of specimens of modern *Mus* sp., especially those within buildings, is extremely unlikely. Contamination in buildings, especially those in Area K, and the features within them, such as burials, is easy to identify as the walls and floors of buildings were routinely plastered, creating sealed layers. Any burrowing activity cutting through these layers was clearly visible in the archaeology, and the burrows were fully excavated with the contents discarded, before the features themselves were excavated and recorded (Baird pers comm. 2018).

Four of the five specimens recovered were mandibles which contained an *in-situ* first molar. These samples, plus an additional Boncuklu *Mus* sp. specimen from previous analysis at Boncuklu (Clarkson *et al*. Forthcoming) were photographed, measured, and sent for geometric morphometric (GMM) analysis. The original intention had been to conduct this analysis myself but, due to Covid-19 restrictions this was not possible because I was unable to travel to take photos of the necessary reference taxa.

The results for the GMM at Boncuklu concluded that the specimens sent for analysis belonged to *Mus musculus domesticus*, and were not the 'wild' type mouse, *Mus macedonicus* (Figure 6.38). One of the *M. m. domesticus* samples was recovered from Building 2 in the sequence of buildings in Area K. This building pre-dates Building 9, which has been radiocarbon dated to c.8300 cal. BCE. As such, these are now the earliest identified house mice in Central Anatolia, pre-dating the Çatalhöyük specimens by more than 1000 years. Caution, however, needs to be applied as this was a very small number of specimens on a site with a high level of ground squirrel activity. As previously stated, it is unlikely that these specimens are intrusive as the bones themselves did not appear to be different to those believed to be contemporary, and their restriction to occupation areas of the site, with no specimens recovered in open areas or middens, would suggest a spatial limit to mouse distribution. If the specimens were intrusions into the archaeology, their distribution over the site would be expected to be random, as the ground squirrel activity is ubiquitous. However, Cucchi *et al.* (2012) stated that archaeological samples of house mice had to pass sample size validation thresholds in order to be determined as reliable. With so few specimens at Boncuklu this is perhaps a threshold that would not be passed; however, it can be used to ask questions of the microfauna in research going forward at this site, and could be used to assess heavy residue processing in future.

Insectivore specimens were restricted to *Crocidura suaveolens*, the lesser white-toothed shrew, and *Erinaceus concolor*, the white-breasted hedgehog, and these were only recovered in Area M. The lack of these specimens in Areas H and K, also suggests that these animals are limited to the open areas of the site, perhaps attracted to insect activity in the middens, which were more dumps, or spreads on the ground, rather than confined to discrete areas or pits.

MNI

As with NISP, Minimum Numbers of Individuals was heavily weighted to anura, with specimens further identified as *Pelophylax* sp, having the next highest MNI (Table 6.24). This is mostly a result of having an assemblage dominated by a taxon that can only be identified to genus or species using a select number of elements. The fragmentary nature of the assemblage will also have had an impact of identifiable elements.

Body Part Representation

All contexts with an individual taxa MNI greater than 10, were examined for body part representation. At Boncuklu, only anura and species of amphibians had MNIs greater than ten. The results showed a hindlimb bias for all contexts analysed, with hindlimbs being over-represented in comparison to other body part categories. In the 'expected %' category, hindlimbs have the lowest percentage, with the cranial body part category having the highest percentage in a complete individual. The cranial body part category in the archaeological assemblage is the least well-represented body category. Mandibles and maxilla were not included in the cranial category due to the very high level of fragmentation and the difficulty in assigning a zone, which made MNE calculations difficult. In order not to bias the cranial body part category, mandibles and maxilla were excluded from the calculations, both for the expected and observed data (Figure 6.22).

Element frequency for anura and amphibian species e.g., *Pelophylax* sp., showed the most common elements in nearly all contexts was the ilia or the urostyle, both of which were assigned to the hindlimb body part category (Table 6.25).

When rodent and micromammal post-cranial elements were analysed by size category, a distinction could be made which differentiated between the smaller micromammals,

such as *Microtus* sp. or *Mus* sp., and large-bodied rodents, such as *A. amphibius*. More than 80% of the rodent specimens were recorded as large-bodied, along with 73.7% of specimens identified as micromammal. This suggests that those post-cranial remains are likely to belong to *A. amphibius*, rather than other *Microtus* species (Table 6.48).

7.1.2.2. Taphonomy

Predator induced modification

The low number of small mammal post-cranial elements in each context prevented a fragmentation analysis by context, and so the assemblage was looked at as a whole. 'Portions' of elements represented tended to be those that were most diagnostic, such as fused or just fused ends. The percentage present showed that the majority of specimens were in the small to medium fragmentation category ('less than 1/3' or '1/3 – 2/3'). However, this is unsurprising given that the majority of contexts at Boncuklu were sieved to 4mm, rather than 2mm, so some small specimens, especially those of the smaller frogs and some species of arvicolids and murids, may not have been recovered.

Maxillary breakage was different to Çatalhöyük. Alveolar spaces for arvicolid molars create a weakness in the maxilla not found in murines, and breakage reflects this with the majority of recovered specimens being palate fragments, which were broken through the alveolar spaces, rather than down the middle of the palate to create individual maxilla with teeth *in-situ*. Mandibular breakage was more variable with high numbers in the 'ascending ramus missing' and 'ascending ramus missing and inferior border broken' categories. As the majority of mandibles belonged to *A. amphibius* which are larger than those of *Mus* sp., more of the portions of the mandibles that had broken off were also recovered and identified.

Incisor and molar retention in arvicolids were also much more variable than at Çatalhöyük, although this could be due to sample size, with fewer specimens recorded at Boncuklu. Incisor retention was more variable. However, many contexts contained higher numbers of loose incisors than those *in-situ*. Molar retention was variable and appeared to change by Area. In Area H, the majority of molars were recorded as *in-situ*, but in Areas K and M, the majority were recorded as loose. Area K had a very small sample size, whereas Area M contained some of the largest assemblages recorded and had the highest number of molar specimens (Table 6.30). The difference in retention of molars between areas could be due to increased levels of breakage in specimens

recovered from middens, although this is difficult to confirm as maxillary breakage was high across the site, or perhaps there were less stable contexts, with a higher potential for disturbance in the midden area.

As with mammals, fragmentation in anura relating to the zones was biased towards those zones that were highly diagnostic, with very few complete elements present. Fragmentation by percentage category was also similar to that of the small mammals, in that the vast majority of elements fell into the 'less than 1/3' or '1/ - 2/3' category, which again may have been due to these fragments being more easily identifiable to those doing the sorting following flotation and sieving, as well as the larger sieve size being used for many of the contexts (Table 6.32).

Gnawing at Boncuklu was very limited, with only two elements being gnawed and a further five specimens with possible gnawing. One of the potentially gnawed specimens was a *Mus* sp. mandible. Only 0.07% of anura specimens were gnawed, which is exceptionally low given their abundance and distribution on site (Table 6.41).

Very few rodent specimens were digested, which is telling given that the majority of rodents on site were arvicolids, whose teeth are more susceptible to digestion than murines due to the morphology of their molars. Only 1.6% of the rodent assemblage was digested, and the digestion levels were limited to 'light' and 'moderate' suggesting a Category 1 predator, such as an avian predator (Table 6.42). Despite high levels of fragmentation, low levels of both gnawing and digestion would suggest that the main taphonomic pathway for anura or rodents at Boncuklu was not one which was primarily derived from external predators.

Burning

Levels of burning at Boncuklu were much higher than at Çatalhöyük, at 10.5%. This was not necessarily attributed to the burning of buildings as part of a ritual closure, as at Çatalhöyük, but more associated with domestic events, such as discard from hearths, fire pits, or cooking waste. Area M, the middens, contained the most burnt elements, with Area H, buildings and middens, containing the next highest proportion, with the sequence of buildings in Area K containing the least (Table 6.36).

Anura were the taxa most affected, with *Arvicola amphibius*, and snake the next most affected. (Table 6.33) Certain species, such as *Crocidura suaveolens*, *Erinaceus concolor*, *Mus* sp., and toad, showed no evidence of thermal alteration. These species are not ones that would be expected to form part of the human diet, with the exception of *Erinaceus concolor*, for which only a single molar was recovered.

Arvicola amphibius and snake specimens affected by thermal alteration, both making up 10.1% each of the burnt assemblage, and 16.9% and 7.9% burning by taxa respectively (Table 6.33), could suggest that both water voles and snakes were also being exploited as a food item. The majority of burnt specimens of *Arvicolinae*, rodent, and micromammal bones that were attributed a size category had been recorded as large, most likely belonging to *Arvicola amphibius.*

Burn colour suggested lower temperatures as the majority of burnt specimens were brown or black in colour, rather than the greys, blues, and whites associated with higher temperatures. This could suggest cooking. However, 91.9% of the burnt specimens were completely burnt, rather than partially burnt, suggesting that no flesh was present to protect the bones, or that they were reintroduced to the fire once the flesh had been removed. Burning in microfauna, however, does require additional experimental work as Lev et al (2020) stated that squamate vertebra turn black more readily than macrofauna. If evidence of burning is essential to the identification of the inclusion of herpetofauna and squamate remains in the diet of humans, then more accurate data is needed to determine cooking patterns and techniques, and the actual effects of thermal alteration.

7.1.2.3. Anthropogenic contexts

A small area in Area M was identified during one fieldwork season as containing a latrinal area with a considerable deposit of suspected human coprolites. Samples from this area were subject to analysis of sterols and bile acids using Gas Chromatography Mass Spectrometry (GC-MS), to determine the species of the producer, which concluded they were of human origin (Baird pers comm 2020).

Similar coprolite specimens were recorded in Area R, to the southeast of Area M, and these were dry sieved to 2mm to retrieve the small bone samples. A preliminary assessment yielded identifiable anura elements from the crania, axial skeleton, forelimb,

and pes. More work needs to be done on these samples, including Zooarchaeology by Mass Spectrometry (ZooMS) to identify the species of the anura consumed, and to get a better understanding of how the animals were cooked and eaten.

7.1.2.4. Summary

The Boncuklu macrofaunal assemblage is very different to Çatalhöyük. The predominance of anura, and the higher levels of burning, and a hindlimb bias, suggests that the depositional pathway for this assemblage was driven by human consumption, almost certainly of frogs, but also of water voles and snakes. Taking the size of rodent post-crania into account, the assemblage was skewed to crania, suggesting a removal and potential curation of water vole 'heads' in the midden deposits, with the body eaten, although more work needs to be done on how thermal alteration affects microfauna.

The identification of *Mus* sp. at Boncuklu to *Mus musculus domesticus* is significant, as they are now the earliest identified house mice in Central Anatolia, predating Çatalhöyük by1000 years. Despite the high levels of potential contaminants at the site, with extensive digging by ground squirrels, the securely dated stratigraphy within the houses, and the spatial limit of the mice remains all suggest that these were contemporaneous with the houses. Where Çatalhöyük had been a proto-urban centre, with a possible mouse infestation, Boncuklu, as an early agricultural village, had created conditions suitable enough to allow the beginnings of exploitation by this anthrodependant rodent.

7.1.3. Pınarbaşı

Figure 7.7 Pınarbaşı looking east to the promontory that would have jutted out into the Hotamiş marsh to the left of the picture. Area B was directly adjacent to the rockface and just to the right of the large crag in the centre of the photograph (Photo: M. Feider 2018)

In summary, analysis of the Pınarbaşı microfauna covers three phases of occupation at the site and allows us to examine how a single site was occupied and utilised over millennia. The 14th-12th Millennium BCE occupation, or Epipalaeolithic, in Area B, immediately adjacent to the promontory (Figure 7.7), was a temporary seasonal site for people with mobile lifeways and was contemporary with the Natufian culture in the Levant. The 10th-9th Millennium BCE occupation in Areas A and D on a mound to the west of the promontory (Figure 7.8), was used by sedentary inhabitants, but who maintained a continued reliance on hunter-gathering. The 7th Millennium BCE occupation, again in Area B, was one that had gone back to seasonal use, possibly by shepherds from Çatalhöyük, as large numbers of ovicaprine remains were recovered, along with the more substantial late Neolithic structures.

A total of 2522 specimens were recorded across the three different phases of occupation at Pınarbaşı, with the 7th Millennium BCE occupation accounting for 312 specimens, the 10th-9th Millennium BCE for 616, and the Epipalaeolithic, 14th-12th Millennium BCE occupation for 1594 specimens (Tables 6.51 and 6.52).

Figure 7.8 Pınarbaşı: the mound to the west of the promontory and the site of the 10th-9th Millennium BCE occupation in Areas A and D (Photo: M. Feider 2018)

7.1.3.1. Quantification and Taxonomy

NISP

The numbers of specimens for the various Areas differ, despite having a similar numbers of contexts. The 7th Millennium BCE occupation phase in Area B, however, is the exception, as only five contexts were analysed for this phase.

Table 7.2 Summary of the context and NISP for the three different phases of occupation at Pınarbaşı

7th Millennium BCE		10th-9th Millennium BCE				14th-12th Millennium BCE	
Context	NISP	Context	NISP	Context	NISP	Context	NISP
BBH	4	ADJ	54	DCI	3	BIA	143
BDF	16	ADN	121	DCL	15	BIB	122
BFV	2	ADX	17	DFA	1	BIE	405
BHL	44	AER	25	DFH	2	BIF	81
BJY	246	AFA	73	DFM	22	BIH	556
		AFC	23	DGK	3	BIJ	116
		AFI	26	DGL	4	BIK	11
		AHA	29	DGN	15	BIL	62
		ZAM	23	DGS	72	BIP	23
				DGT	88	ZBB	37
						ZBD	38
Total	**312**		**391**		**225**		**1594**

Despite almost twice the number of contexts in the 10th-9th Millennium BCE settlement, a far greater number of microfauna were recovered from the Epipalaeolithic occupation phase of the settlement (Table 7.3). The difference was also seen in the adjusted NISP per litre, with the Epipalaeolithic occupations generally having a higher NISP per litre

than the 7th millennium, or 10th-9th millennium occupation contexts (Table 6.50). The Epipalaeolithic contexts were made up of occupational layers with rock shatter debris separating out the different contexts. However, little contextual information was available for the individual contexts.

Species Composition

Species composition for the 7th millennium occupation in Area B, and the 10th-9th millennium occupation in Areas A and D, are largely similar in that they are both dominated by anura and have very similar percentages for other taxonomic groups (Table 7.4). The Epipalaeolithic, however, shows a vastly different species composition, one not as dominated by a single taxon group as the other phases of occupation but with snake as the dominant taxa, and a much higher proportion of small mammals compared to anura.

Table 7.3 Summary table showing the comparison between percentages of higher taxonomic groups for each phase of occupation (excluding 'microfauna' category for 14th-12th Millennium) at Pınarbaşı

	Anura		Snake		Rodent		Insectivore		Micromammal	
	N	%	N	%	N	%	N	%	N	%
7th Millennium BCE	259	83	28	9	14	4.5	2	0.6	9	2.9
10th-9th Millennium BCE	507	82.3	61	9.9	27	4.4	2	0.3	19	3.1
14th-12th Millennium BCE	257	16.1	816	51.2	252	15.2	15	0.9	243	15.8

Specimens identified to genus or species are also much greater in number during the Epipalaeolithic occupation phase than in the 7th millennium, or 10th-9th Millennium phases (Figure 6.31).

The species richness of the Epipalaeolithic assemblage is most likely due to the make-up of each of the contexts, including debris and inclusions from non-anthropogenic activity. The number and diversity of taxa probably increased when humans disperse from the site, as many of the species are anthropophobic. This is also evidenced by the area being used as a wolf nursery den, which would only have occurred when people were absent from the area (Baird *et al*. 2013).

Geometric morphometric (GMM) analysis on a single *Mus* sp. specimen from the 7th Millennium BCE occupation phase, was reported as belonging to *Mus macedonicus*, the 'wild' mouse (Figure 6.39). This fits with the prevailing theory that the 7th millennium site was a seasonal site used by sheep herders, potentially from Çatalhöyük which

would not have created a niche robust enough to allow *M. m. domesticus* to outcompete the wild mice.

Taxa in all phases of occupation are indicative of the varied landscapes in the immediate vicinity to Pınarbaşı, with anura and other water-based species such as grass snake and water voles, coming from the Hotamiş marsh at the base of the promontory and the species that require drier, rockier ground being able to exploit the more rugged terrain created by the rising hills of the Bozdağ.

Table 7.4 Summary of genus and species that occur at each of the three phases of occupation at Pınarbaşı

7th Millennium	10th-9th Millennium	14th-12th Millennium
Pelophylax sp.	*Pelophylax* sp.	*Pelophylax* sp.
		Pelophylax ridibundus
	Pelobates sp.	*Pelobates* sp.
Arvicola amphibius	*Arvicola amphibius*	*Arvicola amphibius*
		Microtus sp.
		Microtus guentheri
		Mesocricetus sp.
		Cricetulus migratorius
Mus sp.		*Mus* sp.
	Meriones sp.	*Meriones* sp.
		Crocidura sp.
Crocidura suaveolens		
Erinaceus concolor	*Erinaceus concolor*	*Erinaceus concolor*
		Pipistrellus sp.
		Myotis myotis

MNI

Minimum Numbers of Individuals is low across all contexts, for all phases of occupation at the site, with the majority of species identified per context accounting for a single individual (Table 6.57).

Body Part Representation

Body part representation at Pınarbaşı was not calculated in the same way as the other sites due to the very low numbers of MNEs, from which the calculations were made. Instead, in order to compare occupation phases, the NISP was used to compare body part categories. Although NISP is a less accurate way to compare body part frequencies, as element breakage may account for higher numbers of some elements, it is interesting to note that a hindlimb bias for anura and *Pelophylax* sp. was found in

only one occupation phase, the 10th-9th Millennium BCE, (Figure 6.34). If breakage occurs in areas of weakness in the bones, then the same elements would be expected to break in the same place, and to roughly the same degree, if other biasing factors were not at play. As such, it is an interesting, if not accurate way to examine body part representation in an assemblage that doesn't allow for analysis by MNE. This can allow us to pull out broader pictures of each phase of occupation, rather than look at a more detailed pattern by context.

7.1.3.2. Taphonomy

Predator induced modification

The small samples sizes of the 7th millennium and 10th-9th millennium occupation phases, and the domination of anura in these phases, meant that levels of breakage was not assessed for rodents, as percentages would have been inflated due to small sample size. Fragmentation in rodents was analysed for the whole Epipalaeolithic microfaunal assemblage and showed similar patterns to those found at Boncuklu. The 'portion' of the bone most commonly found were those that were fused, or that were highly diagnostic, for example proximal ulnae and distal humeri, and very few elements were recorded as complete. Fragmentation was also similar to those from Boncuklu, with the 1/3-2/3 category being the most common for all four elements analysed (Table 6.58). The Pınarbaşı samples were nearly all sieved to 4 mm, with some sieved to 2 mm and/or 1 mm. The mesh size may have played a role in element identification, especially during the initial sort on site, as smaller specimens may have been missed. Fragmentation in the Epipalaeolithic phases may also have been affected by rock shatter and falling debris, as this was noted as being present, acting as a layer separating out the human-derived deposits between occupation layers.

Only a single specimen showed evidence of gnawing and this was from the Epipalaeolithic phase of the occupation of the site. Digestion was also low across all phases, with only 1.3% of the whole assemblage digested. Nearly all of the digested specimens were rodents, with only two digested *Crocidura* sp. specimens. All were from Area B, from two contexts from the 7th millennium BCE, and seven contexts from the Epipalaeolithic. This perhaps reflects the periods during both the 7th millennium BCE and Epipalaeolithic when humans had moved away from the area giving predators more access. With the majority of the digestion being light, and a very low incidence of gnawing, it is more likely that an avian predator is responsible for accumulation of the

assemblage, one that perhaps took advantage of the rocky edge of the promontory for perching or roosting. It is telling that there are no digested remains at the 10th-9th millennium BCE settlement, as perhaps Area B, with its ecotonal setting, offered more hunting opportunity to predators, and a small settlement occupied year-round, but one that was not occupied by a farming community and did not offer enough to entice predators into the settlement or offer places to roost.

Burning

Burnt elements were recovered from all phases of occupation, however levels of burning were much lower in the 7th millennium BCE and Epipalaeolithic phases, at 0.6% and 3.5% respectively. The 10th-9th millennium BCE phase had a much higher rate of burning at 14.6% (Table 6.67). Anura were the most burnt taxa, which along with a domination of the assemblage by this taxon, and a potential hindlimb bias based on NISP, may suggest that the inhabitants of the 10th-9th millennium BCE settlement were exploiting the close proximity of the Hotamiş marsh and were including frogs in their diet. Burn colour was also similar to that found at Boncuklu, with the majority of burnt specimens exposed to lower temperatures as evidenced by brown or black coloured elements, rather than the lighters greys, blues or whites associated with higher burning temperatures (Table 6.65).

7.1.3.3. Summary

The way the site was utilised over the millennia changed, going from a seasonal, temporary site to one that was permanently occupied. Unlike at Boncuklu, the inhabitants of Pınarbaşı did not take up farming and the site remained one with an economy based on settled hunter-gathering. Much later, the site re-entered use as a temporary or seasonal site once again, perhaps being used by farmers from Çatalhöyük as they herded their domesticated sheep across the Konya Plain.

The different uses of the settlements can be seen in the microfaunal assemblages for each occupation phase. The Epipalaeolithic phase has a much broader range of microfauna than any other phase of occupation at the site, or at Çatalhöyük or Boncuklu. Many of the taxa present are anthropophobic, and most likely relate to the times when humans had moved away from the site and the area was once again exploited by wildlife. With the majority of specimens affected by digestion coming from this phase of the site, it provides evidence that the rock face was being used as

either perches, or roosting sites for nesting predators, with pellets being incorporated into the rock shatter layers below, which separated the layers of human use.

The 10th-9th millennium BCE phase had fewer species identified than the Epipalaeolithic, the majority of which were anura. The lack of gnaw marks or digestion by predators in this phase, and the high incidence of burning and the potential for a hindlimb bias in frogs, also suggests that these animals were being exploited as part of the human subsistence diet. No specimens of *Mus* sp. were recovered for this phase despite it being a sedentary settlement. Perhaps *M. m. domesticus* was more population dependant, or had yet to reach central Anatolia. House mice were only found in very low numbers at Boncuklu, which is much later than some of these contexts. However, there is an overlap with the end of Pınarbaşı and the beginning of Boncuklu of several hundred years.

Mus sp. were recovered from the 7th millennium BCE phase, however GMM analysis identified this specimen as belonging to *Mus macedonicus*, rather than *M. m. domesticus*. The 7th millennium BCE occupation was one that was temporary or seasonal, and as such did not allow for the outcompeting of 'wild' type mice by the anthrodependent species. Although anura also dominated in this phase of occupation, having very similar percentages of higher taxonomic groups to the early Neolithic phase, there is no evidence of a hindlimb bias, even by NISP, and a low incidence of burning. This would suggest that there is little to no exploitation of frogs as food during this phase of occupation, or that the sample size of that assemblage was too small to be conclusive.

7.2. Part 2

7.2.1. Palaeoenvironmental Reconstruction

As discussed in sub-chapter 4.2, palaeoenvironmental reconstruction is the reconstruction of local or regional environments based on certain proxies. Like some other proxies, microfauna can be biased when collected from human mediated environments due to the depositional pathways involved in the accumulation of the assemblage. Microfauna can be very good indicators of the palaeoenvironment in palaeontological assemblages, such as those recovered from cave sites etc. However, in archaeology too many additional factors can skew the assemblage so that it is rarely indicative of the local environment. Biasing factors include human curation for inclusion in diet, human impact on species diversity, predation, and ecological niche construction and habitat partitioning, to name a few.

The close geographical range of the three sites analysed here means that the type and species of small vertebrates that could have been present would have been similar, with the exception of those that would have taken advantage of the rocky outcrop at Pınarbaşı, such as bat species. Additional palaeoenvironmental proxies, including sediment coring and pollen analysis at Çatalhöyük, have concluded that the Çarşamba River was an anabranching river system, and that seasonal flooding would not have created the backswamp, as suggested by previous research, but that areas of higher ground would have been suitable for agriculture year-round (Ayala et al 2021). At Boncuklu, palaeoenvironmental reconstruction using charcoal, phytolith, and faunal data suggested the area was surrounded by marshland, and Pınarbaşı, as an ecotonal site, was at the juncture of hills, plain, and marsh (Baird et al 2012).

The microfaunal assemblages from each of the three sites, and even between different phases of occupation at Pınarbaşı, do differ, sometimes significantly (Table 7.7).

Table 7.5 Summary table showing percentages of higher taxonomic groups on each site to show which taxa are most dominant

Çatalhöyük		Boncuklu		7th Millennium Pınarbaşı		10th-9th Millennium Pınarbaşı		14th-12th Millennium Pınarbaşı	
Taxa	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**
Anura	0.7	Anura	72.7	Anura	83	Anura	82.3	Anura	16.1
Snake	0.5	Snake	13.6	Snake	9	Snake	9.9	Snake	51.2
Rodent	61.2	Rodent	11.6	Rodent	4.5	Rodent	4.4	Rodent	15.2
Insectivore	0.6	Insectivore	0.1	Insectivore	0.6	Insectivore	0.3	Insectivore	0.9
Micromammal	36.4	Micromammal	1.7	Micromammal	2.9	Micromammal	3.1	Micromammal	15.8

When genus and species are examined without the inclusion of the higher taxonomic groups (Table 7.6), more details in the composition of the assemblage can be seen. However, some of the data no longer reflects the dominance of the higher taxonomic groups, for example in Boncuklu, *A. amphibius* becomes the dominant species despite anura accounting for 72.7% of the overall assemblage. This is due to the diagnostic elements for species identification in anura requiring complete, or mostly complete elements, which makes identification difficult in fragmentary assemblages. As such, fewer specimens could be identified to genus or species level.

What Table 7.6 does show, however, is that in the different assemblages, the importance or dominance of certain species is starkly different. In Çatalhöyük, *M. m. domesticus* is by far the most prevalent species, whereas at Boncuklu, anura, and *A. amphibius* provide much higher proportions of the assemblages. At Pınarbaşı, percentages of the higher taxonomic groups for the 7th millennium BCE and 10th-9th millennium BCE occupations phases are very similar (Table 7.7), even though the specimens identified to species are low. The 14th-12th millennium BCE occupation phase has a much higher number of specimens identified to genus and species, and the dominance of anura, as in other phases of occupation at this site, is replaced with higher numbers of snake and small mammals.

Table 7.6 Summary table showing genus and species of specimens identified on each site. Not including specimens identified to higher taxonomic groups

Çatalhöyük		Boncuklu		7th Millennium Pınarbaşı		10th-9th Millennium		14th-12th Millennium	
Species	**%**	**Species**	**%**	**Species**	**%**	**Species**	**%**	**Species**	**%**
Pelobates sp.	0.05	*Pelophylax* sp.	33.4	*Pelophylax* sp.	35	*Pelophylax* sp.	32.3	*Pelophylax* sp.	3
Pelophylax ridibundus	0.1	*Pelophylax ridibundus*	0.8					*Pelophylax ridibundus*	1.2
						Pelobates sp.	2.9		
Bufo viridis	0.1	*Bufo viridis*	0.2						
		Arvicola amphibius	55.5	*Arvicola amphibius*	10	*Arvicola amphibius*	29.4	*Arvicola amphibius*	14.2
Microtus sp.	0.05							*Microtus* sp.	3.6
		Microtus guentheri	0.2					*Microtus guentheri*	2.4
								Mesocricetus sp.	0.6
								Cricetulus migratorius	1.2
Apodemus sp.	0.1								
Apodemus	0.05								
Mus sp.	97.7	*Mus* sp.	1	*Mus* sp.	5			*Mus* sp.	2.4
Meriones sp.	0.1					*Meriones* sp.	2.9	*Meriones* sp.	0.6
Crocidura sp.	1.7							*Crocidura* sp.	4.7
		Crocidura suaveolens	0.8	*Crocidura suaveolens*	5				
		Erinaceus concolor	0.2	*Erinaceus concolor*	5	*Erinaceus concolor*	5.9	*Erinaceus concolor*	0.6
								Pipistrellus sp.	0.6
								Myotis myotis	0.6

The microfaunal assemblage at Çatalhöyük indicated an urban environment with very low taxonomic diversity, with the human mediated environment dense enough to support an anthrodependent rodent in numbers high enough to allow for the exclusion, or out-competing, of other species of small mammal. Additional species were present in the assemblage, but in such low numbers that it is unlikely they can be used to determine the local environment outside the area of human occupation. The identity of the predator responsible for a significant amount of the Çatalhöyük assemblage is still unknown, although it is most likely to be a small mammalian carnivore, such as a mustelid. More work on this is needed.

Despite the sites proximity to an anabranching river system, anura at Çatalhöyük were low in numbers. Even previously analysed assemblages from Çatalhöyük that suggested a mixed taphonomic pathway of deposition, such as the 2000-2008 and BACH assemblages (Jenkins 2012b; Jenkins and Yeoman 2013), which both had much higher percentages of amphibians at 19% and 16% respectively, are still much lower than at Boncuklu or Pınarbaşı, suggesting that these animals were not exploited in the same way, or to the same degree, as they were at earlier sites.

That amphibians from many sites are simply dismissed as being intrusive is limiting the consideration of palaeoenvironmental data as well as potential information on human subsistence. At Boncuklu, an assemblage dominated by anura, mostly frogs, is highly suggestive of a wet surrounding area, concurring with other environmental proxies.

However, we must consider the societal filter (e.g., selection, gathering, preferences, storage, disposal) affecting the assemblage. For example, are frogs at Boncuklu a confirmation that the local ecology to the site is wet, when data collected for this thesis suggests frogs were introduced to the site as part of the diet, and therefore may have been collected away from the site and brought in? It is doubtful, as their exploitation is most likely due to the proximity of the site to the habitats of these animals, because Boncuklu was surrounded by marsh. However, microfauna principally found in anthropological deposits cannot be examined for palaeoenvironmental reconstruction without taking the human inhabitants of the site into account. The differences in the microfaunal assemblage, therefore, may have more to do with human exploitation of the landscape, and how humans change the ecology of the immediate vicinity of the site, than with natural distribution of the microfauna.

The ecotonal location of Pınarbaşı is reflected in the diversity of microfauna recovered on the site, from both the Epipalaeolithic phase of occupation, but the 10th-9th millennium BCE, and 7th millennium BCE occupation phases as well. Species from several different ecological niches are present.

The differences between the three sites are stark and reflects the variation of the surrounding environment as well as the settlement size and set-up. Table 7.7 lists all specimens identified to genus or species, their percentage of recovery at each site, and their habitat preferences. The most abundant genus or species has been highlighted to show the potential local ecology of the site. At Çatalhöyük, this relates to the built environment and the impacts humans had on their surroundings, with *M. m. domesticus* the most prevalent species on site by far. Both Boncuklu and the 7th millennium and 10th-9th millennium BCE Pınarbaşı are dominated by wetland species, emphasising the proximity of the site to marshy and wetland areas. In the Epipalaeolithic settlements, the majority of genus and species also represent wet or marshy local environments, but the increase in the number of species requiring well-drained, dry, rocky and/or steppic habitats provides insights into the ecotonal nature of the area.

Table 7.7 Showing the species recorded, the percentage of recovery, and habitat preferences for each of the sites

Site	Species	%	Habitat Preferences
Çatalhöyük	*Mus musculus domesticus*	*97.7*	Commensal; human dwellings as well as isolated outbuildings.
	Crocidura sp.	*1.7*	Species dependant but can include rocky areas, grassland, forests, hedges, dense bushlands, reedbeds, hedgerows, marshland
	Pelophylax ridibundus	*0.1*	Aquatic habitat - tolerant of brackish conditions. Drainage ditches, pools.
	Bufotes viridis	*0.1*	Wet and swampy to dry, desert habitats, including forests, steppe, and semi-desert. Water needed for reproduction, including ditches, puddles, pools, ponds, lakes etc.
	Apodemus sp.	*0.1*	Species dependant but can include mixed habitat including forests, forest edges, gardens, hedgerows, and woodland with sparse vegetation, and thickets
	Meriones sp.	*0.1*	Dry steppe, semi-desert. Short and tall grass, open hillside, field margins
	Pelobates sp.	*0.05*	Lowland, steppic habitat, marsh, with areas of sandy soils or soft clay soils for burrowing
	Microtus sp.	*0.05*	Varied based on species
	Apodemus mystacinus	*0.05*	Rocky scrubland and forests, rocky outcrops, pastures with scattered bushes
Boncuklu	*Pelophylax* sp.	*33.4*	Aquatic habitat - tolerant of brackish conditions. Drainage ditches, pools and ponds
	Arvicola amphibius	*55.5*	Associates with bodies of water; streams, rivers, irrigation ditches
	Mus musculus domesticus	*1*	Commensal; human dwellings as well as isolated outbuildings.
	Pelophylax ridibundus	*0.8*	Aquatic habitat - tolerant of brackish conditions. Drainage ditches, pools.
	Crocidura suaveolens	*0.8*	Dense bushlands, reedbeds, hedgerows, marshland, rocky areas
	Bufotes viridis	*0.2*	Wet and swampy to dry, desert habitats, including forests, steppe, and semi-desert. Water needed for reproduction, including ditches, puddles, pools, ponds, lakes etc.
	Microtus guentheri	*0.2*	Well drained meadows, pasture, areas with sparse vegetation
	Erinaceus concolor	*0.2*	Steppe, semi-arid areas, farmland, gardens, and forests
Pınarbaşı 7th Millennium BCE	*Pelophylax* sp.	*35*	Aquatic habitat - tolerant of brackish conditions. Drainage ditches, pools and ponds
	Arvicola amphibius	*10*	Associates with bodies of water; streams, rivers, irrigation ditches
	Mus macedonicus	*5*	Dense vegetation, in association with arable land and water e.g. irrigation ditches. Human settlement avoidant
	Crocidura suaveolens	*5*	Dense bushlands, reedbeds, hedgerows, marshland, rocky areas
	Erinaceus concolor	*5*	Steppe, semi-arid areas, farmland, gardens, and forests
Pınarbaşı 10th-9th Millennium BCE	*Pelophylax* sp.	*32.3*	Aquatic habitat - tolerant of brackish conditions. Drainage ditches, pools and ponds
	Arvicola amphibius	*29.4*	Associates with bodies of water; streams, rivers, irrigation ditches
	Erinaceus concolor	*5.9*	Steppe, semi-arid areas, farmland, gardens, and forests
	Pelobates sp.	*2.9*	Lowland, steppic habitat, marsh, with areas of sandy soils or soft clay soils for burrowing
	Meriones sp.	*2.9*	Dry steppe, semi-desert. Short and tall grass, open hillside, field margins
Pınarbaşı 14th-12th Millennium BCE	Snake - most likely *Natrix sp.*	50.2	Wetlands, ponds, lakes, marshes
	Arvicola amphibius	14.2	Associates with bodies of water; streams, rivers, irrigation ditches
	Crocidura sp.	4.7	Species dependant but can include rocky areas, grassland, forests, hedges, dense bushlands, reedbeds, hedgerows, marshland
	Microtus sp.	3.6	Varied based on species
	Pelophylax sp.	3	Aquatic habitat - tolerant of brackish conditions. Drainage ditches, pools and ponds
	Microtus guentheri	2.4	Well drained meadows, pasture, areas with sparse vegetation
	Mus sp. most likely *M. macedonicus*	2.4	Dense vegetation, in association with arable land and water e.g. irrigation ditches. Human settlement avoidant
	Pelophylax ridibundus	1.2	Aquatic habitat - tolerant of brackish conditions. Drainage ditches, pools.
	Cricetulus migratorius	1.2	Cultivated areas, including human dwellings. Open woodland, steppes, rocky ground.
	Mesocricetus sp.	0.6	Species dependant but can include dry, rocky, Steppe habitats, irrigated fields, edges of arable land
	Meriones sp.	0.6	Dry steppe, semi-desert. Short and tall grass, open hillside, field margins
	Erinaceus concolor	0.6	Steppe, semi-arid areas, farmland, gardens, and forests
	Pipistrellus sp.	0.6	Open woodland, gardens and parks, open areas with isolated trees, agricultural land
	Myotis myotis	0.6	Woodlands, field systems, meadows, rivers

7.2.2. Broad Spectrum Economy

The evidence for the inclusion of small vertebrates from archaeological sites into the human diet is usually predicated on a series of taphonomic and contextual signatures, which include thermal alteration, a skeletal element bias towards the 'meatier' limbs, such as the hindlimb, and their inclusion in anthropogenic contexts, such as middens.

At the Neolithic site of Skara Brae, Orkney, evidence of burning on specimens of Orkney vole and wood mice, along with low levels of digestion, intermediate levels of fragmentation, and an inclusion in middens was taken as evidence of human exploitation, with consumption the most likely behaviour (Romaniuk et al 2016). However, despite high levels of *Mus* sp. in anthropogenic contexts at Çatalhöyük, the very low incidence of burning in the assemblage, at 0.2%, would suggest that the mice were not being eaten. Even though evidence of direct human consumption of small mammals was found in a human burial from Namaqualand, South Africa (Dewar and Jerardino 2007), the depositional pathway is likely to have been different for those found in human burials at Çatalhöyük, which contained concentrations of rodents above the burials, as discussed further in Sub-Chapter 7.2.3. The evidence from Namaqualand was taken from the stomach and abdominal cavity area of the human burial, whereas the specimens from Çatalhöyük came from above the burial. Also, at Namaqualand, there was no evidence of any predation on the remains, for example, no evidence of gnawing, and there was a complete lack of crania in the burial, and a 'curated pile' in another anthropogenic context at the same site, whereas at Çatalhöyük, all elements were represented, including crania, and specimens also exhibited evidence of gnawing by a small mammalian carnivore.

At Boncuklu, however, there is strong evidence to suggest that the most abundant taxa, anura, mainly frogs, were being eaten. As can be seen from Table 7.8, the microfaunal assemblage from Boncuklu shows the strongest evidence of animals being included in the diet of the human inhabitants. Along with the taphonomic signatures such as burning, and a lack of evidence for other predators being involved in the assemblage formation, at Boncuklu there is also a hindlimb bias, and an inclusion of the bones in anthropogenic contexts, such as middens.

Table 7.8 Taphonomic and contextual signatures required for the identification of inclusion in broad spectrum economy for the three sites (hindlimb bias at Pınarbaşı is based on NISP rather than MNE)*

	Çatalhöyük	Boncuklu	7th Millennium Pınarbaşı	10th-9th Millennium Pınarbaşı	14th-12th Millennium Pınarbaşı
Taxa dominated by a single species or genus	✓	✓	✓	✓	✗
Thermal alteration	✗	✓	✗	✓	✗
Hindlimb bias*	✗	✓	✗	✓	✗
Inclusion in human coprolites	✗	✓	✗	✗	✗
Evidence of other animal predators such as owls or mustelids	✓	✗	✗	✗	✓

In addition to the microfaunal assemblage itself, there is also direct evidence for the consumption of frogs, through the study of small bones recovered from human coprolites, at the site. Coprolite analysis identified sterols and bile acids through Gas Chromatography-Mass Spectrometry, which indicated human origins. Evidence of skull, vertebrae, and forelimb elements of anura in the coprolites confirms human consumption. This, however, does raise an interesting question with regards to the parameters currently used to confirm consumption of small vertebrates, in particular, amphibians, which is the requirement for a hindlimb bias. That elements from the rest of the skeleton, not hindlimb, are recovered in coprolites, suggests that a hind limb bias for confirmation of eating does not necessarily hold for this period in time, and that burning, and the potential inclusion in anthropogenic contexts such as middens, along with other food waste, may be more of an indicator of human consumption. In contemporary western society, frog consumption has been heavily focused on hindlimbs, and therefore we expect a hindlimb bias to indicate that the animals were included in human diets in the past. However, given the evidence from the human coprolites from Boncuklu, this analytical method may be flawed, as the whole body was clearly cooked and consumed.

Unless, that is, the hindlimb bias stands due to the larger size and exceptionally robust nature of the bones following cooking, and the inability to crunch and then swallow these larger bones during consumption.

I participated in an experiment whereby frog legs were cooked, and eaten (Figure 7.9). An attempt was made to thoroughly chew the limb bones, but they were extremely resistant to biting, and the meat came away easily without having to be picked off using teeth. As such, it is possible that it was easier to eat the meat off the hindlimbs and discard the bones, rather than chew them sufficiently so that they passed through the human digestive system. In the experiment, areas of charring, at least to the meat, can be seen in Figure 7.9, however the majority of the femur and tibio-fibula are covered by flesh. The taphonomic effect of human consumption, as evidenced by these specimens, which were collected at the end of the meal, is currently under analysis (Clarkson *et al*. In Press).

Figure 7.9 Frogs legs prepared for cooking (top row), cooked (bottom left), and remains after consumption of meat (bottom right)(Photos: M. Feider 2019)

Many of the faunal reports that contain amphibian remains with few cranial specimens present continually state that these bones may be less well preserved or identifiable, or that they may not be recovered (Whyte and Compton 2020). The microfaunal assemblage from Boncuklu shows that whilst there may still be a hind limb bias due to human consumption, cranial elements can still be recovered, and several elements are in fact quite robust, for example the sphenethmoid. Nicholson (1992), showed that anura elements were robust and not easily prone to breakage following simulated effects of trampling and erosion, and Whyte and Compton (2020) conducted a bone density study which showed that there was very little difference in the density of cranial and post-cranial bones. They do suggest that bone shape may be a factor in bone survivability, with thin flat bones being less structurally sound, and having a larger surface area for any chemical or microbial degradation to penetrate. If this was the case then other amphibian bones in the same context would show evidence of potential acid or biological attack, even if to a lesser degree. If cranial or post-cranial elements are missing from the site entirely, it could suggest that they may have been disposed of elsewhere, or not brought to the site at all, confirming the theory that amphibians were introduced into the faunal assemblage by human agency, either as a food item, or were being used for ritual or medicinal purposes.

There is also the potential that *Arvicola amphibius* were being eaten at Boncuklu because they are the most abundant species in the rodent category, and also exhibit higher levels of burning than other small mammal species. There is a discrepancy between cranial and post-cranial percentages, suggesting that heads may have been removed, and discarded, with the body then eaten. It will be interesting to see if any small mammal bones are recovered from the human coprolites in future, as none were recovered from the small sample looked at for this thesis.

Snakes were also included in the burnt assemblage from Boncuklu and had a relatively high percentage by NISP, at 13.6% of the entire microfaunal assemblage, and also formed 51.2% of the Epipalaeolithic assemblage at Pınarbaşı. As such, there is a possibility that snakes were also being opportunistically exploited at Boncuklu and Pınarbaşı, as has been reported at other sites, for example, at Ain Mallaha, a site contemporary with Epipalaeolithic Pınarbaşı, in the Natufian Levant (Biton *et al.* 2021). The most likely snake species present at Boncuklu is the water snake, *Natrix* sp., which can grow to nearly a meter in length (Sterry 2005), and would be abundant in the

environment around the site. Snake vertebrae were the most common snake element recovered, and were found in all but eight contexts, although MNIs for each context were small, at only one individual. Determining MNI for snakes, though, is problematic due to the number of vertebrae in any individual not being constant, and the lack of literature or access to comparative collections that can show the differences between caudal and thoracic vertebrae etc. (Biton *et al*. 2021). As such, determining how much they contributed to the diet is not an easy task. The number of specimens of snake at Boncuklu, however, are significantly less than those of anura, suggesting that whilst frogs were a frequent component of the diet at the site, snakes were only an occasional addition when perhaps obtained opportunistically.

What is becoming clear is that many individual papers examining the role of squamates in archaeological deposits cite other papers as reporting the bones as being intrusive or predatory derived, and therefore the evidence of consumption at their own site as being exceptional (Monchot *et al.* 2014). Drawing from the literature it appears the consumption of squamates is a more popular practice than previously thought and that a re-examination and review of both the literature and the remains, with specific taxonomic and taphonomic markers, as well as skeletal element representation, should be undertaken in order to understand this more fully. A more comprehensive dataset would be to the advantage of any study in which microvertebrates are considered for human consumption.

7.2.3. Ritual Practice

If ritual activity is defined as a special, i.e., non-normal, activity, what would this look like in a microfaunal assemblage?

For the microfauna analysed for these three site assemblages, several interpretations have been suggested, from potential infestation to inclusion in diet, or as markers of human inactivity on temporary or seasonal sites. What, then, makes a context out-of-the-ordinary?

At Boncuklu, the ubiquitous nature of anura on site means that these deposits are not unusual, but the use of frogs in human diet was unexpected. The spikes in the NISP per litre of microfaunal concentrations at Çatalhöyük, when there is a low background level

of microfauna on the site, may suggest that these contexts are out-of-the-ordinary, or special, but does that mean that there is ritual attached to them?

In previous phases of research at Çatalhöyük, human burials (discussed in more detail in Chapter 4.3) were excavated that contained high levels of microfauna, packed around the human remains. Furthermore, these burials (Burial 460, Burial 513, Burial 492, and the burial from Mellaart's excavation), the contexts with the high NISPs that formed part of this analysis from B.161 and B.17; and a concentration from B.2 analysed previously (Brothwell 1981; Jenkins 2012a), cluster, spatially, on the site. The buildings in which these concentrations were found, abut, or overlay each other, but whilst they share space, they are separated temporally. The buildings involved can be seen in Figures 7.10, 7.11, and 7.12, and cover three temporal levels, all dating to the early era of the site, c7100-6700 cal. BCE.

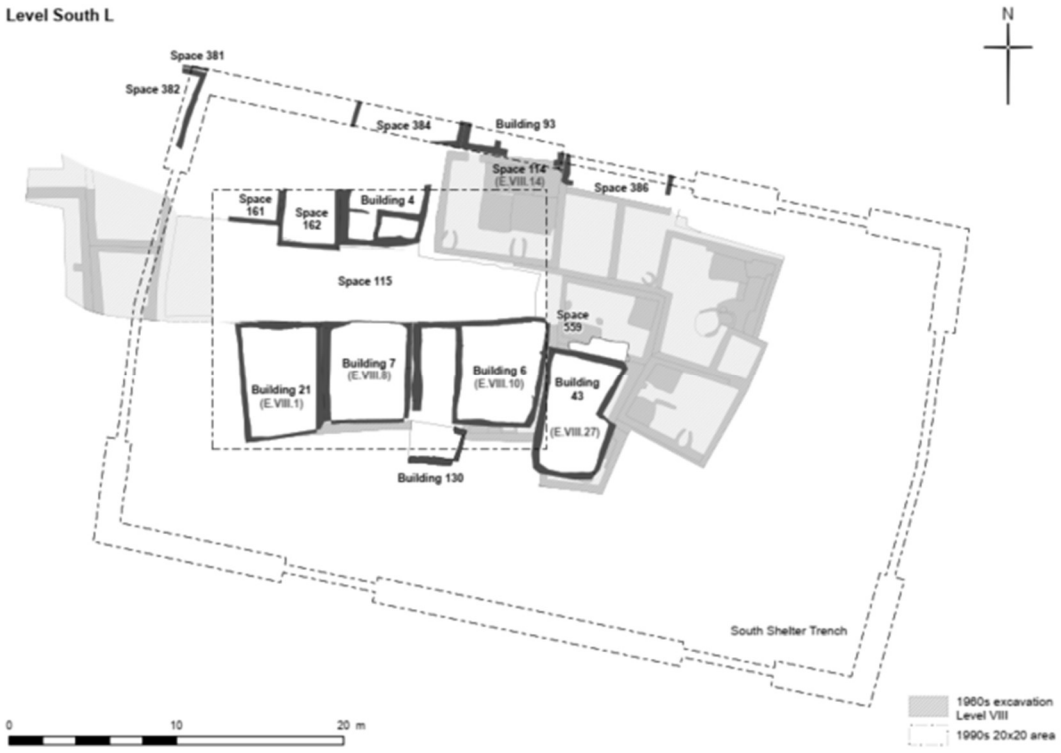

Figure 7.10 GIS Level South L plan showing the location of Building 6 (Plan: Camilla Mazzucato)

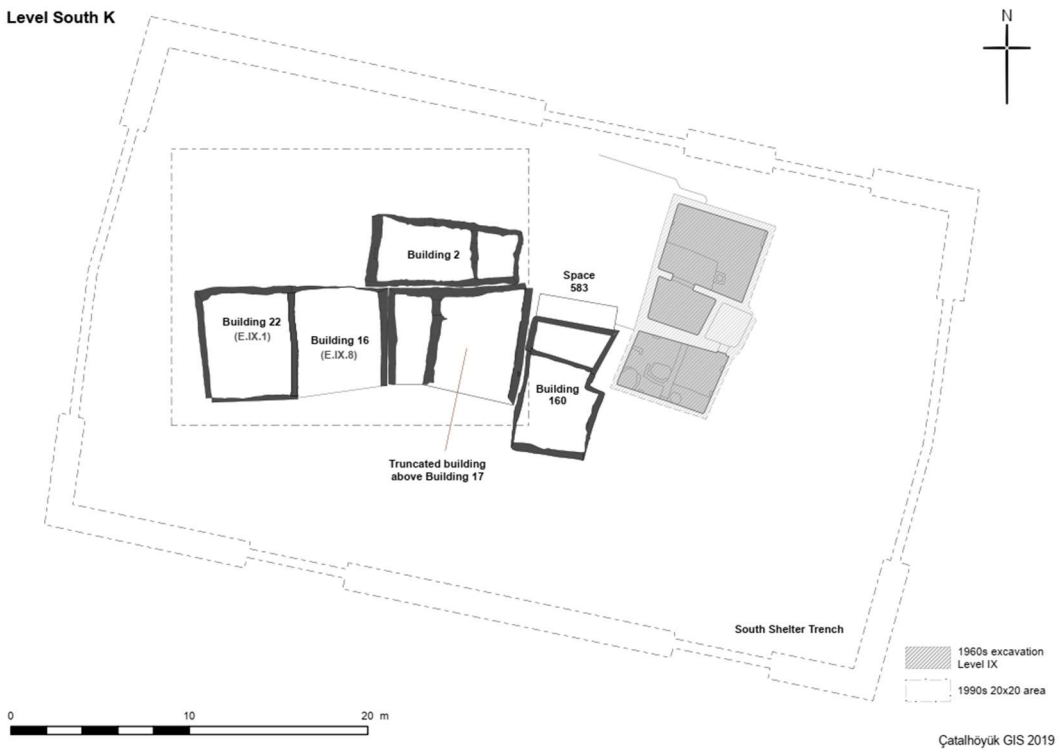

Figure 7.11 GIS Level South K plan showing the location of Building 2, the truncated area above Building 17, and the adjacent Building 160 (Plan: Camilla Mazzucato)

Figure 7.12 GIS Level South J plan showing the location of Building 17, and the adjacent Building 161 (Plan: Camilla Mazzucato)

It is difficult, however, to ascertain if the use of scats containing microfauna in utilitarian structures, such as the niche infill (21842) or oven superstructure (32632), is

practical in nature (used to discourage mice from entering) or ritual in nature (used as a foundational deposit). For example, pellets of mountain lion dung can be purchased online and used as a way of discouraging pest species from entering a garden or outside space. This theory does not, however, explain why the scats were incorporated into burials.

There is also evidence of the small predators themselves being incorporated into burials. The presence of stone marten pelts in a TP walled chamber burial, from the later levels at Çatalhöyük points to that animal's significance in the burial environment, e.g., pelts wrapped around or placed beneath the burial of an infant (Pawlowska and Marciszak 2018). Weasel bones were also found within the same context. However, these consisted of only two mandibles, leading to the conclusion that they did not hold the same significance as the stone marten (Pawlowska and Marciszak 2018). Weasel remains were also recovered from the human burials in B.49 and B.6, which also had higher NISPs than the average background data (Jenkins 2012a).

The incorporation of scats around the human remains analysed for this research is clearly different to the inclusion of microfauna in the previously analysed burials (Jenkins 2005, 2012a). The human remains, F.7049, in B.161 do not conform to the typical burial practices at Çatalhöyük, which usually take place under the raised platforms within buildings. This individual was thrown, or placed, in an abandoned building, and subsequently covered over with primary room infill. As the burial had no discernible grave cut, and was treated in such a haphazard fashion, it is unlikely that the care and attention shown to other burials, including the incorporation of scat material, would be applied. The fact that the building was abandoned at the time the remains were left, makes it more likely that the scat inclusion is incidental to the burial, and that the empty building was used as a hunting and/or latrinal area for small predators on site. There is evidence of delayed burial on the body, with some elements of the skeleton being in disarticulation. If the scat material utilised in other areas of the site were collected from abandoned or empty spaces, perhaps the predators themselves have an association with liminal spaces and the horizon between life and death, and the life and closing of the houses. It is also interesting to note that several of the other burials that included scat material (Burial 460, 513, and 492) also had non-typical burials, in that they were buried under the floor of B.6, rather than under the platforms (Nakamura et al 2013).

Alternatively, mice could have been interpreted as a good thing, e.g., the spirit of the household and therefore, the association of their bones in burials becomes more important than the scat material they were found in.

In order to fully understand any potential special, or ritual use of microfauna at Çatalhöyük, it is important to recognise the difference between incidental incorporation and the intentional inclusion of microfauna or scat material. The relationship between the inhabitants of Çatalhöyük and the mice exploiting the site is not fully understood, nor do we know if the significance of the scats lies with the mice bones that would have been visible in them, the small carnivores that produced them, or the scat material itself.

7.2.4. Anthrodependency and Sedentism

Microfauna can be just as affected by humans, as humans are by them. With *M. m. domesticus* identified at both Boncuklu and Çatalhöyük, it is clear that these anthrodependant small rodents were present in Central Anatolia in the early Neolithic and were quick to take advantage of the habitat partitioning created by permanent human occupation of the landscape. These mice would have been eating and fouling stored food, as evidenced by burned mouse bones and the charred remains of their faecal pellets in food storage bins at Çatalhöyük. There was no evidence of *M. m. domesticus* at the 10th-9th millennium BCE settlement at Pınarbaşı, despite it being a sedentary site. However, this could be due to the early date of the settlement, or perhaps that it was a hunter-gatherer community, rather than one that relied on farming.

The Neolithic site of Aşıklı Höyük (8350-7350 BCE), in Cappadocia, is very similar to the early Neolithic settlement at Pınarbaşı, and Boncuklu. The site comprised semi-subterranean, sub-oval buildings in level 4, currently the earliest dated, which transitioned during Level 3 to rectangular and oval buildings in the earliest phase of occupation in this Level. Rectangular buildings then continued throughout Level 2, with the large multi-roomed buildings similar to Çatalhöyük ending in Level 2 (Özbaşaran et al 2018). The site is contemporary with Boncuklu in its early levels with similarities of settlement type, moving through to a similar settlement type to that found at Çatalhöyük, despite pre-dating it. The site is close to one of the obsidian sources used across Neolithic Anatolia, and so the potential for trade between settlements is high. However, no *Mus* sp. were recorded in Aşıklı at all. The settlement is much smaller than Çatalhöyük, at 240m by 230m, rising 13-15m above the plain, but if sedentism is the driver for anthrodependency then mice would be expected at Aşıklı, particularly as they were found in the houses at Boncuklu which is a much sparser settlement compared with the contemporary Level 2 at Aşıklı? The prevailing rodent recorded at Aşıklı Höyük was the grey dwarf hamster, which is known to be readily commensal (Bailey 2018). The hamsters are slightly larger, and so may have been able to outcompete the house mouse, in a similar way that *Apodemus* sp. possibly prevented the spread of house mouse into Europe until the Iron Age. (O'Connor 2013). The anura assemblage at Aşıklı was also dominated by toad species rather than frog despite a similar environment to Çatalhöyük, with close proximity to a river.

At the Late Natufian and PPNA (Pre-pottery Neolithic A) cave site of Iraq ed-Dubb, in the northern Jordan Valley, microfauna, despite being recovered and recorded, were excluded from analysis of human use of the caves, as the authors assumed that their presence was most likely to be intrusive, or non-cultural (Edwards and Martin 2007). With the exception of *Mus* sp., the species present were only used to provide a palaeoenvironmental reconstruction. With regards to sedentism, measurements of the mandibular M1 were taken, and it was determined that the *Mus* sp. present at the site were *M. m. domesticus*. The increase in numbers of the house mouse from the Late Natufian through to the PPNA (from *ca* 4% to 16% of the rodent assemblage), was stated as being indicative of increasing levels of sedentism. This site is contemporary with the very end of the Epipalaeolithic phase at Pınarbaşı, with the Late Natufian dating to 11,600-10,100 cal. BCE, and the PPNA dating to 10,100-8,500 ca. BCE, in line with the 10th-9th millennium BCE settlement at Pınarbaşı. The sample of *M. m. domesticus* at Iraq ed-Dubb was very small with a NISP of only 13 in the Late Natufian, and 22 in the PPNA. This may suggest that despite their presence at other Natufian sites, *M. m. domesticus* were still establishing itself as an anthrodependent rodent, or that some other factors, such as this being a cave site rather than one with man-made structures, limited their numbers. At Hayonim Cave, no specimens of *M. m. domesticus* were recorded during the Kebaran levels (c.10,000 BCE), but were prevalent later in the Natufian levels (c.9,000 BCE) (Bar-Yosef and Tchernov 1966, Hesse 1979). The large sample of over 7,000 house mice elements from Tepe Ganj Dareh, western Iran, was also dated to 7,000-8,000 BCE (Hesse 1979), contemporary with Boncuklu. The increasing numbers of house mouse specimens through occupation levels at Tepe Ganj Dareh was also used to suggest increasing levels of sedentism (Hesse 1979). Perhaps then, despite the 10th-9th millennium BCE settlement at Pınarbaşı being one that was sedentary, for which we would expect to see specimens of house mice, it was too early, and too far north of the Fertile Crescent, where anthrodependency evolved, for the commensal/anthrodependent relationship to have taken hold.

Tracking the spread of house mice through the early Holocene Fertile Crescent was undertaken by Cucchi et al (2020) with the earliest evidence of house mice in association with a sedentary site being that of the Early Natufian site ‘Ain Mallaha (Eynan), in northern Israel (c12,500 cal. BCE). Accordingly, it would appear that commensalism and anthrodependency were built on sedentary practices, rather than the onset of farming (Weissbrod *et al*. 2017; Cucchi et al 2020), as Natufian communities

were, like those at Pınarbaşı, sedentary hunter-gatherers. However, there does appear to be a correlation with human density and the life span of the human settlement, as the early identification of *M. m. domesticus* only occurred in long-term, open-air sites, whereas smaller, short-lived sites have shown no evidence of the anthrodependent relationship. The spread of farming was then most likely catalyst for spreading *M. m. domesticus* out from the Fertile Crescent, with increased levels of stored foods becoming available (Cucchi *et al*. 2020).

At Çatalhöyük, maxillae recovered from B.161 had interesting features on some of the first molars. Cusplets and paramolar teeth were recorded from three contexts within this one building, but across two different phases of occupation. Specimens recovered from the oven superstructure (32632), in the final phase of occupation of the building, and contexts (32611) and (32616), relating to the abandonment and closing of the building, have exhibited molars with additional cusplets and, rarely, paramolar teeth (Figures 6.10 – 6.13). Cusplets have been seen in other *M. m. domesticus* populations. However, these have been from isolated populations restricted to islands where genetic drift is fuelled by inbreeding (Renaud et al 2018), and there have yet to be paramolar teeth, adjacent to the existing molars and not in the diastema, observed in mice. The presence of insular populations of mice, created by isolation within a restricted area of Çatalhöyük, shows the levels of impact human occupation can have on mouse populations within the large 13 ha site. From this it is apparent that humans have an effect on the local environment of the site, and can change the behaviour of local fauna, for example, encouraging the commensal behaviour of predators.

As mentioned previously, the identity of the predators responsible for microfaunal accumulation on Çatalhöyük remains unknown. It is unlikely to be the domesticated or possibly feral dogs on and around the site, both due to the extremely small size of the gnaw marks on the specimens, but also because dog faeces are readily identifiable on the site and were curated by the human inhabitants. Dog faeces, and the scats containing high levels of microfauna were treated very differently, leading to the assumption that these were two separate animals that were thought of and treated differently on the site. However, when the most recent tranche of research was analysed, the macrofaunal team saw no evidence of special treatment of mustelids (Twiss et al 2021). This is not in agreement with previous research, which uncovered

complete burials of mustelids with humans, as well as the incorporation of a mustelid skull in the wall as an installation (Jenkins 2012a; Pawlowska and Marciszak 2018).

Several species of mustelid have been positively identified at Çatalhöyük, including *Martes foina*, the marten, *Vormela peregusna*, the marbled-polecat, and *Mustela nivalis*, the weasel. Whilst cranial material is more frequently identified, elements from all body parts are present, suggesting the presence of complete individuals, rather than skins (Russell et al 2013).

Weasels, as a small predator, are also potential prey to larger species of carnivores, for examples pine martens, red foxes, or occasionally snakes. Studies have shown that weasel behaviour takes into account other predators that may be acting in that region and therefore their hunting behaviour is such that they avoid them, such as temporal rather than spatial avoidance of red foxes (Bischof et al 2014). If weasels were the main predator of house mice at Çatalhöyük it may have offered an ideal hunting ground for these small carnivores as it would have provided an area almost entirely devoid of other predators that may have preyed upon them, as well as sufficient prey items to sustain them.

The common weasel in Anatolia differs in size from the European form. Demirbaş and Baydemir (2013) found that specimens from Central Anatolia are larger than European specimens with respect to external and cranial measurements, confirming previous conclusions that extremely large weasels were found in Turkey (Kasparek 1988). Male weasels are also much larger than females (King and Powell 2007). The species' considerable size, and the existence of two types of weasels (*nivalis* type and *minuta* type) in Turkey, has often led to the incorrect assumption that the stoat (Mustela erminea) also occurs in Turkey (Kasparek 1988). Weasels rarely continue to hunt in areas where prey species are in short supply (King & Powell 2007). It is unlikely that the areas outside of Çatalhöyük was unsuitable for hunting, as other small mammal species have been found at the settlement, and the area would have offered inviting habitats to species that were anthrophobic. The number of weasels found at Çatalhöyük are low, and therefore it is unlikely that these animals were domesticated, or even living on the site, however they may very well have been exploited.

Another predator to consider for the accumulation of mice, is the cat. Until recently the only evidence of cats on site was the presence of head and foot bones, highly suggestive of skins only, rather than the presence of live feral or semi-feral predators. However, in the last round of analysis conducted on the site, the complete skeleton of a kitten was found in B.160 (Twiss *et al*. 2021). The individual was aged at 3-4 months, and was interpreted as a votive, commemorative or foundational deposit beneath the rebuilding of the northern wall of the building (Taylor 2021). More research is needed to determine whether domesticated cats were present on site, or if wild cats were encouraged on to site to act as a form of pest control, but as only a single individual has been recorded after 20 years of excavation, it is unlikely that cats were present in high enough numbers to produce the scats utilised on site.

A spatial analysis of the species of microfauna across sites is one that could shed light on the effect of habitat partitioning on anthrodependant and commensal microvertebrates. At Boncuklu, *M. m. domesticus* was only found in contexts associated with houses, which despite the small number of specimens recovered, does suggest that these mice were spatially limited on the site, possibly due to the presence of other small mammals or predators. Other, potentially commensal animals, such as shrews and hedgehogs, also exhibited a spatial restriction, as these animals were only found in the outside spaces associated with middens, perhaps attracted by the prevalence of insect activity.

7.3. Summary

The microfaunal assemblages of the three sites analysed for this thesis all vary, with the differences in species composition and taphonomy being driven by the age of the site, its built environment, and its immediate ecology.

Çatalhöyük exhibited some interesting features, with the cluster of 'hotspots' of anthropogenic microfaunal activity in the South Area, and what appears to be a genetically isolated population of mice, despite no evidence of physical separation from other individuals at the site. Çatalhöyük also had an anthrodependent population of *M. m. domesticus* large enough to sustain a predator without the need for hunting offsite, as shown in the extremely low taxonomic diversity in the species recovered, and the evidence that the majority of contexts were predatory-derived.

The presence of house mice at Boncuklu, even in small numbers, is enough to suggest that this site was permanently occupied, as there was a commensal niche strong enough to support the presence of this species. That they were limited spatially suggests the habitat partitioning in the creation of the niche may have been delicately balanced, with other small vertebrate species being more dominant in the open areas. Insectivores, such as shrews and hedgehogs were also spatially limited to the outside areas. Anura, however, dominated the assemblage at Boncuklu, and with evidence for thermal alteration, as well as a hindlimb bias, the conclusion was made that these animals were being routinely eaten. The presence of anura bones in human coprolites confirmed the consumption of frogs, but raised questions regarding the parameters for determining inclusion in broad spectrum economy at archaeological sites. There is also the potential for the inclusion of *A. amphibius* and snake in the human diet.

The microfauna at Pınarbaşı differ in the three separate phases of occupation, going from one with a high number of species present during the Epipalaeolithic phase, where nature reclaimed the area following the end of seasonal use by people, to one which showed exploitation by sedentary hunter-gatherers. During the early Neolithic phase, the 10th-9th millennium BCE, an assemblage dominated by frogs with evidence of thermal alteration, and a potential hindlimb bias, suggests that the inhabitants of the site at this time were exploiting its ecotonal nature and consuming frogs collected from the Hotamiş marsh. The lack of *M. m. domesticus* is not unexpected, given the early date of the site and the current dates given for the house mouse expansion out of the Levant (Cucchi *et al*. 2020). The 7th millennium BCE assemblage was very small and therefore it is difficult to make any generalisations. It suggests that anura were present on the site, however a lack of burning or significant hindlimb bias, does not indicate consumption. The identification of a *Mus* sp. specimen as *Mus macedonicus* also suggests that at this time the settlement was not permanently occupied.

The differences between the assemblages from the three sites has shown how informative the analysis of microfaunal assemblages from archaeological sites can be and that considering them merely as non-cultural artefacts only suitable for palaeoenvironmental reconstruction can lead to the loss of important information. This research also shows that a thorough understanding of the taphonomic pathways for

assemblage formation must be obtained before any environmental reconstruction can be done, due to potential biasing factors introduced by humans themselves.

8. Conclusion

This work evaluated three microfaunal assemblages from three very different archaeological sites in relatively close proximity to each other on the Konya Plain. Çatalhöyük (7100-5950 cal. BCE) and Boncuklu (8300-7800 cal. BCE) were both Neolithic in date, with Pınarbaşı having three phases of occupation; one dating to the Epipalaeolithic (approx. 14150-11000 cal. BCE), an early Neolithic phase (9800-7800 cal. BCE), and a late Neolithic phase (ca. 6500-6000 BCE).

Of the objectives, a full taxonomic and taphonomic analysis of the three assemblages was undertaken in accordance with the methodologies set out in Chapter 5. Species identifications for small mammals were confirmed using specimens available at the Harrison Institute, Sevenoaks, Kent. Geometric morphometrics was outsourced due to the impact of the Covid-19 lockdowns, however the analysis was undertaken, and is discussed below.

8.1. Aim 1: Reconstructing the local environment

Despite microfauna being used extensively for palaeoenvironmental reconstruction in the past, it is clear that the way people used occupation sites has an impact on the microfaunal assemblages recovered from archaeological excavations and that this can bias ecological reconstructions based on those remains.

At Çatalhöyük, the dominance of the house mouse even in the early levels of the site, shows that habitat partitioning was already in place, and that these species were present due to the settlement itself, and not because they are indicative of local off-site ecology. The mice at Çatalhöyük tell us that the site was a proto-urban settlement, large enough to provide the habitat partitioning required for the domination of this species to the exclusion of almost all others. For this site, palaeoenvironmental reconstruction will require the use of other proxies, rather than the microfaunal assemblage, as other small species found at this site are recorded in such low numbers that their inclusion is unlikely to accurately reflect the local ecology.

Palaeoenvironmental reconstruction at Boncuklu through other proxies has shown that the area around the site incorporated wetlands as well as woodland and grassland (Baird

et al. 2012), which appeared to be supported by the dominance of marsh frogs and water voles in the microfaunal assemblage. However, following a taphonomic analysis, the incorporation of frog remains into the microfaunal assemblage may principally be due to their part in the diet of human inhabitants. How accurate, therefore, is the palaeoenvironmental reconstruction based on these remains? It is highly likely that these animals were selected as a prey item by people due to the close proximity of their preferred habitat to the settlement, and that they were therefore, easy to acquire without too much initial expenditure of energy of the people who collected them. They could even, however unlikely, have been collected elsewhere and brought to the site, making any reconstruction of the local environment based on the prevailing species by NISP or MNI, inaccurate.

Three different phases of occupation were analysed at Pınarbaşı, with differences in the microfaunal assemblages potentially reflecting both the local ecology and the human use of the sites. The Epipalaeolithic phase had a much higher diversity of small mammal species than in any other phase of occupation at Pınarbaşı, or at Boncuklu and Çatalhöyük. The species present in the Epipalaeolithic clearly represent those taking advantage of the ecotonal nature of the site, namely those that could exploit the wetlands of the Hotamiş marsh, as well as those who could live in the craggy rock face of the rising hills of the Bozdağ, such as bats, and other species that preferred the steppic environments on the Plain. The high level of species diversity is suggestive of a transitory human settlement, shown in the archaeology as occupation layers separated by rock shatter debris. The period when humans abandoned the site allowed other species to move back into the area, which is seen in the site being used a wolf den or nursery (Baird *et al*. 2013). The Early Neolithic site, situated away from the rock face to the west of the Epipalaeolithic one, had a much-reduced species diversity, with the majority of the assemblage being composed of species that would have exploited the marsh, such as marsh frogs and water voles. However, the patterns of thermal alteration, and a potential hindlimb bias suggest that marsh frogs most likely were included in the diets of the Early Neolithic settlers. Do we then remove these species from our palaeoenvironmental proxy list? The 7th millennium phase was also characterised by low species diversity, one that closely matched that of the Early Neolithic settlement. Taphonomic analysis did not now suggest, however, that frogs were being included in the diet, and so for this phase at least, the suggestion that their presence indicates that the site was close to an expanse of water holds true.

8.2. Aim 2: Inclusion of microfauna in human diet

Taphonomic analysis of the three microfaunal assemblages showed that at Catalhoyuk, whilst the markers associated with predation, such as digestion and gnawing, were much higher than at the other sites, there were few other taphonomic signatures that would suggest that the large numbers of mice at the site were included in human diet. Incidence of burning was low, with a body part representation that was predominately made up of cranial specimens. Levels of digestion were also low, although both humans and small mammalian carnivores are both classed as a Category 5 predator (Andrews 1990), so this was unexpected given a taphonomic pathway that was mainly derived from mammalian predators. The inclusion of the remains in almost all types of context, which included but were not limited to middens, also suggests that the high number of house mouse remains at Çatalhöyük is not due to their inclusion in human diet, but to density of human occupation at the site, and the niche this created.

Alternatively, at Boncuklu, the domination of the microfaunal assemblage by marsh frogs, with taphonomic markers that included thermal alteration and a hind limb bias, as well as high numbers in midden contexts, is one that is indicative of the inclusion in the human diet. As mentioned above, this is most likely due to the proximity of the site to the preferred habitat of the frogs, and they were therefore a useful resource to supplement human diet. The identification of amphibian remains within human coprolites, is also direct evidence that these animals were eaten. The analysis of small mammals at Boncuklu also showed that water voles were potentially being eaten, due to the higher levels of thermal alteration on their bones compared to other species. The body part representation was also skewed towards crania, which suggested that heads were being removed following cooking but prior to the animals being eaten. However, no mammalian elements were recovered from the single coprolite sample.

At Pınarbaşı the use of microfauna in diet was more variable. The Epipalaeolithic assemblage was not dominated by anura, unlike the early and late Neolithic phases, and the higher numbers of small mammal species was most likely to be the result of species moving back into the spaces when humans had temporarily abandoned the area. The early Neolithic phase of the settlement also shows the taphonomic and contextual signatures required for the identification of inclusion in human subsistence. The 10^{th}-9^{th} millennium BCE settlement shows a taxa dominated by a single species, in this case

anura; a higher level of thermal alteration than found for any other species, and a potential hindlimb bias. The evidence strongly suggests that frogs were being eaten during the early Neolithic period at Pınarbaşı. In contrast to this, despite percentages of higher taxonomic groups being very similar in the 7th millennium BCE settlement to the 10th-9th millennium BCE settlement (Table 7.7), there is no evidence to suggest that the high number of frogs present are being eaten. This assemblage lacks a hind limb bias, and the incidence of burning is much lower at 0.4% compared to 16.6% for anura in the early Neolithic phase (Table 6.67). The assemblage for the 7th millennium BCE assemblage, however, is much smaller and so perhaps the results are a reflection of sample size, and further analysis will expand upon conclusions drawn here.

8.3. Aim 3: Microfauna in ritual practice

In previous phases of research at Çatalhöyük, human burials were excavated in which large numbers of microfauna were recovered, packed around the human remains (Brothwell 1981; Jenkins 2012a). These concentrations were identified as once having been scat material placed onto the corpse at the point of burial, rather than whole animals or pellets produced by birds of prey. During the last round of excavation, another human burial was recovered (F.7049 in B.161) that contained high numbers of microfauna in close proximity, and the question was raised as to whether it was similar to any of the others that had previously been analysed. However, these human remains had not been buried in the typical fashion at Çatalhöyük, which was under the floor of houses. This 'burial' appeared to be haphazard, as though the corpse has been thrown into an abandoned building, with primary room infill then used to cover them. It is interesting to note that these remains are also the only ones so far at Çatalhöyük that show peri-mortem injury which, with the style of burial received, raises questions about how the individual died and why he was buried this way. The microfauna incorporated in the fill around the body was identified as scat material due to the evidence of digestion and puncture marks made by small teeth. However, that there was a higher level of microfauna in the fill below the remains, as well as the haphazard method of burial, would suggest that the care shown to the previously studied burials does not apply here. The building was in the process of abandonment and demolition when the human remains were incorporated. As such, an empty space, devoid of people, would be an attractive space to a small predator. The scat material is therefore most likely to

be incidental to the 'burial', with the small mammalian predator using the space as a latrinal area (Feider and Jenkins 2021).

What is also interesting, is that many of the contexts that have high concentrations of microfauna, encountered both in this and previous analses, cluster spatially (Figures 7.10, 7.11, and 7.12). Building 161 contained a high concentration of microfauna associated with an oven feature, potentially a foundational deposit, as well as below and around the 'burial' mentioned above. Building 17, adjacent to the west of Building 161, had a niche infill which had a high adjusted NISP per litre. Building 6, a later version of B.17, contained several burials that were high in microfauna, including Burial 513. Building 2, adjacent to the north of B.6 but in a different temporal Level, contained a high concentration of scat material, either deposited there by the carnivores when the building was abandoned or collected by the inhabitants, as it also contained dog faeces collected by humans (Russell and Twiss 2017). In the same Level as B.2, was Building 160 which is a later incarnation of, and sits on the same footprint as, B.161. B.160 contained the only complete skeleton of a cat found on site. Until the excavation of this specimen, the majority of cat bones had consisted of heads and feet, and therefore the interpretation was that the bones had become incorporated into the macrofaunal assemblage as skins. Contamination of contexts is highly unlikely, due to the nature of archaeology at Çatalhöyük, with discrete contexts sealed beneath plaster floors, which would conspicuously show any modern or historical burrowing. Despite several of these buildings being in different temporal levels, it is interesting that scats containing microfauna are utilised in this area, either for utilitarian purposes, such as niche infill, or oven superstructure, or possible ritual purposes, such as foundational deposits and incorporation into burials.

8.4. Aim 4: Anthrodependency and sedentism in Central Anatolia

As mentioned above, the three sites analysed for this thesis straddle the end of the Pleistocene and the beginning of the Holocene, marked by the transition from mobile hunter-gatherers to settled farmers. The effect this had on microfauna on archaeological sites can be seen in the assemblages examined here. The impact people had on the local environment, and the habitat partitioning that followed allowed some small mammals to out-compete their sympatric competitors and thrive in these new niches. As well as reduced competition with other species, human habitation provided a source of food,

and protection from predators. A commensal relationship grew, although in some cases, such as with house mice, the relationship was not one that benefited one species and was neutral to the other. Mice both eat and foul stored food, spread diseases, and can destroy property through gnawing, and so have a detrimental impact on the human inhabitants of sites. As such, their relationship with people is one that is anthrodependent, rather than commensal.

House mice are ubiquitous at Çatalhöyük, even in the early levels on the site, dating to 7100 cal. BCE. That they comprise 97.7% of the specimens identified to species (Figure 6.2) shows they were very successful in outcompeting other small mammals even at this early date. As previously mentioned, the spatial clustering of large concentrations of microfauna in the South Area at Çatalhöyük is made even more interesting with the discovery of specimens exhibiting a paramolar tooth, or additional cusplets on the maxillary M1. Paramolar teeth adjacent to the maxillary M1 are very rare. However, the additional cusplets have been reported on before in mice that have been geographically restricted (Renaud *et al.* 2018), such as small island populations. There does not appear to be any reason in the archaeology for the localised isolation of this specific group of mice, and the additional teeth and cusplets are only found in B.161, although in two phases of occupation. Mice from other areas on the site have not been found to have these biological traits, which suggests that mice from Building 161 were spatially restricted and isolated from other mouse populations in adjacent spaces.

Photographs of five *Mus* sp. mandibular M1s from Boncuklu, and one from Pınarbaşı were sent for geometric morphometric analysis (GMM) in order to identify the specimens to species. Following analysis, the samples from Boncuklu were all identified as *Mus musculus domesticus*, the house mouse, whilst the sample from Pınarbaşı was identified as *Mus macedonicus,* the Macedonian (wild) mouse. Although house mice were found in small numbers at Boncuklu, they were found exclusively in 'house' contexts, with no specimens recovered in the open areas of the site. The *M. m. domesticus* specimens at Boncuklu are now the oldest known house mice in Central Anatolia, pre-dating those at Çatalhöyük by over 1000 years. This also confirms that Boncuklu was a permanently occupied site, in order for the creation of niches suitable for the house mouse to exploit. The samples sent from Pınarbaşı were from the 7th Millennium BCE settlement, which is known to be a transitory settlement. It is

therefore unsurprising that the specimen from this site was identified as the 'wild-type' *M. macedonicus*.

8.5. Limitations and Further Work

There are always limitations on analysis which are usually beyond the control of the author, and some of these have been listed below;

The microfaunal assemblages for both Çatalhöyük and Boncuklu are vast, containing many hundreds of thousands of specimens. There is always the possibility that interesting contexts or patterns in the data have been missed due to the limited number of contexts that are selected for analysis. It is unfeasible that the whole microfaunal assemblage for either site will be analysed, and so the data will always be a sub-sample.

As mentioned in previous chapters, there is the potential for further analysis of spatial patterning of microfauna at Çatalhöyük. However, the previous excavations do not allow for further analysis due to the limited area of the whole settlement that has been excavated so far. Is there a difference, for example, in the microfaunal species distribution at the periphery of the site compared to the middle of this proto-urban settlement?

In order to more fully understand some of the taphonomic effects on microfaunal bones, further analysis needs to be undertaken, especially when certain depositional pathways, such as consumption by humans, is predicated on a series of taphonomic markers. Some further work and experimentation that could therefore aid future study is listed below;

- Taphonomic analysis for burning in small mammals, amphibians and squamates to understand patterning of burning during cooking, as well as burn colour and its relationship to temperature and exposure.
- Taphonomic experiments looking at predator markers specifically on mice bones. How do different predators affect mice specifically, and could this allow predator species identity to be established at sites like Çatalhöyük? This could potentially also be used to examine the domestication or 'commensalisation' of species like cats, ferrets, and possibly weasels.

- Further analysis of the mice found in B.161 at Çatalhöyük to examine the indicators of population isolation more closely.
- Further analysis of the microfaunal assemblage from the 10th-9th Millennium site at Pınarbaşı to establish whether any specimens of *Mus* sp. were recovered, and, if so, the identification of the species represented by these specimens.
- A further examination of the coprolite samples recovered at Boncuklu in order to examine more closely the direct evidence of frog consumption at the site. The use of Zoology by Mass Spectrometry (ZooMS), would aid in species identification from samples where diagnostic material is not available.

8.6. Summary

In summary, this thesis has provided insight into the microfaunal assemblages from three important archaeological sites in Central Anatolia. These sites, in close geographical proximity to each other, straddle the change from mobile hunter-gatherers to settled hunter-gatherers, to small village settlements, through to large proto-urban sites, with the microfauna reflecting this change. These three sites have provided an insight into how people made use of the resources around them, but also how they changed the local environment to create new ecological niches that could be exploited by incoming species. The presence of mice in food storage bins at Çatalhöyük shows that this was not always a positive association, and the identification of house mice at Boncuklu has shown that anthrodependent mice were in Central Anatolia over 1000 years earlier than previously thought. The inclusion of frogs in human diet has also shown that we need to be looking at more than palaeoenvironmental reconstruction when analysing these assemblages, and in fact, microfauna from archaeological sites may not be the best reflection of local ecology, due to the impact humans have on the depositional pathways of microfauna. This analysis has highlighted the importance that microfauna can play as bio-proxies in understanding and interpreting human settlements, and therefore the need to step away from only using these assemblages as a tool to reconstruct past environments. Future research, which has been detailed above, will provide the additional information needed to explore more fully the use of microfauna in human diet, ritual practice, and the identification of predators that produce these assemblages, including humans themselves.

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Appendix A: Covid Statement

The national lockdowns from March 2020 through to summer 2021, in response to the global Covid-19 crisis had a serious impact on my PhD. This included removing access to university resources such as labs and libraries, as well as the companionship and support of the PGR community and staff, to the cancellation of training, and lack of access to external Institutions. Below is brief summary as to how the Covid-19 lockdowns affected this thesis, not including the profound impact it had on my mental health, which has not been recorded here.

The finalisation of this thesis was undertaken whilst suffering from a Covid-19 infection.

Loss of visits to outside institutions for the purposes of identifying unknown specimens to species.

A trip to the Harrison Institute, in Sevenoaks, Kent, was required in order to identify unknown mammalian specimens recorded whilst working from home.
During lockdown #2 in November 2020, an email to all staff stated that the university was not supporting travel for business during that lockdown period. In December, whilst the Harrison Institute was open, the University was not supporting travel to areas in Tier 3, and as such the trip was moved to January 2021 pending government guidelines and the easing of travel restrictions. In late December 2020, Kent was placed into Tier 4 along with large parts of London and the Southeast. In January the country entered a third national lockdown. As such, visits to the Harrison Institute were not allowed until May 2021.

The visit to this Institute was important as species identification was required to address one of the three main aims of my thesis which is palaeoenvironmental reconstruction. This is done by analysing the different species present on a site along with the environmental niches they occupy. As small mammals and amphibians have a narrow environmental tolerance, they are excellent indictors of the local and wider environment during their lifespan. Understanding the nuance of the different species in the

assemblage is key to being able to recreate the environmental conditions at the time the archaeological site was inhabited.

Specimens were recorded to higher taxonomic classifications on a database, whilst working from home, and retained with an ID number to be identified at a later date when access to the Harrison Institute, and travel for work were once again allowed following another national lockdown.

A visit to the Harrison Institute was made on the 21st of May, their first available appointment, and the specimens requiring species identification were examined. The trip was extremely successful. This allowed further analysis of species identification prior to the submission of the thesis, which was especially important for Pınarbaşı, the oldest site under investigation.

Scanning Electron Microscope (SEM) temporarily unavailable

The SEM was unavailable during the initial lockdowns due to closure of the university campus. It was then unavailable due to breakdown, until its repair in November 2021. The SEM was required to take photographs of specimens that exhibited taphonomic markers, such as evidence of digestion and weathering effects, as well as evidence of gnawing by predators. SEM images of microfaunal taphonomy are standard practice in the field as they allow for a confirmation of identification of both specimens and taphonomic markers. Without these images I would have expected questions to be raised regarding the validity of my identifications. There was also an issue with regards to training on the SEM apparatus as I had previously received training for the SEM back in 2018, however due to the time elapsed since I last used the equipment a training 'top-up' was required. This was critical because an untrained user could have easily disrupted the machine so as to cause an issue with the software and make it unusable by others. Following discussion with my supervisor, my DHoD and departmental technical support staff it was decided that I would receive top-up training from another PGR who was a regular and competent user of the machine. Training was therefore scheduled from early June 2021.

Outsourcing of Geometric morphometric (GMM) analysis

Lockdown in 2020 led to a lack of access to known microfaunal collections in external institutions, as well as an inability to meet with staff required in order to allow for in-house training on how to undertake GMM analysis. Geometric morphometric analysis is currently the only way to distinguish different species of *Mus* (mice), based on tooth morphology. Differences in the shape of teeth in the house mouse and the Macedonian mouse, both species present in my site area, are indistinguishable under a microscope however, micro-variations of shape can be discerned using spatial analysis software, such as geometric morphometrics. The species present on the archaeological site had huge implications for the aims and discussion of my thesis, due to the house mouse being an indicator of sedentism, and my sites straddling the transition of mobile hunter-gathering and settled farming. That house mice were confirmed as present on Boncuklu, is evidence that these are the oldest house mice recovered on archaeological sites in Anatolia. Due to the intrinsic nature of the analysis to my PhD output, outsourcing of the GMM analysis was arranged.

The GMM analysis was undertaken by our external colleague, Dr Katerina Papayiannis, University of Athens, who is experienced at GMM analysis, specifically on mice teeth, and who my Ph.D. supervisor has worked and published with her before.

Inadequate home working environment

Although I did have office space at home the set-up was not ideal for all day working, and was only intended for a few hours of an evening or at weekends. As such it was not an ideal full-time working environment and I experienced physical discomfort, as well as headaches, which restricted the number of hours I could spend working per day, particularly on the microscope. I replaced my office chair in a bid to improve the situation, however the effect was limited. As such, progress was much slower than anticipated, had I been able to continue working at the university. I was, however, extremely grateful that I was able to continue to work on the assemblages at home during the course of the lockdowns.

Appendix B: Çatalhöyük Assemblage Results

Minimum Number of Elements (MNE) and Frequency calculations

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
18523	Anuran	Scapula			1	2	1	2	50
18523	Anuran	Humerus			**1**	2	1	2	50
18523	Anuran	Coracoid			2	2	2	2	100

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
18578	Natrix	Vetebra			**1**	200+			
18578	Pelophylax ridibundus	Pelvis		**2**		2	2	4	50

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
19802	Rodent	Mandible with & without teeth	1	2		2	3	34	8.8
19802	Rodent	Maxilla with & without teeth	2	1		2	3	34	8.8
19802	Rodent	Premaxilla with & without teeth	2	1		2	3	34	8.8
19802	Rodent	Humerus	4	6		2	10	34	29.4
19802	Rodent	Ulna		1		2	1	34	2.9
19802	Rodent	Radius			5	2	5	34	14.7
19802	Rodent	Pelvis	2	3		2	5	34	14.7
19802	Rodent	Femur	5	4		2	9	34	26.5
19802	Rodent	Tibia	**17**	14		2	31	34	91.2
19802	Rodent	Loose lower incisor	15	15		2	30	34	88.2
19802	Rodent	Loose upper incisor	1			2	1	34	2.9
19802	Rodent	Loose upper M2		1		2	1	34	2.9
19802	Rodent	Loose M3 (U/L indeterminate)			1	4	1	68	1.5
19802	Mus	Maxilla with & without teeth	10	5	1	2	15	32	44.1
19802	Mus	Mandible with & without teeth	8	9		2	17	32	50
19802	Mus	Upper M1 In situ & loose	11	6		2	17	32	53.1
19802	Mus	Upper M2 In situ & loose	8	1		2	9	32	28.1
19802	Mus	Upper M3 In situ & loose	6			2	6	32	18.8
19802	Mus	Lower M1 In situ & loose	8	8		2	16	32	50
19802	Mus	Lower M2 In situ & loose	6	5		2	11	32	34.4
19802	Mus	Lower M3 In situ & loose	1	2		2	3	32	9.4
19802	Mus	Upper incisor loose	14	**16**		2	30	32	93.8
19802	Crocidura	Mandible		**1**		2	1	2	50
19802	Meriones	Loose M1			**1**	4	1	4	25
19802	Anuran	Indeterminate metapodial			2	18	2	18	11.1
19802	Anuran	Humerus	**1**			2	1	2	50
19802	Micromammal	Axis			1	1			
19802	Micromammal	Caudal vertebra			2	28			
19802	Micromammal	Thoracic vertebra			2	13			
19802	Micromammal	Rib			1	26			
19802	Micromammal	Sacrum			1	1 fused, 4 unfused			
19802	Micromammal	Indeterminate metatarsal			23	10			
19802	Micromammal	Indeterminate metapodial			3	20			
19802	Microfauna	Indeterminate metatarsal			1				

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
21367	Testudinae	Carapace fragments			8	N/A			
21367	Anuran	Humerus			**1**	2	1	2	50

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
21573	Rodent	Premaxilla		1		2	1	6	16.7
21573	Rodent	Scapula	2	1		2	3	6	50
21573	Rodent	Humerus	**3**	2		2	5	6	83.3
21573	Rodent	Pelvis	2	1		2	3	6	50
21573	Rodent	Femur	1	2		2	3	6	50
21573	Rodent	Tibia		1		2	1	6	16.7
21573	Mus	Maxilla	1	2		2	3	4	75
21573	Mus	Mandible	1			2	1	4	25
21573	Mus	Loose upper incisor		**2**		2	2	4	50
21573	Mus	Upper M1 In situ & loose	1	1		2	2	4	50
21573	Mus	Upper M2 In situ & loose	1	1		2	2	4	50
21573	Mus	Lower M1 In situ & loose	1	1		2	2	4	50
21573	Mus	Lower M2 In situ & loose	1			2	1	4	25
21573	Micromammal	Atlas			2	1			
21573	Micromammal	Axis			2	1			
21573	Micromammal	Cervical vertebra			3	5			
21573	Micromammal	Thoracic vertebra			1	13			
21573	Micromammal	Lumbar vertebra			16	6			
21573	Micromammal	Radius			1	2			
21573	Micromammal	Sacrum			1	4			
21573	Micromammal	Tibia	2	2		2			
21573	Micromammal	Indeterminate metatarsal			1	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
21810	Rodent	Ulna	**1**			2	1	2	50
21810	Rodent	Femur	1			2	1	2	50
21810	Rodent	Tibia		1		2	1	2	50
21810	Mus	Upper incisor loose		**1**		2	1	2	50
21810	Anuran	Vertebra			**1**	7	1	7	14.3
21810	Micromammal	Vertebra			1	N/A			
21810	Micromammal	Caudal vertebra			1	28			
21810	Micromammal	Indeterminate metacarpal			1	10			
21810	Micromammal	Indeterminate metatarsal			2	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
21814	Rodent	Maxilla		1		2	1	10	10
21814	Rodent	Humerus		3		2	3	10	30
21814	Rodent	Ulna	2	1		2	3	10	30
21814	Rodent	Femur	2	2		2	4	10	40
21814	Rodent	Tibia	1			2	1	10	10
21814	Rodent	Loose lower incisor	**5**	4		2	9	10	90
21814	Mus	Maxilla		1		2	1	4	25
21814	Mus	Mandible	**2**			2	2	4	50
21814	Mus	Upper M1 In situ & loose		1		2	1	4	25
21814	Mus	Upper M2 In situ & loose		1		2	1	4	25
21814	Mus	Lower M1 In situ & loose	2			2	2	4	50
21814	Mus	Lower M2 In situ & loose	1			2	1	4	25
21814	Mus	Upper incisor loose	2	1		2	3	4	75
21814	Crocidura	Mandible	**1**			2	1	2	50
21814	Anuran	Tarsal			**1**	2	1	2	50
21814	Anuran	Indeterminate metapodial			2	18	2	18	11.1
21814	Anuran	Phalanx			3	48	3	48	6.25
21814	Micromammal	Atlas			2	1			
21814	Micromammal	Axis			2	1			
21814	Micromammal	Cervical vertebra			1	5			
21814	Micromammal	Thoracic vertebra			2	13			
21814	Micromammal	Lumbar vertebra			3	6			
21814	Micromammal	Caudal vertebra			6	28			
21814	Micromammal	Radius			2	2			
21814	Micromammal	Indeterminate metatarsal			3	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
21842	Rodent	Mandible		1		2	1	22	4.5
21842	Rodent	Premaxilla		1		2	1	22	4.5
21842	Rodent	Scapula	1	2		2	3	22	13.6
21842	Rodent	Humerus	7	5		2	13	22	59.1
21842	Rodent	Ulna	4	4		2	8	22	36.4
21842	Rodent	Pelvis	1	2		2	3	22	13.6
21842	Rodent	Femur	2	5		2	7	22	31.8
21842	Rodent	Tibia	10	**11**		2	21	22	95.5
21842	Rodent	Loose lower incisor	5	6		2	12	22	54.5
21842	Rodent	Loose upper incisor	2	4		2	6	22	27.3
21842	Mus	Maxilla	3	5		2	8	12	66.7
21842	Mus	Mandible	5	4		2	9	12	75
21842	Mus	Upper M1 In situ & loose	**6**	5		2	11	12	91.7
21842	Mus	Upper M2 In situ & loose	3	2		2	5	12	41.7
21842	Mus	Upper M3 In situ & loose	1	2		2	3	12	25
21842	Mus	Lower M1 In situ & loose	6	4		2	10	12	83.3
21842	Mus	Lower M2 In situ & loose	3	4		2	7	12	58.3
21842	Mus	Lower M3 In situ & loose	1			2	1	12	8.3
21842	Mus	Upper incisor In situ & loos	2	1		2	3	12	25
21842	Mus	Lower incisor In situ	1			2	1	12	8.3
21842	Insecitvore	Humerus	**1**	1		2	2	2	100
21842	Insecitvore	Ulna		1		2	1	2	50
21842	Insecitvore	Pelvis			1	2	1	2	50
21842	Insecitvore	Tibia	1	1		2	2	2	100
21842	Crocidura	Mandible	**1**	1		2	2	2	100
21842	Crocidura	Maxilla	1			2	1	2	50
21842	Anuran	Mandible	**1**			2	1	2	50
21842	Anuran	Vertebra			1	7	1	7	14.3
21842	Anuran	Tibio-fibula			1	2	1	2	50
21842	Snake	Vertebra			37 **(1)**	200+			
21842	Micromammal	Axis			2	1			
21842	Micromammal	Vertebra			10	N/A			
21842	Micromammal	Caudal vertebra			162	28			
21842	Micromammal	Pelvis	1			2			
21842	Micromammal	Femur	11	5		2			
21842	Micromammal	Calcaneus	**22**	13		2			
21842	Micromammal	Indeterminate metatarsal			1	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
21849	Rodent	Mandible		1		2	1	10	10
21849	Rodent	Premaxilla	1			2	1	10	10
21849	Rodent	Scapula	1			2	1	10	10
21849	Rodent	Humerus	1	**5**		2	6	10	60
21849	Rodent	Ulna	1	1		2	2	10	20
21849	Rodent	Tibia	1	1		2	2	10	20
21849	Rodent	Loose lower incisor	1			2	1	10	10
21849	Rodent	Loose upper incisor	1			2	1	10	10
21849	Mus	Maxilla	1	1		2	2	16	12.5
21849	Mus	Mandible	2			2	2	16	12.5
21849	Mus	Upper M1 In situ & loose	1	2		2	3	16	18.8
21849	Mus	Upper M2 In situ & loose	1	1		2	2	16	12.5
21849	Mus	Upper M3 In situ & loose	1			2	1	16	6.3
21849	Mus	Lower M1 In situ & loose	3	3		2	6	16	46.2
21849	Mus	Lower M2 In situ & loose	1			2	1	16	6.3
21849	Mus	Lower M3 In situ & loose	1			2	1	16	6.3
21849	Mus	Upper incisor loose	2	**8**		2	10	16	62.5
21849	Micromammal	Axis			1	1			
21849	Micromammal	Thoracic vertebra			1	13			
21849	Micromammal	Caudal vertebra			10	28			
21849	Micromammal	Humerus			2	2			
21849	Micromammal	Radius			1	2			
21849	Micromammal	Indeterminate metacarpals			1	10			
21849	Micromammal	Femur	3			2			
21849	Micromammal	Calcaneus		1		2			
21849	Micromammal	Indeterminate metatarsals			6	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
22512	Rodent	Loose lower incisor	1	**2**		2	3	4	75
22512	Mus	Upper incisor loose		**3**		2	3	6	50
22512	Anuran	Maxilla			**1**	2	1	2	50
22512	Anuran	Indeterminate metapodials			2	18	2	18	11.1
22512	Anuran	Phalanx			2	48	2	48	4.2
22512	Micromammal	Caudal vertebra			3	28			
22512	Micromammal	Indeterminate metatarsals			3	10			
22512	Micromammal	Phalanx			1	56			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
22513	Mus	Upper incisor loose		**1**		2	1	2	50
22513	Anuran	Indeterminate metapodial			**1**	18	1	18	5.6
22513	Anuran	Phalanx			5	48	5	48	10.4
22513	Micromammal	Cervical vertebra			1	5			
22513	Micromammal	Lumbar vertebra			1	6			
22513	Micromammal	Caudal vertebra			3	28			
22513	Micromammal	Indeterminate metatarsal			1	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
22515	Rodent	Lower incisor loose	**1**			2	1	2	50
22515	Rodent	Upper incisor loose		1		2	1	2	50
22515	Rodent	Ulna		1		2	1	2	50
22515	Mus	Loose upper incisor	**1**			2	1	2	50
22515	Micromammal	Vertebra			2	N/A			
22515	Micromammal	Caudal vertebra			1	28			
22515	Micromammal	Femur			1	2			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
30217	Anuran	Vertebra			**1**	7	1	7	14.3

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
30269	Pelobates	Ilium		**1**		2	1	2	50

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
30543	Anuran	Coracoid			**1**	2	1	2	50
30543	Anuran	Indeterminate metapodial			1	18	1	18	5.6

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
30554	Rodent	Pelvis		**1**		2	1	2	50
30554	Bufo viridis	Scapula		1		2	1	2	50
30554	Bufo viridis	Ilium		**1**		2	1	2	50
30554	Anuran	Sphenethmoid			**1**	1	1	1	100
30554	Anuran	Humerus			1	2	1	2	50
30554	Anuran	Tibio-fibula			1	2	1	2	50
30554	Anuran	Indeterminate metapodials			1	18	1	18	5.6

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
30591	Rodent	Caudal vertebra			1	28	1	28	3.6
30591	Rodent	Tibia	**1**			2	1	2	50

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
32334	Mus	Maxilla	**1**			2	1	2	50
32334	Insectivore	Mandible	**1**			2	1	2	50
32334	Micromammal	Caudal vertebra			1	28			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
32403	Rodent	Loose lower incisor			3 **(2)**	2	3	4	75
32403	Rodent	Humerus	1			2	1	4	25
32403	Rodent	Pelvis	1			2	1	4	25
32403	Rodent	Femur	1	1		2	2	4	50
32403	Rodent	Tibia			1	2	1	4	25
32403	Mus	Maxilla	1	**2**		2	3	4	75
32403	Mus	Mandible	2			2	2	4	50
32403	Crocidura	Mandible		**1**		2	1	2	50
32403	Micromammal	Radius			1	2			
32403	Micromammal	Vertebra			1	N/A			
32403	Micromammal	Tibia	1		2	2			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
32611	Rodent	Mandible	6	8		2	14	122	11.5
32611	Rodent	Maxilla	1			2	1	122	0.8
32611	Rodent	Premaxilla	2	8		2	10	122	8.2
32611	Rodent	Loose lower incisor	32	35		2	67	122	54.9
32611	Rodent	Loose upper incisor	1			2	1	122	0.8
32611	Rodent	Scapula	2	2		2	4	122	3.3
32611	Rodent	Humerus	21	26		2	47	122	38.5
32611	Rodent	Ulna	9	20		2	29	122	23.8
32611	Rodent	Radius			2	2	2	122	1.6
32611	Rodent	Pelvis	1	2		2	3	122	1.6
32611	Rodent	Femur	17	20		2	37	122	30.3
32611	Rodent	Tibia	**61**	49		2	110	122	90.2
32611	Rodent	Calcaneus	12	10		2	22	122	18
32611	Mus	Maxilla	28	29		2	57	86	66.3
32611	Mus	Mandible	28	23		2	51	86	59.3
32611	Mus	Premaxilla	1	1		2	2	86	2.3
32611	Mus	Upper M1 In situ & loose	28	27		2	55	86	64
32611	Mus	Upper M2 In situ & loose	19	18		2	37	86	43
32611	Mus	Upper M3 In situ & loose	7	10		2	17	86	19.8
32611	Mus	Lower M1 In situ & loose	28	19		2	47	86	54.7
32611	Mus	Lower M2 In situ & loose	17	12	1	2	30	86	34.9
32611	Mus	Lower M3 In situ & loose	2	2		2	4	86	4.7
32611	Mus	Upper incisor In situ & loose	34	**43**		2	77	86	89.5
32611	Mus	Lower incisor In situ	3	4		2	7	86	8
32611	Insectivore	Tibia	**1**			2	1	2	50
32611	Anuran	Indeterminate metapodial			2 **(1)**	18	2	18	11.1
32611	Snake	Vertebra			**1**	200+			
32611	Micromammal	Atlas			1	1			
32611	Micromammal	Axis			4	1			
32611	Micromammal	Cervical vertebra			2	5			
32611	Micromammal	Thoracic vertebra			13	13			
32611	Micromammal	Lumbar vertebra			1	6			
32611	Micromammal	Caudal vertebra			203	28			
32611	Micromammal	Vertebra (indeterminate)			2	N/A			
32611	Micromammal	Rib			4	26			
32611	Micromammal	Scapula	7	2		2			
32611	Micromammal	Radius			12	2			
32611	Micromammal	Sacrum			2	1			
32611	Micromammal	Pelvis	9	5		2			
32611	Micromammal	Calcaneus	11	12		2			
32611	Micromammal	Indeterminate metacarpal			3	10			
32611	Micromammal	Indeterminate metatarsal			97	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
32616	Rodent	Mandible	10	7		2	17	202	8.4
32616	Rodent	Maxilla	9	6		2	15	202	7.4
32616	Rodent	Premaxilla	8	11		2	19	202	9.4
32616	Rodent	Loose lower incisor	75	**101**		2	176	202	87.1
32616	Rodent	Loose upper incisor	5	2		2	7	202	3.5
32616	Rodent	Scapula		2	1	2	3	202	1.5
32616	Rodent	Humerus	30	25		2	55	202	27.2
32616	Rodent	Ulna	13	19		2	32	202	15.8
32616	Rodent	Radius			25	2	25	202	12.4
32616	Rodent	Pelvis	6	4		2	10	202	5
32616	Rodent	Femur	17	13		2	30	202	14.8
32616	Rodent	Tibia	58	48		2	106	202	52.5
32616	Mus	Maxilla	57	53		2	110	140	78.6
32616	Mus	Mandible	32	58		2	90	140	64.3
32616	Mus	Upper M1 In situ & loose	57	53		2	110	140	78.6
32616	Mus	Upper M2 In situ & loose	40	33	4	2	77	140	55
32616	Mus	Upper M3 In situ & loose	14	11	2	2	27	140	19.3
32616	Mus	Lower M1 In situ & loose	32	56		2	88	140	62.9
32616	Mus	Lower M2 In situ & loose	22	42		2	64	140	45.7
32616	Mus	Lower M3 In situ & loose	3	10	2	2	15	140	10.7
32616	Mus	Upper incisor In situ & loose	50	**70**		2	120	140	85.7
32616	Mus	Lower incisor In situ	4	6		2	10	140	7.1
32616	Meriones	M1 (upper or lower?)			**1**	4	1	4	25
32616	Apodemus	Maxilla		**1**		2	1	2	50
32616	Insectivore	Pelvis			1	2	1	2	50
32616	Insectivore	Tibia	**1**			2	1	2	50
32616	Anuran	Indeterminate metapodial			2	18	2	18	11.1
32616	Anuran	Scapula			**1**	2	1	2	50
32616	Micromammal	Cervical vertebra			1	5			
32616	Micromammal	Thoracic vertebra			5	13			
32616	Micromammal	Caudal vertebra			89	28			
32616	Micromammal	Vertebra (indeterminate)			3	N/A			
32616	Micromammal	Rib			1	26			
32616	Micromammal	Sacrum			2	1			
32616	Micromammal	Calcaneus	1	13		2			
32616	Micromammal	Indeterminate metacarpal			3	10			
32616	Micromammal	Indeterminate metatarsal			183	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
32632	Rodent	Mandible	42	53		2	95	500	19
32632	Rodent	Maxilla	20	24		2	44	500	8.8
32632	Rodent	Premaxilla	67	69		2	136	500	27.2
32632	Rodent	Loose lower incisor	**250**	244		2	494	500	98.8
32632	Rodent	Loose upper incisor	23	15		2	38	500	7.6
32632	Rodent	Lower M2 loose			4	2	4	500	0.8
32632	Rodent	Upper M3 In situ & loose			1	2	1	500	0.2
32632	Rodent	Indeterminate M3			5	2	5	500	1
32632	Rodent	Scapula	4	13		2	17	500	3.4
32632	Rodent	Humerus	35	48		2	83	500	16.6
32632	Rodent	Ulna	28	38		2	66	500	13.2
32632	Rodent	Radius			27	2	27	500	5.4
32632	Rodent	Sacrum			1	2	1	500	0.2
32632	Rodent	Pelvis	17	10		2	27	500	5.4
32632	Rodent	Femur	20	22		2	42	500	8.4
32632	Rodent	Tibia	151	191		2	342	500	68.4
32632	Rodent	Calcaneus	7	12		2	19	500	3.8
32632	Mus	Maxilla	183	173		2	356	384	92.7
32632	Mus	Mandible	148	141		2	289	384	75.3
32632	Mus	Premaxilla	12	17		2	29	384	7.6
32632	Mus	Upper M1 In situ & loose	171	181	30	2	382	384	99.5
32632	Mus	Upper M2 In situ & loose	116	129	11	2	256	384	66.7
32632	Mus	Upper M3 In situ & loose	51	52	12	2	115	384	29.9
32632	Mus	Lower M1 In situ & loose	151	140	12	2	303	384	78.9
32632	Mus	Lower M2 In situ & loose	107	96	6	2	209	384	54.4
32632	Mus	Lower M3 In situ & loose	22	27	14	2	63	384	16.4
32632	Mus	Upper incisor In situ & loose	190	**192**		2	382	384	99.5
32632	Mus	Lower incisor In situ	28	32		2	60	384	16
32632	Murid	Upper M2 loose		**1**					
32632	Murid	Upper M3 loose		1					
32632	Murid	Maxilla	1						
32632	Microtus	Upper M1 loose	**1**			2	1	2	50
32632	Apodemus mystacinus	Maxilla		**1**		2	1	2	50
32632	Apodemus sp	Lower M1 loose		**1**		2	1	2	50
32632	Crocidura	Maxilla	6	4		2	10	12	83.3
32632	Crocidura	Mandible	5	**6**		2	11	12	91.7
32632	Crocidura	Lower incisor loose		1		2	1	12	8.3
32632	Crocidura	Lower M3 loose		1		2	1	12	8.3
32632	Crocidura	Upper M2 loose	1			2	1	12	8.3
32632	Crocidura	Upper PM4 loose	2			2	2	12	16.7
32632	Insectivore	Mandible		**1**		2	1	2	50
32632	Insectivore	Humerus	1	1		2	2	2	100
32632	Insectivore	Ulna	1			2	1	2	50
32632	Insectivore	Pelvis	1		1	2	2	2	100
32632	Insectivore	Femur	1	1		2	2	2	100
32632	Insectivore	Tibia		1	1	2	2	2	100
32632	Anuran	Indeterminate metapodial			**1**	18	1	18	5.6
32632	Micromammal	Mandible			3	2			
32632	Micromammal	Atlas			4	1			
32632	Micromammal	Axis			2	1			
32632	Micromammal	Cervical vertebra			4	5			
32632	Micromammal	Thoracic vertebra			13	13			
32632	Micromammal	Caudal vertebra			493	28			
32632	Micromammal	Vertebra (indeterminate)			90	N/A			
32632	Micromammal	Rib			25	26			
32632	Micromammal	Radius			24	2			
32632	Micromammal	Ulna			2	2			
32632	Micromammal	Sacrum			2	1			
32632	Micromammal	Pelvis		1	1	2			
32632	Micromammal	Femur	3	3		2			
32632	Micromammal	Tibia			1	2			
32632	Micromammal	Fibula			6	2			
32632	Micromammal	Carpal			2	2			
32632	Micromammal	Astragalus	4	9		2			
32632	Micromammal	Calcaneus	40	36		2			
32632	Micromammal	Indeterminate metacarpal			140	10			
32632	Micromammal	Indeterminate metatarsal			923	10			
32632	Micromammal	Phalanx			43	56			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
32717	Rodent	Pelvis	**1**			2	1	2	50
32717	Mus	Upper incisor loose		**1**		2	1	2	50
32717	Anuran	Coracoid			**1**	2	1	2	50
32717	Anuran	Tibio-fibula			2	2	2	2	50
32717	Anuran	Indeterminate metapodial			2	18	2	18	11.1
32717	Anuran	Phalanx			2	48	2	48	4.2
32717	Snake	Vertebra			2 **(1)**	200+			
32717	Micromammal	Atlas			1	1			
32717	Micromammal	Femur			1	2			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
32782	Rodent	Loose lower incisor			2	2	2	6	33.3
32782	Rodent	Loose upper incisor		1		2	1	6	16.7
32782	Rodent	Scapula	1			2	1	6	16.7
32782	Rodent	Humerus	1			2	1	6	16.7
32782	Rodent	Femur		1		2	1	6	16.7
32782	Rodent	Tibia	1	**3**		2	4	6	66.7
32782	Mus	Upper incisor loose	**2**	1		2	3	4	75
32782	Mus	Maxilla	1	1		2	2	4	50
32782	Anuran	Coracoid			**1**	2	1	2	50
32782	Toad	Radio-ulna			**1**	2	1	2	50
32782	Micromammal	Thoracic vertebra			2	13			
32782	Micromammal	Lumbar vertebra			2	6			
32782	Micromammal	Caudal vertebra			10	28			
32782	Micromammal	Rib			1	26			
32782	Micromammal	Tibia			1	2			
32782	Micromammal	Indeterminate metatarsal			4	10			

Context	Taxa	Element	MNE Left	MNE Right	MNE Indeterminate or Central	Skeletal frequency	Observed	Expected	% present
32793	Rodent	Loose lower incisor			1	2	1	2	50
32793	Rodent	Humerus		**1**		2	1	2	50
32793	Anuran	Vertebra			**1**	7	1	7	14.3
32793	Micromammal	Vertebra			1	N/A			
32793	Micromammal	Tibia			1	2			

Body Part Representation

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
19802	Molar	12	62	2		
19802	Incisor	4	30	31		
19802	Mandible	2	17	3		
19802	Maxilla	2	15	3		
19802	Premaxilla	2		3		
19802		**22**	**124**	**42**		**166**
19802	Scapula	2				
19802	Humerus	2		10		
19802	Radius	2		5		
19802	Ulna	2		1		
19802		**8**		**16**		**16**
19802	Vertebra	54			5	
19802	Rib	26			1	
19802		**80**			**6**	**6**
19802	Sacrum	1			1	
19802	Pelvis	2		5		
19802	Femur	2		9		
19802	Tibia	2		31		
19802		**7**		**45**	**1**	**46**
19802	Astragulus	2				
19802	Calcaneus	2				
19802	Metacarpal	10				
19802	Metatarsal	10			23	
19802	Indeterminate metapodial	*20			3	
19802	Phalanx	56				

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
21573	Molar	12	7			
21573	Incisor	4	2			
21573	Mandible	2	1			
21573	Maxilla	2	3			
21573	Premaxilla	2		1		
21573		**22**	**13**	**1**		**14**
21573	Scapula	2		3		
21573	Humerus	2		5		
21573	Radius	2			1	
21573	Ulna	2				
21573		**8**		**8**	**1**	**9**
21573	Vertebra	54			24	
21573	Rib	26				
21573		**80**			**24**	**24**
21573	Sacrum	1			1	
21573	Pelvis	2		3		
21573	Femur	2		3		
21573	Tibia	2		1	4	
21573		**7**		**7**	**5**	**12**
21573	Astragulus	2				
21573	Calcaneus	2				
21573	Metacarpal	10				
21573	Metatarsal	10				
21573	Indeterminate metapodial	*20				
21573	Phalanx	56				

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
21814	Molar	12	5			
21814	Incisor	4	3	9		
21814	Mandible	2	2			
21814	Maxilla	2	1	1		
21814	Premaxilla	2				
21814		**22**	**11**	**10**		**21**
21814	Scapula	2				
21814	Humerus	2		3		
21814	Radius	2			2	
21814	Ulna	2		3		
21814		**8**		**6**	**2**	**8**
21814	Vertebra	54			16	
21814	Rib	26				
21814		**80**			**16**	**16**
21814	Sacrum	1				
21814	Pelvis	2				
21814	Femur	2		4		
21814	Tibia	2		1		
21814		**7**		**5**		**5**
21814	Astragulus	2				
21814	Calcaneus	2				
21814	Metacarpal	10				
21814	Metatarsal	10			3	
21814	Indeterminate metapodial	*20				
21814	Phalanx	56				

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
21842	Molar	12	37			
21842	Incisor	4	4	17		
21842	Mandible	2	9	1		
21842	Maxilla	2	8			
21842	Premaxilla	2		1		
21842		**22**	**58**	**19**		**77**
21842	Scapula	2		3		
21842	Humerus	2		12		
21842	Radius	2				
21842	Ulna	2		8		
21842		**8**		**23**		**23**
21842	Vertebra	54			174	
21842	Rib	26				
21842		**80**				**174**
21842	Sacrum	1				
21842	Pelvis	2		3	1	
21842	Femur	2		7	16	
21842	Tibia	2		21		
21842		**7**		**31**	**17**	**48**
21842	Astragulus	2				
21842	Calcaneus	2			35	
21842	Metacarpal	10				
21842	Metatarsal	10				
21842	Indeterminate metapodial	*20				
21842	Phalanx	56				

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
21849	Molar	12	14			
21849	Incisor	4	10	2		
21849	Mandible	2	2	1		
21849	Maxilla	2	2			
21849	Premaxilla	2		1		
21849		**22**	**28**	**4**		**32**
21849	Scapula	2		1		
21849	Humerus	2		6	2	
21849	Radius	2			1	
21849	Ulna	2		2		
21849		**8**		**9**	**3**	**12**
21849	Vertebra	54			12	
21849	Rib	26				
21849		**80**			**12**	**12**
21849	Sacrum	1				
21849	Pelvis	2				
21849	Femur	2			3	
21849	Tibia	2		2		
21849		**7**		**2**	**3**	**5**
21849	Astragulus	2				
21849	Calcaneus	2			1	
21849	Metacarpal	10			1	
21849	Metatarsal	10			6	
21849	Indeterminate metapodial	*20				
21849	Phalanx	56				

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
32611	Molar	12	189			
32611	Incisor	4	84	68		
32611	Mandible	2	51	14		
32611	Maxilla	2	57	1		
32611	Premaxilla	2	2	10		
32611		**22**	**383**	**93**		**476**
32611	Scapula	2		4	9	
32611	Humerus	2		47		
32611	Radius	2		2	12	
32611	Ulna	2		29		
32611		**8**		**82**	**21**	**103**
32611	Vertebra	54			224	
32611	Rib	26			4	
32611		**80**			**228**	**228**
32611	Sacrum	1			2	
32611	Pelvis	2		3	14	
32611	Femur	2		37		
32611	Tibia	2		110		
32611		**7**		**150**	**16**	**166**
32611	Astragulus	2				
32611	Calcaneus	2		22	23	
32611	Metacarpal	10			3	
32611	Metatarsal	10			97	
32611	Indeterminate metapodial	*20				
32611	Phalanx	56				

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
32616	Molar	12	373			
32616	Incisor	4	130	183		
32616	Mandible	2	90	17		
32616	Maxilla	2	110	15		
32616	Premaxilla	2		19		
32616		**22**	**703**	**234**		**937**
32616	Scapula	2		3		
32616	Humerus	2		55		
32616	Radius	2		25		
32616	Ulna	2		32		
32616		**8**		**115**		**114**
32616	Vertebra	54			98	
32616	Rib	26			1	
32616		**80**			**99**	**99**
32616	Sacrum	1			2	
32616	Pelvis	2		10		
32616	Femur	2		30		
32616	Tibia	2		106		
32616		**7**		**146**	**2**	**148**
32616	Astragulus	2				
32616	Calcaneus	2			14	
32616	Metacarpal	10			3	
32616	Metatarsal	10			183	
32616	Indeterminate metapodial	*20				
32616	Phalanx	56				

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
32632	Molar	12	1328	10		
32632	Incisor	4	442	532		
32632	Mandible	2	289	95	3	
32632	Maxilla	2	356	44		
32632	Premaxilla	2	29	136		
32632		**22**	**2444**	**817**	**3**	**3264**
32632	Scapula	2		17		
32632	Humerus	2		83		
32632	Radius	2		27	24	
32632	Ulna	2		66	2	
32632		**8**		**193**	**24**	**217**
32632	Vertebra	54			606	
32632	Rib	26			25	
32632		**80**			**631**	**631**
32632	Sacrum	1		1	2	
32632	Pelvis	2		27	2	
32632	Femur	2		42	6	
32632	Tibia	2		342	1	
32632		**7**		**412**	**11**	**423**
32632	Astragulus	2			13	
32632	Calcaneus	2		19	76	
32632	Metacarpal	10			140	
32632	Metatarsal	10			923	
32632	Indeterminate metapodial	*20				
32632	Phalanx	56			43	

Context	Element	Skeletal frequency	Mus	Rodent	Micromammal	Total
32782	Molar	12				
32782	Incisor	4	3	3		
32782	Mandible	2				
32782	Maxilla	2	2			
32782	Premaxilla	2				
32782		**22**	**5**	**3**		**8**
32782	Scapula	2		1		
32782	Humerus	2		1		
32782	Radius	2				
32782	Ulna	2				
32782		**8**		**2**		**2**
32782	Vertebra	54			14	
32782	Rib	26			1	
32782		**80**			**15**	**15**
32782	Sacrum	1				
32782	Pelvis	2				
32782	Femur	2		1		
32782	Tibia	2		4	1	
32782		**7**		**5**	**1**	**6**
32782	Astragulus	2				
32782	Calcaneus	2				
32782	Metacarpal	10				
32782	Metatarsal	10			1	
32782	Indeterminate metapodial	*20				
32782	Phalanx	56				

Appendix C: Boncuklu Assemblage Results

Minimum Number of Elements (MNE)

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
HBG	Anuran	Scapula	Left		2	2	2			
HBG	Anuran	Scapula	Right		2	3	4			
HBG	Anuran	Humerus	Left		10	10	9	1		
HBG	Anuran	Humerus	Right		9	9	5	1		
HBG	Anuran	Humerus	Indeterminate				1	2		
HBG	Anuran	Radio-Ulna	Left		1	1	1			
HBG	Anuran	Radio-Ulna	Right		2	2	2			
HBG	Anuran	Urostyle	Central		16	**17**	10	7	9	
HBG	Anuran	Ilium	Left		3	16	2	11	1	
HBG	Anuran	Ilium	Right		5	16	2	9	1	
HBG	Anuran	Ilium	Indeterminate						2	
HBG	Anuran	Femur	Indeterminate		2	4				
HBG	Anuran	Tibio-Fibula	Indeterminate		25 (7)	16	1			
HBG	Pelophylax sp	Ilium	Left		1	2	2	2		
HBG	Pelophylax sp	Ilium	Right			1	1	1		
HBG	Pelophylax sp	Scapula	Left		**3**	3	3			
HBG	Pelophylax sp	Scapula	Right		2	2	2			
HBG	Rodent	Axis	Central	1						
HBG	Rodent	Scapula	Left	1						
HBG	Rodent	Humerus	Right	1						
HBG	Rodent	Radius	Indeterminate	2 (1)						
HBG	Rodent	Ulna	Left	1						
HBG	Rodent	Ulna	Right	1						
HBG	Rodent	Sacrum	Central	1						
HBG	Rodent	Tibia	Left	1						
HBG	Rodent	Tibia	Right	2						
HBG	Rodent	Phalanx	Indeterminate	3 (1)						
HBG	Snake	vertebra	Central	100 **(1)**						
HBG	Micromammal	Calcaneus	left	1						
HBG	Micromammal	Caudal vertebra	Central	1						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
HBG	Arvicola amphibius	Loose lower tooth	Left					4	1	
HBG	Arvicola amphibius	Loose lower tooth	Right					1		
HBG	Arvicola amphibius	Mandible	Left	1						
HBG	Arvicola amphibius	Mandible	Right	**6**						
HBG	Arvicola amphibius	Palate fragment	Central	3						
HBG	Rodent	Loose lower	Indeterminate		5 **(3)**					
HBG	Rodent	Loose lower	Left		1					
HBG	Rodent	Loose upper	left		1					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
HEJ	Anuran	Scapula	Left			1	1			
HEJ	Anuran	Scapula	Right		2	2	4			
HEJ	Anuran	Humerus	Left		1	1	1			
HEJ	Anuran	Humerus	Right		3	3	3			
HEJ	Anuran	Urostyle	Central		8	8	6	4	2	
HEJ	Anuran	Ilium	Left		3	9		5		
HEJ	Anuran	Ilium	Right		2	10		**13**		
HEJ	Anuran	Ilium	Indeterminate						2	
HEJ	Anuran	Tibio-Fibula	Indeterminate		11	10				
HEJ	Pelophylax sp	Ilium	Left		3	**4**	4	4		
HEJ	Pelophylax sp	Ilium	Right		2	2	2	2		
HEJ	Pelophylax sp	Scapula	Right		1	1	1			
HEJ	Rodent	Femur	Right	1						
HEJ	Rodent	Phalanx	Indeterminate	1						
HEJ	Snake	vertebra	Central	20 (1)						
HEJ	Micromammal	Rib	Indeterminate	1						
HEJ	Micromammal	Phalanx	Indeterminate	2 (1)						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
HEJ	Arvicola amphibius	Mandible	Left	**2**						
HEJ	Arvicola amphibius	Maxilla	Indeterminate	1						
HEJ	Arvicola amphibius	Palate fragment	Central	2						
HEJ	Rodent	Loose lower	Right		1					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
HFG	Anuran	Scapula	Left			1	1			
HFG	Anuran	Scapula	Right		1	1	1			
HFG	Anuran	Humerus	Left				2	1		
HFG	Anuran	Humerus	Right		1	1	1	1		
HFG	Anuran	Radio-Ulna	Left		1	1	1			
HFG	Anuran	Radio-Ulna	Right		2	2	2			
HFG	Anuran	Radio-Ulna	Indeterminate			1	1			
HFG	Anuran	Urostyle	Central		10	10	8	7	8	
HFG	Anuran	Ilium	Left		2	11		11	3	
HFG	Anuran	Ilium	Right		2	7		**14**	4	
HFG	Anuran	Ilium	Indeterminate						1	
HFG	Anuran	Femur	Indeterminate		4	4	4			
HFG	Anuran	Tibio-Fibula	Indeterminate		14	16	3			
HFG	Pelophylax sp	Ilium	Right			3	3			
HFG	Pelophylax sp	Scapula	Left		1	1	1			
HFG	Pelophylax sp	Scapula	Right		**3**	3	3			
HFG	Rodent	Tibia	Right	**1**						
HFG	Snake	vertebra	Central	53 **(1)**						
HFG	Micromammal	Cervical vertebra	Central	1						
HFG	Micromammal	Indeterminate metatarsal	Indeterminate	1						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
HFG	Arvicola amphibius	Loose lower tooth	Left						2	
HFG	Arvicola amphibius	Loose Upper tooth	Left						1	
HFG	Arvicola amphibius	Mandible	Left	**3**						
HFG	Arvicola amphibius	Mandible	Right	1						
HFG	Arvicolinae	Palate fragment	Central	2						
HFG	Rodent	Loose lower	Left		1					
HFG	Rodent	Loose lower	Right		1					
HFG	Rodent	Loose upper	Left		1					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
HFO	Anuran	Scapula	Right		1					
HFO	Anuran	Humerus	Right				1			
HFO	Anuran	Urostyle	Central		1	1			2	
HFO	Anuran	Ilium	Left		2	**3**		3		
HFO	Anuran	Ilium	Right			3		2		
HFO	Anuran	Tibio-Fibula	Indeterminate		2					
HFO	Snake	vertebra	Central	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
HFW	Anuran	Scapula	Left		1	2	3			
HFW	Anuran	Scapula	Right		4	4	5			
HFW	Anuran	Humerus	Left		8	11	11	3		
HFW	Anuran	Humerus	Right		4	6	7	1		
HFW	Anuran	Humerus	Indeterminate					1		
HFW	Anuran	Radio-Ulna	Left				1	1		
HFW	Anuran	Radio-Ulna	Right		2	2	2			
HFW	Anuran	Urostyle	Central		24	23	19	14	11	
HFW	Anuran	Ilium	Left		7	34	1	33	1	
HFW	Anuran	Ilium	Right		10	37 **(40)**	2	31	1	
HFW	Anuran	Ilium	Indeterminate			9			2	
HFW	Anuran	Femur	Indeterminate		2	10				
HFW	Anuran	Tibio-Fibula	Indeterminate		22	24		2		
HFW	Pelophylax sp	Sphenethmoid	Central	5						
HFW	Pelophylax sp	Ilium	Left		1	2	2	2		
HFW	Pelophylax sp	Ilium	Right		1	**5**	5	5	1	
HFW	Pelophylax sp	Scapula	Left		4	3	4			
HFW	Pelophylax sp	Scapula	Right		4	3	4			
HFW	Toad	Tibio-fibula	Indeterminate		1	1				
HFW	Rodent	Tibia	Left	**3**						
HFW	Rodent	Tibia	Right	2						
HFW	Snake	vertebra	Central	97 **(1)**						
HFW	Micromammal	Axis	Central	1						

Context	Taxa	Element	Side		I1	C	PM	M1	M2	M3
HFW	Arvicola amphibius	Loose lower tooth	Left					1	1	
HFW	Arvicola amphibius	Loose lower tooth	Right							
HFW	Arvicola amphibius	Mandible	Left	**3**						
HFW	Arvicola amphibius	Mandible	Right	1						
HFW	Arvicola amphibius	Palate fragment	Central	2						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
HGG	Anuran	Scapula	Left		1	2	1			
HGG	Anuran	Scapula	Right		1		1			
HGG	Anuran	Humerus	Left		6	5	5	2		
HGG	Anuran	Humerus	Right		8	8	7	2		
HGG	Anuran	Humerus	Indeterminate		1					
HGG	Anuran	Radio-Ulna	Left		1	1	1			
HGG	Anuran	Urostyle	Central		7	7	3	1	4	
HGG	Anuran	Ilium	Left		2	9		**10**	2	
HGG	Anuran	Ilium	Right		1	7		6		
HGG	Anuran	Ilium	Indeterminate						1	
HGG	Anuran	Femur	Indeterminate			1				
HGG	Anuran	Tibio-Fibula	Indeterminate		10	13	3			
HGG	Pelophylax sp	Sphenethmoid	Central	**3**						
HGG	Pelophylax sp	Ilium	Left							
HGG	Pelophylax sp	Ilium	Right		1	2	2	2		
HGG	Pelophylax sp	Scapula	Left		2	2	2			
HGG	Pelophylax sp	Scapula	Right		2	2	2			
HGG	Rodent	Tibia	Left	**1**						
HGG	Snake	vertebra	Central	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
HGG	Arvicola amphibius	Loose lower tooth	Right					1		
HGG	Arvicola amphibius	Mandible	Left	3						
HGG	Arvicola amphibius	Mandible	Right	**4**						
HGG	Arvicola amphibius	Palate fragment	Central	2						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
HJW	Anuran	Scapula	Left		1	1				
HJW	Anuran	Humerus	Left		4	4	4			
HJW	Anuran	Humerus	Right		3	3	2	1		
HJW	Anuran	Humerus	Indeterminate		2					
HJW	Anuran	Radio-Ulna	Left		9	11	10	3		
HJW	Anuran	Urostyle	Central		12	**12**	10	7	4	
HJW	Anuran	Ilium	Left		2	9		7	1	
HJW	Anuran	Ilium	Right		2	8	1	8		
HJW	Anuran	Tibio-Fibula	Indeterminate		15	10	2			
HJW	Pelophylax sp	Frontoparietal	Left	1						
HJW	Pelophylax sp	Sphenethmoid	Central	1						
HJW	Pelophylax sp	Ilium	Left			2	1	2		
HJW	Pelophylax sp	Scapula	Left		1	1	1			
HJW	Pelophylax sp	Scapula	Right		**3**	3	3			
HJW	Toad	Tibio-fibula	Indeterminate		1	1	1			
HJW	Toad	Ilium	Left		**1**	1	1			
HJW	Rodent	Humerus	Left	1						
HJW	Rodent	Humerus	Right	1						
HJW	Rodent	Femur	Left	1						
HJW	Snake	vertebra	Central	7 **(1)**						
HJW	Micromammal	Humerus	Right	1						
HJW	Micromammal	Radius	Indeterminate	1						
HJW	Micromammal	Ulna	Left	1						
HJW	Micromammal	Caudal vertebra	Central	1						
HJW	Micromammal	Pelvis	Right	1						
HJW	Micromammal	Indeterminate metapodial	Indeterminate	1						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
HJW	Arvicola amphibius	Loose lower tooth	Left					1		
HJW	Arvicola amphibius	Loose upper tooth	Left					2		
HJW	Arvicola amphibius	Loose upper	Right					1		**3**
HJW	Arvicola amphibius	Mandible	Left	1						
HJW	Arvicola amphibius	Palate fragment	Central	2						
HJW	Rodent	Loose lower	Left		**2**					
HJW	Rodent	Loose lower	Right		1					
HJW	Rodent	Loose lower	Indeterminate		2					
HJW	Mus	Mandible	Right	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
HLD	Anuran	Scapula	Left		2	2	3			
HLD	Anuran	Humerus	Left		4	4	**9**	3		
HLD	Anuran	Humerus	Right		4	4	6	1		
HLD	Anuran	Humerus	Indeterminate				1	1		
HLD	Anuran	Radio-Ulna	Left		1	2	2			
HLD	Anuran	Radio-Ulna	Right		1	2	2	1		
HLD	Anuran	Urostyle	Central		4	4	4	3	1	
HLD	Anuran	Ilium	Left			2		2		
HLD	Anuran	Ilium	Right		4	6	1	7	2	
HLD	Anuran	Femur	Indeterminate		1					
HLD	Anuran	Tibio-Fibula	Indeterminate		16 (4)	9	1			
HLD	Pelophylax sp	Ilium	Left			1	1	1		
HLD	Pelophylax sp	Scapula	Right		1		1			
HLD	Toad	Tibio-fibula	Indeterminate		2	2	2			
HLD	Bufo viridis	Ilium	Right		1	1	1		1	
HLD	Rodent	Premaxilla	Right	1						
HLD	Rodent	Ulna	Right	2						
HLD	Rodent	Tibia	Left	2						
HLD	Rodent	Tibia	Right	1						
HLD	Micromammal	Caudal vertebra	Central	1						
HLD	Micromammal	Indeterminate metacarpal	Indeterminate	1						
HLD	Micromammal	Indeterminate metapodial	Indeterminate	1						
HLD	Micromammal	Phalanx	Indeterminate	1						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
HLD	Arvicola amphibius	Mandible	Right	**1**						
HLD	Arvicola amphibius	Palate fragment	Central	1						
HLD	Rodent	Loose lower	Left		1					
HLD	Rodent	Loose upper	left		1					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ZHH	Anuran	Scapula	Left				1			
ZHH	Anuran	Scapula	Right			1				
ZHH	Anuran	Humerus	Left		1	1	**2**			
ZHH	Anuran	Radio-ulna	Right		2	2	1			
ZHH	Anuran	Urostyle	Central		2	2	2	1		
ZHH	Anuran	Ilium	Right			1				
ZHH	Anuran	Tibio-Fibula	Indeterminate		4	4	1			
ZHH	Pelophylax sp	Ilium	Riight		**1**	1	1	1		
ZHH	Rodent	Pelvis	Left	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
ZHH	Rodent	Loose upper	Left		**1**					
ZHH	Arvicola amphibius	Mandible	Right	**1**						
ZHH	Arvicola amphibius	Palate fragment	Central	1						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ZHI	Anuran	Scapula	Left				1			
ZHI	Anuran	Scapula	Right							
ZHI	Anuran	Humerus	Left		1	1	1			
ZHI	Anuran	Humerus	Right		2	2	2			
ZHI	Anuran	Radio-ulna	Right		1	1	1			
ZHI	Anuran	Urostyle	Central		2	2	2	2	1	
ZHI	Anuran	Ilium	Right			**2**		1		
ZHI	Anuran	Tibio-Fibula	Indeterminate		4	4				
ZHI	Pelophylax sp	Ilium	Left		2	**3**	3	3		
ZHI	Pelophylax sp	Ilium	Right		1	2	2	2		
ZHI	Rodent	Femur	Left	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
ZHI	Mus	Mandible	Left	**1**						
ZHI	Mus	Loose upper	Left		1					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KAJ	Anuran	Scapula	Left			2	3			
KAJ	Anuran	Scapula	Right		1	1	3			
KAJ	Anuran	Humerus	Left		3	4	3	1		
KAJ	Anuran	Humerus	Right		4	4	4			
KAJ	Anuran	Humerus	Indeterminate		3		2	1		
KAJ	Anuran	Radio-Ulna	Left		1	2				
KAJ	Anuran	Radio-Ulna	Right		4	4	2			
KAJ	Anuran	Urostyle	Central		5	4				
KAJ	Anuran	Ilium	Left			9 **(11)**		9	1	
KAJ	Anuran	Ilium	Right			9	3	7		
KAJ	Anuran	Ilium	Indeterminate			3			1	
KAJ	Anuran	Tibio-Fibula	Indeterminate		9	7				
KAJ	Pelophylax sp	Ilium	Right		1	1	1	1		
KAJ	Rodent	Mandible without teeth	Right	1						
KAJ	Rodent	Scapula	Left	1						
KAJ	Rodent	Humerus	Left	1						
KAJ	Rodent	Tibia	Left	1						
KAJ	Rodent	Astragalus	Indeterminate	1						
KAJ	Rodent	Calcaneus	Indeterminate	1						
KAJ	Snake	vertebra	Central	134 **(1)**						
KAJ	Micromammal	Caudal vertebra	Central	1						
KAJ	Micromammal	Femur	Left	1						
KAJ	Micromammal	Tibia	Left	1						
KAJ	Micromammal	Indeterminate metapodial	Indeterminate	1						
KAJ	Micromammal	Phalanx	Indeterminate	2						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
KAJ	Arvicola amphibius	Loose lower tooth	Left						1	1
KAJ	Arvicola amphibius	Loose lower tooth	Right						1	1
KAJ	Arvicola amphibius	Loose upper tooth	Left							1
KAJ	Arvicola amphibius	Mandible	Indeterminate	1						
KAJ	Arvicolinae	Mandible	Indeterminate	1						
KAJ	Rodent	Loose lower	Indeterminate		1					
KAJ	Rodent	Loose upper	Indeterminate		1					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KAN	Anuran	Scapula	Left		1	2	2			
KAN	Anuran	Scapula	Right		1		1			
KAN	Anuran	Humerus	Left		1	1	2			
KAN	Anuran	Humerus	Right		1	1				
KAN	Anuran	Radio-Ulna	Left		1	1	1			
KAN	Anuran	Radio-Ulna	Right			1	1			
KAN	Anuran	Urostyle	Central		1	1	1	1		
KAN	Anuran	Ilium	Left			**4**	1	1	1	
KAN	Anuran	Ilium	Right			1		1		
KAN	Anuran	Ilium	Indeterminate						2	
KAN	Anuran	Tibio-Fibula	Indeterminate		2					
KAN	Pelophylax sp	Ilium	Right		**1**	1	1	1		
KAN	Pelophylax sp	Scapula	Left		1	1	1			
KAN	Snake	Vertebra	Central	6 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KAR	Anuran	Scapula	Left		1	1				
KAR	Anuran	Scapula	Right		1	1	1			
KAR	Anuran	Humerus	Left			1	1			
KAR	Anuran	Humerus	Right		2	2	1			
KAR	Anuran	Radio-Ulna	Indeterminate		1	1				
KAR	Anuran	Urostyle	Central		2	2	1	1		
KAR	Anuran	Ilium	Left			**4**	1	2		
KAR	Anuran	Ilium	Right			1		1		
KAR	Anuran	Ilium	Indeterminate		1					
KAR	Anuran	Tibio-Fibula	Indeterminate		9 (3)	3	1			
KAR	Pelophylax sp	Ilium	Left			**3**	3	3		
KAR	Pelophylax sp	Ilium	Right			1	1	1		
KAR	Pelophylax sp	Scapula	Left		1	1	1			
KAR	Pelophylax sp	Scapula	Right		2	2	2			
KAR	Pelophylax ridibundu	Ilium	Right		**1**	1	1	1		
KAR	Rodent	Tibia	Right	**1**						
KAR	Snake	Vertebra	Central	6 **(1)**						
KAR	Micromammal	Caudal vertebra	Central	2						
KAR	Micromammal	Indeterminate meta	Indeterminate	1						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
KAR	Rodent	Loose lower tooth	Left		1					
KAR	Mus	Mandible	Left	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KAZ	Anuran	Humerus	Indeterminate				1			
KAZ	Anuran	Urostyle	Central		1	1				
KAZ	Anuran	Ilium	Left		1	**2**		2	1	
KAZ	Anuran	Ilium	Right			1		1		
KAZ	Anuran	Tibio-Fibula	Indeterminate		1	2				
KAZ	Rodent	Femur	Right	1						
KAZ	Rodent	Tibia	Right	1						
KAZ	Snake	Vertebra	Central	5 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KBB	Anuran	Scapula	Left		1	1	1			
KBB	Anuran	Scapula	Right		1		1			
KBB	Anuran	Humerus	Left				1	1		
KBB	Anuran	Humerus	Right		2	2	3			
KBB	Anuran	Radio-Ulna	Left		1	1	1			
KBB	Anuran	Radio-Ulna	Indeterminate		1	1				
KBB	Anuran	Urostyle	Central		1	1	1	1		
KBB	Anuran	Ilium	Left			**4**	1	1		
KBB	Anuran	Ilium	Right		1	4		4		
KBB	Anuran	Tibio-Fibula	Indeterminate		4	3				
KBB	Pelophylax sp	Sphenethmoid	Central	1						
KBB	Pelophylax sp	Ilium	Left		1	2	2	2		
KBB	Pelophylax sp	Ilium	Right		2	2	1	1		
KBB	Pelophylax sp	Scapula	Right		1		1			
KBB	Snake	Vertebra	Central	3 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
KBB	Arvicola amphibius	Mandible	Right	**1**						
KBB	Arvicola amphibius	Palate fragment	Central	1						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KDD	Anuran	Humerus	Left		1	1				
KDD	Anuran	Ilium	Right			**2**		2		
KDD	Anuran	Tibio-Fibula	Indeterminate		3 (1)	2				
KDD	Pelophylax sp	Ilium	Left			**1**	1	1		
KDD	Rodent	Femur	Right	**1**						
KDD	Snake	Vertebra	Central	7 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
KDD	Arvicola amphibius	Maxilla	Right	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KGV	Anuran	Humerus	Left	1						
KGV	Anuran	Ilium	Left			1		**2**		
KGV	Anuran	Ilium	Right		1	2		2		
KGV	Anuran	Ilium	Indeterminate						1	
KGV	Pelophylax sp	Ilium	Right			**2**	2	2		

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
KGV	Arvicola amphibius	Mandible	Left	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KJI	Anuran	Humerus	Indeterminate				1	1		
KJI	Anuran	Urostyle	Central		**1**	1	1	1		
KJI	Anuran	Ilium	Left		1	1		1		
KJI	Anuran	Ilium	Right				1	1		

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KRK	Anuran	Scapula	Left			1	1			
KRK	Anuran	Humerus	Right		1	1				
KRK	Anuran	Radio-Ulna	Left		2	2	2	1		
KRK	Anuran	Urostyle	Central		1	1				
KRK	Anuran	Ilium	Left			1				
KRK	Anuran	Ilium	Right			**2**		1		
KRK	Anuran	Tibio-Fibula	Indeterminate		1	2				
KRK	Rodent	Humerus	Right	**1**						
KRK	Rodent	Femur	Left	1						
KRK	Snake	Vertebra	Central	4 **(1)**						
KRK	Micromammal	Phalanx	Indeterminate	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
KRK	Arvicola amphibius	Loose lower	Left						**1**	
KRK	Arvicola amphibius	Loose upper	Right							1
KRK	Arvicolinae	Loose lower	Right					**1**		

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KWA	Anuran	Radio-ulna	Indeterminate		**1**	1	1			
KWA	Anuran	Humerus	Right		1	1	1	1		

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KWT	Anuran	Humerus	Left		1	1	1			
KWT	Anuran	Humerus	Right		1	1	1			
KWT	Anuran	Ilium	Left			**2**				
KWT	Anuran	Ilium	Right			1		2	1	
KWT	Pelophylax sp	Ilium	Left			**1**	1	1		
KWT	Pelophylax sp	Ilium	Right		1	1	1	1		

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
KWV	Anuran	Humerus	Left				1	1		
KWV	Anuran	Humerus	Right				1			
KWV	Anuran	Urostyle	Central		1	1	1	1	1	
KWV	Anuran	Ilium	Left		1	**5**		4		
KWV	Anuran	Ilium	Right		1	2	2	4		
KWV	Anuran	Ilium	Indeterminate						1	
KWV	Anuran	Femur	Indeterminate		1	2	1			
KWV	Anuran	Tibio-Fibula	Indeterminate		5	4	2			
KWV	Pelophylax sp	Spenethmoid	Central	1						
KWV	Pelophylax sp	Ilium	Left			1	1	1		
KWV	Pelophylax sp	Ilium	Right			1	2	2		
KWV	Rodent	Humerus	Right	1						
KWV	Snake	Vertebra	Central	6 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
KWV	Arvicola amphibius	Mandible	Left	**1**						
KWV	Mus	Mandible	Right	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ZKJ	Anuran	Tibio-fibula	Indeterminate		**1**					
ZKJ	Snake	Vertebra	Central	5 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ZKM	Anuran	Humerus	Left		1	1	1			
ZKM	Anuran	Urostyle	Central		**2**	2	1	1		
ZKM	Anuran	Ilium	Right			1		1		
ZKM	Anuran	Tibio-Fibula	Indeterminate		1	2				
ZKM	Pelophylax sp	Ilium	Right		1	1	1	1		

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
ZKM	Arvicola amphibius	Mandible	Right	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
MAL	Anuran	Scapula	Left		3	3	4			
MAL	Anuran	Scapula	Right		1	1	4			
MAL	Anuran	Humerus	Left		24	26	22	3		
MAL	Anuran	Humerus	Right		19	19	23	2		
MAL	Anuran	Humerus	Indeterminate		3		5	3		
MAL	Anuran	Radio-Ulna	Left		5	6	6	2		
MAL	Anuran	Radio-Ulna	Right		2	3	3			
MAL	Anuran	Radio-Ulna	Indeterminate		10	11	3	2		
MAL	Anuran	Urostyle	Central		27	26	16	6	6	
MAL	Anuran	Ilium	Left		7	43	4	41	4	
MAL	Anuran	Ilium	Right		6	47 **(51)**	4	45	3	
MAL	Anuran	Ilium	Indeterminate			12			4	
MAL	Anuran	Femur	Indeterminate		2	1				
MAL	Anuran	Tibio-Fibula	Indeterminate		57	37				
MAL	Pelophylax sp	Frontoparietal	Left	2						
MAL	Pelophylax sp	Sphenethmoid	Central	7						
MAL	Pelophylax sp	Ilium	Left		4	12	10	**13**		
MAL	Pelophylax sp	Ilium	Right		6	12	10	11		
MAL	Pelophylax sp	Scapula	Left		1		1			
MAL	Pelophylax sp	Scapula	Right		4	3	4			
MAL	Pelophylax ridibundus	Ilium	Right		**1**	1	1	1		
MAL	Toad	Sphenethmoid	Central	**2**						
MAL	Rodent	Mandible	Left	1						
MAL	Rodent	Mandible	Right	1						
MAL	Rodent	Premaxilla	Left	2						
MAL	Rodent	Scapula	Left	1						
MAL	Rodent	Scapula	Right	1						
MAL	Rodent	Humerus	Right	2						
MAL	Rodent	Radius	Indeterminate	1						
MAL	Rodent	Ulna	Left	1						
MAL	Rodent	Indeterminate metacarpal	Indeterminate	1						
MAL	Rodent	Femur	Left	1						
MAL	Rodent	Femur	Right	1						
MAL	Rodent	Femur	Indeterminate	2						
MAL	Rodent	Tibia	Left	2						
MAL	Rodent	Tibia	Right	2						
MAL	Rodent	Astragalus	Left	1						
MAL	Rodent	Calcaneus	Left	**3**						
MAL	Rodent	Calcaneus	Right	2						
MAL	Snake	vertebra	Central	57 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
MAL	Arvicola amphibius	Loose lower tooth	Left					4	4	3
MAL	Arvicola amphibius	Loose lower tooth	Right					2	4	3
MAL	Arvicola amphibius	Loose lower tooth	Indeterminate							3
MAL	Arvicola amphibius	Loose upper tooth	Left					5	3	3
MAL	Arvicola amphibius	Loose upper tooth	Right					3		5
MAL	Arvicola amphibius	Loose upper tooth	Indeterminate						2	1
MAL	Arvicola amphibius	Mandible	Left	**7**						
MAL	Arvicola amphibius	Mandible	Right	6						
MAL	Arvicola amphibius	Palate fragment	Central	7						
MAL	Arvicolinae	Mandible	Right	4						
MAL	Arvicolinae	Palate fragment	Central	**4**						
MAL	Arvicolinae	Loose upper tooth	Left					1		
MAL	Microtus guentheri	Loose upper tooth	Right					**1**		
MAL	Rodent	Loose lower	Indeterminate		2					
MAL	Rodent	Loose lower	Left		3					
MAL	Rodent	Loose lower	Right		2					
MAL	Rodent	Loose upper	Indeterminate		3					
MAL	Rodent	Loose upper	Left		2					
MAL	Rodent	Loose upper	Right		2					
MAL	Crocidura suaveolens	Mandible	Left	**1**						
MAL	Crocidura suaveolens	Maxilla	Right	1						
MAL	Crocidura suaveolens	Maxilla	Left	1						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
MCW	Anuran	Scapula	Left		1	1	1			
MCW	Anuran	Scapula	Right			1	1			
MCW	Anuran	Humerus	Left		2	3	3	2		
MCW	Anuran	Humerus	Right		1	1				
MCW	Anuran	Humerus	Indeterminate				1	1		
MCW	Anuran	Urostyle	Central		1	1	1	1		
MCW	Anuran	Ilium	Left			2		1		
MCW	Anuran	Ilium	Right		2	2				
MCW	Snake	Vertebra	Central	4 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
MCW	Arvicola amphibius	Mandible	Left	**1**						
MCW	Arvicola amphibius	Mandible	Right	1						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
MCX	Anuran	Scapula	Left		1		1			
MCX	Anuran	Scapula	Right		1		1			
MCX	Anuran	Scapula	Indeterminate		1	1				
MCX	Anuran	Humerus	Left		1					
MCX	Anuran	Humerus	Right		4	4	5			
MCX	Anuran	Urostyle	Central		7	**7**	4	2	2	
MCX	Anuran	Ilium	Left		1	7	3	3	1	
MCX	Anuran	Ilium	Right		1	6	1	7		
MCX	Anuran	Ilium	Indeterminate						1	
MCX	Anuran	Femur	Indeterminate		1	3				
MCX	Anuran	Tibio-Fibula	Indeterminate		4	5				
MCX	Pelophylax sp	Frontoparietal	Left	1						
MCX	Pelophylax sp	Ilium	Left		1	4	3	4	1	
MCX	Pelophylax sp	Ilium	Right		1	**4**	3	3		
MCX	Pelophylax sp	Scapula	Left		3	3	3			
MCX	Pelophylax sp	Scapula	Right		1		1			
MCX	Rodent	Mandible	Right	1						
MCX	Rodent	Pelvis	Indeterminate	2 (1)						
MCX	Rodent	Femur	Indeterminate	1						
MCX	Rodent	Tibia	Left	1						
MCX	Rodent	Tibia	Right	1						
MCX	Rodent	Indeterminate metapodial	Indeterminate	1						
MCX	Snake	vertebra	Central	9 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
MCX	Arvicola amphibius	Loose lower tooth	Left						2	
MCX	Arvicola amphibius	Loose lower tooth	Right						1	1
MCX	Arvicola amphibius	Loose upper tooth	Left					1		
MCX	Arvicola amphibius	Maxilla	Indeterminate	1						
MCX	Arvicola amphibius	Mandible	Left	1						
MCX	Arvicola amphibius	Mandible	Right	2						
MCX	Arvicola amphibius	Palate fragment	Central	**3**						
MCX	Crocidura	Mandible	Right	**1**						
MCX	Rodent	Loose upper	Indeterminate		3 **(2)**					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
MDC	Anuran	Scapula	Left		1	1				
MDC	Anuran	Scapula	Right		1	1	2			
MDC	Anuran	Humerus	Left		1	1	1			
MDC	Anuran	Humerus	Right		2		3			
MDC	Anuran	Humerus	Indeterminate				1			
MDC	Anuran	Urostyle	Central		**4**	4	2	1	3	
MDC	Anuran	Ilium	Right			1			1	
MDC	Anuran	Tibio-Fibula	Indeterminate		1					
MDC	Pelophylax sp	Sphenethmoid	Central	**4**						
MDC	Pelophylax sp	Scapula	Right		1	1	1			
MDC	Toad	Scapula	Left		**1**	1	1			
MDC	Snake	Vertebra	Central	**1**						
MDC	Rodent	Pelvis	Right	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
MDC	Arvicola amphibius	Mandible	Left	1						
MDC	Arvicola amphibius	Mandible	Right	1						
MDC	Arvicola amphibius	Palate fragment	Central	**2**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
MDJ	Anuran	Humerus	Left		2	2	2	1		
MDJ	Anuran	Humerus	Right		1	1	1	1		
MDJ	Anuran	Radio-Ulna	Right		1	1				
MDJ	Anuran	Urostyle	Central		**4**	4	3	3	1	
MDJ	Anuran	Ilium	Left		1	4	1	4		
MDJ	Anuran	Ilium	Right			3		2		
MDJ	Anuran	Ilium	Indeterminate			1			1	
MDJ	Anuran	Femur	Indeterminate		1	1	1			
MDJ	Anuran	Tibio-Fibula	Indeterminate		6 (2)	3				
MDJ	Pelophylax sp	Frontoparietal	Right	1						
MDJ	Pelophylax sp	Ilium	Left			1		1		
MDJ	Pelophylax sp	Ilium	Right		1	1		1		
MDJ	Pelophylax ridibundus	Frontoparietal	Left	1						
MDJ	Pelophylax ridibundus	Ilium	Right		**1**	1	1	1		
MDJ	Toad	Tibio-fibula	Indeterminate		1					
MDJ	Rodent	Mandible	Indeterminate	1						
MDJ	Rodent	Indeterminate metacarpal	Indeterminate	1						
MDJ	Rodent	Caudal vertebra	Central	1						
MDJ	Rodent	Femur	Right	1						
MDJ	Rodent	Tibia	Left	1						
MDJ	Rodent	Indeterminate metapodial	Indeterminate	1						
MDJ	Snake	vertebra	Central	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
MDJ	Arvicola amphibius	Loose lower tooth	Left		**1**			1		
MDJ	Arvicola amphibius	Loose lower tooth	Right		1			1	1	
MDJ	Arvicola amphibius	Loose lower tooth	Indeterminate		1					
MDJ	Arvicola amphibius	Loose upper tooth	Left		1			1		
MDJ	Arvicolinae	Palate fragment	Central	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
MEO	Anuran	Scapula	Left		1		1			
MEO	Anuran	Humerus	Left				1			
MEO	Anuran	Ilium	Left			**1**				
MEO	Anuran	Ilium	Right			1				
MEO	Anuran	Tibio-Fibula	Indeterminate		1	1				
MEO	Pelophylax sp	Sphenethmoid	Central	**1**						
MEO	Snake	Vertebra	**7 (1)**							

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
MNZ	Anuran	Coracoid	Indeterminate	**10 (5)**						
MNZ	Pelophylax sp	Scapula	Right		**1**	1	1			
MNZ	Rodent	Premaxilla	Right	1						
MNZ	Rodent	Mandible	Right	1						
MNZ	Snake	vertebra	Central	32 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
MNZ	Arvicola amphibius	Loose lower tooth	Left					7	3	2
MNZ	Arvicola amphibius	Loose lower tooth	Right					3	1	
MNZ	Arvicola amphibius	Loose upper tooth	Left					**8**	4	1
MNZ	Arvicola amphibius	Loose upper tooth	Right					4	4	2
MNZ	Arvicola amphibius	Mandible	Left	2						
MNZ	Arvicola amphibius	Mandible	Right	2						
MNZ	Arvicola amphibius	Palate fragment	Central	4						
MNX	Arvicolinae	Palate fragment	Central	**4**						
MNZ	Rodent	Loose upper	Left		2 **(3)**					
MNZ	Rodent	Loose upper	Right		2					
MNZ	Rodent	Loose upper	Indeterminate		2					
MNZ	Rodent	Loose lower	Indeterminate		1					
MNZ	Erinaceus concolor	Lower loose tooth	Right				**1**			

Frequency calculations

HBG anura MNI = 17

Context	Element	Skeletal frequency	Observed	Expected	% present
HBG	Premaxilla	2	0	34	0
HBG	Frontoparietal	2	0	34	0
HBG	Parasphenoid	1	0	17	0
HBG	Sphenethmoid	1	1	17	5.9
HBG	Pterygoid	2	4	34	11.8
HBG	Scapula	2	6	34	17.6
HBG	Humerus	2	19	34	55.9
HBG	Radio-Ulna	2	3	34	8.8
HBG	Coracoid	2	9	34	26.5
HBG	Sacrum	1	0	17	0
HBG	Urostyle	1	17	17	100
HBG	Ilium	2	32	34	94.1
HBG	Ischium	1	1	17	5.9
HBG	Femur	2	4	34	11.8
HBG	Tibio-Fibula	2	16	34	47.1

HEJ anura MNI = 13

Context	Element	Skeletal frequency	Observed	Expected	% present
HEJ	Premaxilla	2	0	26	0
HEJ	Frontoparietal	2	0	26	0
HEJ	Parasphenoid	1	0	13	0
HEJ	Sphenethmoid	1	2	13	15.4
HEJ	Pterygoid	2	0	26	0
HEJ	Scapula	2	5	26	19.2
HEJ	Humerus	2	4	26	15.4
HEJ	Radio-Ulna	2	0	26	0
HEJ	Coracoid	2	3	26	11.5
HEJ	Sacrum	1	0	13	0
HEJ	Urostyle	1	8	13	61.5
HEJ	Ilium	2	22	26	84.6
HEJ	Ischium	1	1	13	7.7
HEJ	Femur	2	0	26	0
HEJ	Tibio-Fibula	2	10	26	38.5

HFG anura MNI = 14

Context	Element	Skeletal frequency	Observed	Expected	% present
HFG	Premaxilla	2	0	28	0
HFG	Frontoparietal	2	3	28	10.7
HFG	Parasphenoid	1	1	14	7.1
HFG	Sphenethmoid	1	5	14	35.7
HFG	Pterygoid	2	2	28	7.1
HFG	Scapula	2	2	28	7.1
HFG	Humerus	2	3	28	10.7
HFG	Radio-Ulna	2	3	28	10.7
HFG	Coracoid	2	3	28	10.7
HFG	Sacrum	1	5	14	35.7
HFG	Urostyle	1	10	14	71.4
HFG	Ilium	2	25	28	89.3
HFG	Ischium	1	1	14	7.1
HFG	Femur	2	4	28	14.3
HFG	Tibio-Fibula	2	16	28	57.1

HFW anura MNI = 40

Context	Element	Skeletal frequency	Observed	Expected	% present
HFW	Premaxilla	2	2	80	2.5
HFW	Frontoparietal	2	2	80	2.5
HFW	Parasphenoid	1	0	40	0
HFW	Sphenethmoid	1	12	40	30
HFW	Pterygoid	2	3	80	3.8
HFW	Scapula	2	8	80	10
HFW	Humerus	2	18	80	22.5
HFW	Radio-Ulna	2	3	80	3.8
HFW	Coracoid	2	23	80	28.8
HFW	Sacrum	1	12	40	30
HFW	Urostyle	1	24	40	60
HFW	Ilium	2	80	80	100
HFW	Ischium	1	2	40	5
HFW	Femur	2	10	80	12.5
HFW	Tibio-Fibula	2	24	80	30

HJW anura MNI = 12

Context	Element	Skeletal frequency	Observed	Expected	% present
HJW	Premaxilla	2	1	24	4.2
HJW	Frontoparietal	2	1	24	4.2
HJW	Parasphenoid	1	2	12	16.7
HJW	Sphenethmoid	1	2	12	16.7
HJW	Pterygoid	2	3	24	12.5
HJW	Scapula	2	1	24	4.2
HJW	Humerus	2	7	24	29.7
HJW	Radio-Ulna	2	11	24	45.8
HJW	Coracoid	2	1	24	4.2
HJW	Sacrum	1	1	12	8.3
HJW	Urostyle	1	12	12	100
HJW	Ilium	2	17	24	70.8
HJW	Ischium	1	0	12	0
HJW	Femur	2	0	24	0
HJW	Tibio-Fibula	2	10	24	41.7

HGG anura MNI = 10

Context	Element	Skeletal frequency	Observed	Expected	% present
HGG	Premaxilla	2	0	20	0
HGG	Frontoparietal	2	2	20	10
HGG	Parasphenoid	1	0	10	0
HGG	Sphenethmoid	1	6	10	60
HGG	Pterygoid	2	0	20	0
HGG	Scapula	2	3	20	15
HGG	Humerus	2	15	20	75
HGG	Radio-Ulna	2	1	20	5
HGG	Coracoid	2	5	20	25
HGG	Sacrum	1	0	10	0
HGG	Urostyle	1	7	10	70
HGG	Ilium	2	17	20	85
HGG	Ischium	1	1	10	10
HGG	Femur	2	1	20	5
HGG	Tibio-Fibula	2	13	20	65

KAJ anura MNI = 11

Context	Element	Skeletal frequency	Observed	Expected	% present
KAJ	Premaxilla	2	2	22	9.1
KAJ	Frontoparietal	2	2	22	9.1
KAJ	Parasphenoid	1	0	11	0
KAJ	Sphenethmoid	1	7	11	63.6
KAJ	Pterygoid	2	4	22	18.2
KAJ	Scapula	2	6	22	27.3
KAJ	Humerus	2	10	22	45.5
KAJ	Radio-Ulna	2	6	22	27.3
KAJ	Coracoid	2	4	22	18.2
KAJ	Sacrum	1	3	11	27.3
KAJ	Urostyle	1	5	11	45.5
KAJ	Ilium	2	21	22	95.5
KAJ	Ischium	1	3	11	27.3
KAJ	Femur	2	0	22	0
KAJ	Tibio-Fibula	2	7	22	31.8

MAL anura MNI = 51

Context	Element	Skeletal frequency	Observed	Expected	% present
MAL	Premaxilla	2	27	102	26.5
MAL	Frontoparietal	2	9	102	8.8
MAL	Parasphenoid	1	4	51	7.8
MAL	Sphenethmoid	1	10	51	19.6
MAL	Pterygoid	2	17	102	16.7
MAL	Scapula	2	8	102	7.8
MAL	Humerus	2	59	102	57.8
MAL	Radio-Ulna	2	20	102	19.6
MAL	Coracoid	2	12	102	11.8
MAL	Sacrum	1	15	51	29.4
MAL	Urostyle	1	27	51	52.9
MAL	Ilium	2	102	102	100
MAL	Ischium	1	3	51	5.9
MAL	Femur	2	1	102	1
MAL	Tibio-Fibula	2	37	102	36.3

Body Part Representation calculations

Context	Element	No. in single specimen	Anura	Pelophylax sp.	Group Total
HBG	Premaxilla	2			
HBG	Frontoparietal	2			
HBG	Parasphenoid	1			
HBG	Sphenethmoid	1	1		
HBG	Pterygoid	2	4		
HBG	Squamosal	2			
HBG	**Cranial total**	**10**	**5**		**5**
HBG	Clavicle	2			
HBG	Sternum	2	1		
HBG	Scapula	2	6	5	
HBG	Humerus	2	19		
HBG	Radio-Ulna	2	3		
HBG	Coracoid	2	9		
HBG	**Forelimb total**	**12**	**38**	**5**	**43**
HBG	Vertebra	8	18		
HBG	Sacrum	1			
HBG	**Axial total**	**9**	**18**		**18**
HBG	Urostyle	1	17		
HBG	Ilium	2	32	3	
HBG	Ischium	1	1		
HBG	Femur	2	4		
HBG	Tibio-Fibula	2	16		
HBG	**Hindlimb total**	**8**	**70**	**3**	**73**
HBG	Carpals	4			
HBG	Tarsals	4			
HBG	Metapodials	18			
HBG	Phalanges	54			

Context	Element	No. in single specimen	Anura	Pelophylax sp.	Group Total
HEJ	Premaxilla	2	1		
HEJ	Frontoparietal	2			
HEJ	Parasphenoid	1			
HEJ	Sphenethmoid	1	2	5	
HEJ	Pterygoid	2			
HEJ	Squamosal	2			
HEJ	**Cranial total**	**10**	**3**	**5**	**8**
HEJ	Clavicle	2			
HEJ	Sternum	2			
HEJ	Scapula	2	5	1	
HEJ	Humerus	2	4		
HEJ	Radio-Ulna	2			
HEJ	Coracoid	2	3		
HEJ	**Forelimb total**	**12**	**12**	**1**	**13**
HEJ	Vertebra	8	2		
HEJ	Sacrum	1			
HEJ	**Axial total**	**9**	**2**		**2**
HEJ	Urostyle	1	8		
HEJ	Ilium	2	22	6	
HEJ	Ischium	1	1		
HEJ	Femur	2			
HEJ	Tibio-Fibula	2	10		
HEJ	**Hindlimb total**	**8**	**41**	**6**	**47**
HEJ	Carpals	4			
HEJ	Tarsals	4			
HEJ	Metapodials	18			
HEJ	Phalanges	54			

Context	Element	No. in single specimen	Anura	Pelophylax sp.	Group Total
HFG	Premaxilla	2			
HFG	Frontoparietal	2	4		
HFG	Parasphenoid	1	1		
HFG	Sphenethmoid	1	5		
HFG	Pterygoid	2	2		
HFG	Squamosal	2	2		
HFG	**Cranial total**	**10**	**14**		**14**
HFG	Clavicle	2			
HFG	Sternum	2			
HFG	Scapula	2	2	4	
HFG	Humerus	2	3		
HFG	Radio-Ulna	2	4		
HFG	Coracoid	2	3		
HFG	**Forelimb total**	**12**	**12**	**4**	**16**
HFG	Vertebra	8	19		
HFG	Sacrum	1	5		
HFG	**Axial total**	**9**	**24**		**24**
HFG	Urostyle	1	10		
HFG	Ilium	2	25	3	
HFG	Ischium	1	1		
HFG	Femur	2	4		
HFG	Tibio-Fibula	2	16		
HFG	**Hindlimb total**	**8**	**56**	**3**	**59**
HFG	Carpals	4			
HFG	Tarsals	4			
HFG	Metapodials	18			
HFG	Phalanges	54			

Context	Element	No. in single specimen	Anura	Pelophylax sp.	Group Total
HFW	Premaxilla	2	2		
HFW	Frontoparietal	2	2		
HFW	Parasphenoid	1			
HFW	Sphenethmoid	1	12	5	
HFW	Pterygoid	2	3		
HFW	Squamosal	2			
HFW	**Cranial total**	**10**	**19**	**5**	**24**
HFW	Clavicle	2			
HFW	Sternum	2	1		
HFW	Scapula	2	8	8	
HFW	Humerus	2	18		
HFW	Radio-Ulna	2	3		
HFW	Coracoid	2	25		
HFW	**Forelimb total**	**12**	**55**	**8**	**63**
HFW	Vertebra	8	48		
HFW	Sacrum	1	14		
HFW	**Axial total**	**9**	**62**		**62**
HFW	Urostyle	1	24		
HFW	Ilium	2	80	7	
HFW	Ischium	1	2		
HFW	Femur	2	10		
HFW	Tibio-Fibula	2	24		
HFW	**Hindlimb total**	**8**	**140**	**7**	**147**
HFW	Carpals	4			
HFW	Tarsals	4			
HFW	Metapodials	18			
HFW	Phalanges	54			

Context	Element	No. in single specimen	Anura	Pelophylax sp.	Group Total
HJW	Premaxilla	2	1		
HJW	Frontoparietal	2	1	1	
HJW	Parasphenoid	1	2		
HJW	Sphenethmoid	1		1	
HJW	Pterygoid	2	3		
HJW	Squamosal	2	1		
HJW	**Cranial total**	**10**	**8**	**2**	**10**
HJW	Clavicle	2			
HJW	Sternum	2	2		
HJW	Scapula	2	1	4	
HJW	Humerus	2	9		
HJW	Radio-Ulna	2	11		
HJW	Coracoid	2	1		
HJW	**Forelimb total**	**12**	**24**	**4**	**28**
HJW	Vertebra	8	3		
HJW	Sacrum	1	1		
HJW	**Axial total**	**9**	**4**		**4**
HJW	Urostyle	1	12		
HJW	Ilium	2	17	2	
HJW	Ischium	1			
HJW	Femur	2			
HJW	Tibio-Fibula	2	10		
HJW	**Hindlimb total**	**8**	**39**	**2**	**41**
HJW	Carpals	4			
HJW	Tarsals	4			
HJW	Metapodials	18			
HJW	Phalanges	54			

Context	Element	No. in single specimen	Anura	Pelophylax sp.	Group Total
HGG	Premaxilla	2			
HGG	Frontoparietal	2	2		
HGG	Parasphenoid	1			
HGG	Sphenethmoid	1	6	3	
HGG	Pterygoid	2			
HGG	Squamosal	2			
HGG	**Cranial total**	**10**	**8**	**3**	**11**
HGG	Clavicle	2			
HGG	Sternum	2			
HGG	Scapula	2	3	4	
HGG	Humerus	2	15		
HGG	Radio-Ulna	2	1		
HGG	Coracoid	2	5		
HGG	**Forelimb total**	**12**	**24**	**4**	**28**
HGG	Vertebra	8	3		
HGG	Sacrum	1			
HGG	**Axial total**	**9**	**3**		**3**
HGG	Urostyle	1	7		
HGG	Ilium	2	17	2	
HGG	Ischium	1	1		
HGG	Femur	2	1		
HGG	Tibio-Fibula	2	13		
HGG	**Hindlimb total**	**8**	**39**	**2**	**41**
HGG	Carpals	4			
HGG	Tarsals	4			
HGG	Metapodials	18			
HGG	Phalanges	54			

Context	Element	No. in single specimen	Anura	Pelophylax sp.	Group Total
KAJ	Premaxilla	2	2		
KAJ	Frontoparietal	2	2		
KAJ	Parasphenoid	1			
KAJ	Sphenethmoid	1	7		
KAJ	Pterygoid	2	4		
KAJ	Squamosal	2			
KAJ	**Cranial total**	**10**	**15**		**15**
KAJ	Clavicle	2			
KAJ	Sternum	2	7		
KAJ	Scapula	2	6		
KAJ	Humerus	2	10		
KAJ	Radio-Ulna	2	6		
KAJ	Coracoid	2	4		
KAJ	**Forelimb total**	**12**	**33**		**33**
KAJ	Vertebra	8	27		
KAJ	Sacrum	1	3		
KAJ	**Axial total**	**9**	**30**		**30**
KAJ	Urostyle	1	5		
KAJ	Ilium	2	21	1	
KAJ	Ischium	1	3		
KAJ	Femur	2			
KAJ	Tibio-Fibula	2	7		
KAJ	**Hindlimb total**	**8**	**36**	**1**	**37**
KAJ	Carpals	4			
KAJ	Tarsals	4			
KAJ	Metapodials	18			
KAJ	Phalanges	54			

Context	Element	No. in single specimen	Anura	Pelophylax sp.	Group Total
MAL	Premaxilla	2	27		
MAL	Frontoparietal	2	8	2	
MAL	Parasphenoid	1	4		
MAL	Sphenethmoid	1	10	7	
MAL	Pterygoid	2	17		
MAL	Squamosal	2	2		
MAL	**Cranial total**	**10**	**68**	**9**	**77**
MAL	Clavicle	2			
MAL	Sternum	2	9		
MAL	Scapula	2	8	5	
MAL	Humerus	2	50		
MAL	Radio-Ulna	2	20		
MAL	Coracoid	2	12		
MAL	**Forelimb total**	**12**	**99**	**5**	**104**
MAL	Vertebra	8	33		
MAL	Sacrum	1	15		
MAL	**Axial total**	**9**	**48**		**48**
MAL	Urostyle	1	27		
MAL	Ilium	2	102	25	
MAL	Ischium	1	3		
MAL	Femur	2	1		
MAL	Tibio-Fibula	2	37		
MAL	**Hindlimb total**	**8**	**170**	**25**	**195**
MAL	Carpals	4			
MAL	Tarsals	4			
MAL	Metapodials	18			
MAL	Phalanges	54			

Appendix D: Pınarbaşı Assemblage Results

Minimum Number of Elements (MNE)

7th millennium BCE

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BBH	Anuran	Humerus	Right		**1**	1	1	1		
BBH	Anuran	Sacrum	Central	1						
BBH	Snake	Vertebra	Central	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BDF	Anuran	Ilium	Right			1		1		
BDF	Anuran	Sacrum	Central	**1**						
BDF	Rodent	Humerus	Left			**1**	1	1	1	1
BDF	Snake	Vertebra	Central	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BDF	Arvicolinae	Mandible	Left	**1**						
BDF	Arvicolinae	Loose tooth Lower	Right					1	1	
BDF	Murinae	Maxilla	Right	**1**						
BDF	Rodent	Loose tooth Upper	Indeterminate		1					

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BFV	Erinaceus concolor	Loose tooth Upper	Right						**1**	

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BHL	Anuran	Sphenethmoid	Central	1						
BHL	Anuran	Humerus	Right		**1**	1	1			
BHL	Anuran	Radio-Ulna	Right		1	1	1			
BHL	Anuran	Radio-Ulna	Indeterminate		1	1	1			
BHL	Anuran	Ilium	Right			1		1		
BHL	Anuran	Femur	Indeterminate			1				
BHL	Snake	Vertebra	Central	24 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BHL	Arvicola amphibius	Loose tooth Lower	Right					1		
BHL	Arvicola amphibius	Mandble	Left	**1**						
BHL	Arvicolinae	Mandible	Right	**2**						
BHL	Arvicolinae	Palate	Central	1						
BHL	Crocidura suaveolens	Mandible	Right	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BJY	Anuran	Sphenethmoid	Central	1						
BJY	Anuran	Squamosal	Left	7						
BJY	Anuran	Atlas	Central	6						
BJY	Anuran	Humerus	Left		3	3	3	1		
BJY	Anuran	Humerus	Right		2	2	2	2		
BJY	Anuran	Radio-Ulna	Left		1	1	1	1		
BJY	Anuran	Radio-Ulna	Right		1	1	1			
BJY	Anuran	Vertebra	Central	73 **(11)**						
BJY	Anuran	Urostyle	Central		3	3	3	2		
BJY	Anuran	Sacrum	Central	7						
BJY	Anuran	Femur	Indeterminate		3	3	2			
BJY	Anuran	Tibio-Fibula	Indeterminate		6 (2)	4 (2)	1			
BJY	Pelophylax sp.	Ilium	Left		1	1	1	1		
BJY	Pelophylax sp.	Ilium	Right		3	**4**	4	4		
BJY	Pelophylax sp.	Scapula	Left		2	2	2			
BJY	Snake	Vertebra	Central	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BJY	Mus	Mandible	Right	**1**						
BJY	Rodent	Loose tooth Lower	Right		**1**					

10^{th}-9^{th} millennium BCE

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ADJ	Anuran	Coracoid	Indeterminate	2						
ADJ	Anuran	Illium	Left						1	
ADJ	Anuran	Illium	Right			**1**				
ADJ	Anuran	Scarum	Central	1						
ADJ	Anuran	Vertebra	Central	5						
ADJ	Arvicola amphibius	Mandible	Left	**1**						
ADJ	Rodent	Premaxilla	Left	**1**						
ADJ	Snake	Vertebra	Central	38 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ADN	Anuran	Scapula	Left		1		1			
ADN	Anuran	Scapula	Right		2		2			
ADN	Anuran	Humerus	Left		2	1	1			
ADN	Anuran	Humerus	Right		4	2	5	1		
ADN	Anuran	Radio-Ulna	Left		1	1				
ADN	Anuran	Radio-Ulna	Right		1	1				
ADN	Anuran	Urostyle	Central		4	4	1	1	1	
ADN	Anuran	Ilium	Left		1	**14**		7	1	
ADN	Anuran	Ilium	Right			8		5		
ADN	Anuran	Femur	Indeterminate		2	1				
ADN	Anuran	Tibio-Fibula	Indeterminate		2					
ADN	Pelophylax sp	Ilium	Right			**1**	1	1		
ADN	Pelophylax sp	Scapula	Left		1	1	1			
ADN	Snake	Vertebra	Central	7 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
ADN	Arvicola amphibius	Loose tooth Lower	Right					**2**	1	
ADN	Arvicola amphibius	Loose tooth Upper	Right						1	
ADN	Arvicolinae	Mandible	Left	**1**						
ADN	Arvicolinae	Palate	Central	1						
ADN	Rodent	Loose tooth Lower	Left		**1**					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ADX	Anuran	Radio-ulna	Indeterminate		**1**	1	1			
ADX	Anuran	Tibio-fibula	Indeterminate		1					
ADX	Micromammal	Femur	Indeterminate							**1**

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
ADX	Arvicola amphibius	Loose tooth Upper	Right					1		
ADX	Murinae	Mandible	Right	1						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
AER	Anuran	Sphenethmoid	Central	2						
AER	Anuran	Scapula	Right		1	2	1			
AER	Anuran	Humerus	Left				1	1	1	
AER	Anuran	Sacrum	Central	3						
AER	Anuran	Ilium	Left			3	1	2		
AER	Anuran	Ilium	Right			1			1	
AER	Pelophylax sp	Sphenethmoid	Central	2						
AER	Snake	Vertebra	Central	1						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
AFA	Anuran	Scapula	Left		1		1			
AFA	Anuran	Humerus	Left		3	3	1			
AFA	Anuran	Humerus	Right		6	5	5	3		
AFA	Anuran	Humerus	Indeterminate				1	1		
AFA	Anuran	Radio-Ulna	Left		1	1	1			
AFA	Anuran	Radio-Ulna	Right		1	1	1			
AFA	Anuran	Urostyle	Central		3	3			1	
AFA	Anuran	Ilium	Left		1	7		5		
AFA	Anuran	Ilium	Right		1	3		1		
AFA	Anuran	Femur	Indeterminate		1	2	1			
AFA	Anuran	Tibio-Fibula	Indeterminate		2					
AFA	Micromammal	Tibia	Right							1
AFA	Pelophylax sp	Ilium	Left			2	2	2		
AFA	Snake	Vertebra	Central	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
AFA	Arvicola amphibius	Mandible	left	1						
AFA	Arvicola amphibius	Mandible	Right	1						
AFA	Arvicola amphibius	Loose tooth Lower	Left					1		
AFA	Arvicolinae	Loose tooth	Indeterminate	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
AFC	Anuran	Scapula	Right				1			
AFC	Anuran	Humerus	Left				1	1		
AFC	Anuran	Humerus	Right				1			
AFC	Anuran	Radio-Ulna	Right		1	1	1			
AFC	Anuran	Ilium	Left			1		1		
AFC	Anuran	Ilium	Right			1		1	1	
AFC	Anuran	Femur	Indeterminate			2 (1)				
AFC	Anuran	Tibio-Fibula	Indeterminate		4 (1)	1				
AFC	Snake	Vertebra	Central	1						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
AFC	Arvicolinae	Mandible	Right	1						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
AFI	Anuran	Scapula	Left		1		1			
AFI	Anuran	Scapula	Right		1		1			
AFI	Anuran	Sphenethmoid	Central	**4**						
AFI	Anuran	Ilium	Left			4		3		
AFI	Anuran	Ilium	Right			3		4		
AFI	Anuran	Tibio-Fibula	Indeterminate		1					
AFI	Pelophylax sp	Sphenethmoid	Central	1						
AFI	Pelophylax sp	Scapula	Right		1	**1**	1			
AFI	Snake	Vertebra	Central	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
AFI	Erinaceus concolor	Loose tooth Lower	Right					**1**		

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
AHA	Anuran	Sphenethmoid	Central	1						
AHA	Anuran	Humerus	Left		**2**	2	2			
AHA	Anuran	Humerus	Indeterminate		1	1				
AHA	Anuran	Radio-Ulna	Right		1	1	1			
AHA	Anuran	Radio-Ulna	Indeterminate		1	1				
AHA	Anuran	Ilium	Right			1		1		
AHA	Anuran	Femur	Indeterminate		2	2	2			
AHA	Anuran	Tibio-Fibula	Indeterminate		5 (2)	4 (2)	1			
AHA	Rodent	Mandible	Indeterminate	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ZAM	Anuran	Sphenethmoid	Central	1						
ZAM	Anuran	Humerus	Left		1	1	1			
ZAM	Anuran	Sacrum	Central	1						
ZAM	Anuran	Urostyle	Central			1				
ZAM	Anuran	Ilium	Left			**3**				
ZAM	Anuran	Ilium	Right			1				
ZAM	Anuran	Tibio-Fibula	Indeterminate		1	2				
ZAM	Pelophylax sp	Ilium	Left		**1**	1	1	1		
ZAM	Rodent	Skull	Central	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DCl	Anuran	Ilium	Left			**1**				

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DCL	Anuran	Sacrum	Central	1						
DCL	Anuran	Femur	Indeterminate			1				
DCL	Anuran	Ilium	Left			**2**		1		
DCL	Anuran	Humerus	Left			1	1			
DCL	Anuran	Humerus	Right			1	1			
DCL	Pelobates sp	Maxilla	Left	**1**						
DCL	Rodent	Ulna	Left	**1**						
DCL	Rodent	Humerus	Left			1	1	1	1	1
DCL	Snake	Vertebra	Central	3 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
DCL	Erinaceus concolor	Loose tooth Lower	Left						**1**	

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
DFA	Arvicola amphibius	Mandible	Right	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DFH	Anuran	Phalanx	Indeterminate	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DFM	Anuran	Scapula	Left			1	1			
DFM	Anuran	Scapula	Right			1	1			
DFM	Anuran	Humerus	Indeterminate		1		1			
DFM	Anuran	Ilium	Left			1		2		
DFM	Anuran	Ilium	Right			**3**	1	1		
DFM	Anuran	Femur	Indeterminate			1				
DFM	Anuran	Tibio-Fibula	Indeterminate			1				
DFM	Snake	Vertebra	Central	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DGK	Anuran	Sacrum	Central	**1**						
DGK	Anuran	Radio-Ulna	Right		1	1				

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DGL	Anuran	Urostyle	Central		1	1				
DGL	Anuran	Ilium	Right			**2**		2		
DGL	Anuran	Humerus	Right		1	1	1			

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DGN	Anuran	Sphenethmoid	Central	**2**						
DGN	Anuran	Scapula	Left		1		1			
DGN	Anuran	Humerus	Right		1	1	1			
DGN	Anuran	Ilium	Left		1	1	1		1	
DGN	Anuran	Ilium	Right			1		1		
DGN	Anuran	Femur	Indeterminate		1					
DGN	Anuran	Tibio-Fibula	Indeterminate							
DGN	Pelophylax sp	Scapula	Right		**1**	1	1			

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DGS	Anuran	Sphenethmoid	Central	5						
DGS	Anuran	Scapula	Left		1	1	1			
DGS	Anuran	Scapula	Right		1	1	1			
DGS	Anuran	Humerus	Left		2	2	2			
DGS	Anuran	Humerus	Right		2	1	1			
DGS	Anuran	Humerus	Indeterminate		1					
DGS	Anuran	Urostyle	Central		4	5	2	1		
DGS	Anuran	Ilium	Left		1	6		4		
DGS	Anuran	Ilium	Right		2	**7**		3		
DGS	Anuran	Femur	Indeterminate		1	2				
DGS	Anuran	Tibio-Fibula	Indeterminate		1					
DGS	Snake	Vertebra	Central	4 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
DGT	Anuran	Sphenethmoid	Central	1						
DGT	Anuran	Scapula	Left		1	2	2			
DGT	Anuran	Scapula	Right			2	1			
DGT	Anuran	Humerus	Left		3	2	1			
DGT	Anuran	Humerus	Right		1	1				
DGT	Anuran	Radio-Ulna	Left		1	1	1			
DGT	Anuran	Radio-Ulna	Right		1	1				
DGT	Anuran	Sacrum	Central	**8**						
DGT	Anuran	Urostyle	Central		4	4	2	1		
DGT	Anuran	Ilium	Left			3				
DGT	Anuran	Ilium	Right		1	7		1		
DGT	Anuran	Tibio-Fibula	Indeterminate		1	2				
DGT	Pelophylax sp	Scapula	Right		**1**	1	1			
DGT	Snake	Vertebra	Central	2 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
DGT	Arvicolinae	Palate	Central	**1**						
DGT	Arvicolinae	Loose tooth Lower	Right						1	
DGT	Meriones	Loose tooth	Indeterminate	**1**						
DGT	Rodent	Loose tooth Lower	Right		**1**					

14th-12th millennium BCE

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIA	Anuran	Sphenethmoid	Central	9						
BIA	Anuran	Humerus	Right		1	1				
BIA	Anuran	Radio-Ulna	Indeterminate		2	2	1			
BIA	Anuran	Urostyle	Central		3	**4**				
BIA	Anuran	Sacrum	Central	1						
BIA	Anuran	Tibio-Fibula	Indeterminate		1	1				
BIA	Pelophylax ridibundus	Scapula	Right		**1**	1	1			
BIA	Rodent	Femur	Right	**1**						
BIA	Rodent	Humerus	Left	1						
BIA	Rodent	Humerus	Right	1						
BIA	Rodent	Scapula	Right	1						
BIA	Snake	Vertebra	Central	38 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BIA	Arvicola amphibius	Mandible	Right	**1**						
BIA	Arvicola amphibius	Palate	Central	1						
BIA	Arvicola amphibius	Loose tooth Lower	Left						1	
BIA	Arvicola amphibius	Loose tooth Upper	Right						1	
BIA	Arvicolinae	Mandible	Left	1						
BIA	Arvicolinae	Palate	Central	**2**						
BIA	Erinaceus concolor	Loose tooth Upper	Left						**1**	
BIA	Insectivora	Mandible	Right	**1**						
BIA	Meriones	loose tooth	Indeterminate	**1**						
BIA	Microtus	loose tooth Lower	Left					**1**		
BIA	Mus	Mandible	Right	**1**						
BIA	Rodent	Loose tooth Lower	Left		1					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIB	Anuran	Scapula	Left		2	1	2			
BIB	Anuran	Scapula	Right				1			
BIB	Anuran	Humerus	Left		1	1				
BIB	Anuran	Humerus	Right		1	2	2			
BIB	Anuran	Radio-Ulna	Left		1	1	1			
BIB	Anuran	Radio-Ulna	Right		2	2	2			
BIB	Anuran	Radio-Ulna	Indeterminate		5 **(4)**	5	2			
BIB	Anuran	Urostyle	Central		3	2				
BIB	Anuran	Ilium	Left			2	2	1		
BIB	Anuran	Ilium	Right			1		1		
BIB	Pelophylax ridibundus	Sphenethmoid	Central	**1**						
BIB	Pelophylax sp	Ilium	Right			1	1	1		
BIB	Pelophylax sp	Scapula	Right		**3**	1	2			
BIB	Snake	Vertebra	Central	36 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BIB	Arvicolinae	Mandible	Right	**1**						
BIB	Arvicolinae	Loose tooth Upper	Left							1
BIB	Arvicolinae	Loose tooth Lower	Right					1		
BIB	Rodent	Loose tooth Lower	Right		**1**					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIE	Anuran	Scapula	Left			1	1			
BIE	Anuran	Scapula	Right		1	2	1			
BIE	Anuran	Humerus	Indeterminate				1			
BIE	Anuran	Radio-Ulna	Left		1	1	1			
BIE	Anuran	Urostyle	Central		2	2	1			
BIE	Anuran	Ilium	Left		3	3		**4**		
BIE	Anuran	Ilium	Right		1	4		2		
BIE	Anuran	Tibio-Fibula	Indeterminate		2	2				
BIE	Rodent	Humerus	Left			1	1		2	2
BIE	Rodent	Humerus	Right						1	
BIE	Rodent	Femur	Left		1	1				
BIE	Rodent	Femur	Right		1	2	1			1
BIE	Snake	Vertebra	Central	198 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BIE	Arvicola amphibius	loose tooth Upper	Left						1	
BIE	Arvicola amphibius	Mandible	Right	**1**						
BIE	Arvicolinae	Mandible	Left	2						
BIE	Arvicolinae	Mandible	Right	3						
BIE	Arvicolinae	Palate	Central	3						
BIE	Arvicolinae	Loose tooth Lower	Left					2	1	
BIE	Arvicolinae	Loose tooth Lower	Right					**4**	1	
BIE	Crocidura	Maxilla	Right	**1**						
BIE	Insectivora	Mandible	Right	**1**						
BIE	Murinae	Maxilla	Indeterminate	**1**						
BIE	Mus	Loose tooth Upper	Left		**1**					
BIE	Rodent	Loose tooth Lower	Right		2					
BIE	Rodent	Loose tooth Upper	Right		**3**					
BIE	Spalacidae	Mandible	Indeterminate	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIF	Anuran	Scapula	Right				1			
BIF	Anuran	Humerus	Left		1	1	1			
BIF	Anuran	Humerus	Right		1	1	1			
BIF	Anuran	Radio-Ulna	Right		1	1	1			
BIF	Anuran	Urostyle	Central		1	1	1	1		
BIF	Anuran	Ilium	Left			1		**2**		
BIF	Anuran	Ilium	Right					1		
BIF	Rodent	Humerus	Indeterminate		1					
BIF	Snake	Vertebra	Central	20 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BIF	Arvicola amphibius	Mandible	Left	**1**						
BIF	Arvicola amphibius	Mandible	Right	1						
BIF	Arvicola amphibius	Loose tooth Lower	Indeterminate					1		
BIF	Arvicolinae	Palate	Central	**1**						
BIF	Murinae	Mandible	Right	**1**						
BIF	Rodent	Loose tooth Lower	Indeterminate		**3 (2)**					
BIF	Rodent	Loose tooth Lower	Right		1					
BIF	Spalacidae	Loose tooth Upper						**1**		

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIH	Anuran	Humerus	Indeterminate				1			
BIH	Anuran	Radio-Ulna	Right		1	1	1			
BIH	Anuran	Urostyle	Central		1	1				
BIH	Anuran	Ilium	Left			**3**		2	1	
BIH	Anuran	Tibio-Fibula	Indeterminate		3	1				
BIH	Insectivora	Tibia	Right	1						
BIH	Rodent	Humerus	Left			1	2	3	4	2
BIH	Rodent	Humerus	Right			2	3	4	**5**	2
BIH	Rodent	Tibia	Left				1	4	5	2
BIH	Rodent	Tibia	Right			1	2	2	1	1
BIH	Snake	Vertebra	Central	367 **(2)**						
BIH	Snake	Compound bone	Indeterminate	2						
BIH	Snake	Dentary	Left	1						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BIH	Arvicola amphibus	Loose tooth Lower	Left					**1**		
BIH	Arvicola amphibus	Loose tooth Upper	Right					1		1
BIH	Arvicolinae	Palate	Central	7						
BIH	Arvicolinae	Mandible	Left	7						
BIH	Arvicolinae	Mandible	Right	**7**						
BIH	Arvicolinae	Loose tooth Lower	Left					1		
BIH	Arvicolinae	Loose tooth Lower	Right						1	
BIH	Arvicolinae	Loose tooth Lower	Indeterminate					1		
BIH	Arvicolinae	Loose tooth Upper	Right						1	
BIH	Cricetulus migratorius	Loose tooth Lower	Indeterminate					**1**		
BIH	Crocidura	Mandible	Left	**1**						
BIH	Crocidura	Mandible	Right	1						
BIH	Crocidura	Maxilla	Right	1						
BIH	Crocidura	Loose tooth Upper	Indeterminate	2						
BIH	Insectivora	Mandible	Right	**1**						
BIH	Mesocricetus	Loose tooth Upper	Right							**1**
BIH	Microtus	Loose tooth Lower	Left					**2**		
BIH	Microtus	Loose tooth Lower	Right					1	1	
BIH	Microtus guentheri	Loose tooth Lower	Left					**1**	1	
BIH	Microtus guentheri	Loose tooth Lower	Right					1	1	
BIH	Murinae	Maxilla	Left	1						
BIH	Murinae	Maxilla	Right	**1**						
BIH	Mus	Mandible	Left	**1**						
BIH	Rodent	Mandible	Left	1						
BIH	Rodent	Loose tooth Lower	Left		3					
BIH	Rodent	Loose tooth Lower	Right		2					
BIH	Rodent	Loose tooth Lower	Indeterminate		8					
BIH	Rodent	Loose tooth Upper	Left		2					
BIH	Rodent	Loose tooth Upper	Right		1					
BIH	Rodent	Loose tooth Upper	Indeterminate		2					
BIH	Myotis myotis	Maxilla	Right	**1**						
BIH	Spalacidae	Loose tooth Lower	Indeterminate					**1**		

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIJ	Anuran	Radio-Ulna	Left			**1**	1			
BIJ	Rodent	Femur	Right		1	1	1			
BIJ	Snake	Vertebra	Central	72 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BIJ	Arvicolinae	Mandible	Left	1						
BIJ	Arvicolinae	Mandible	Right	1						
BIJ	Arvicolinae	Palate	Central	1						
BIJ	Arvicolinae	Loose tooth Lower	Left					1	**2**	
BIJ	Crocidura	Mandible	Right	**2**						
BIJ	Mus	Loose tooth Upper	Left		**1**					
BIJ	Rodent	Loose tooth Lower	Right		1					
BIJ	Rodent	Loose tooth Lower	Indeterminate		2					
BIJ	Rodent	Loose tooth Upper	Left		1					
BIJ	Spalacidae	Loose tooth	Indeterminate	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIK	Anuran	Coracoid	Indeterminate	**1**						
BIK	Snake	Vertebra	Central	8 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIL	Anuran	Radio-Ulna	Left		**1**	1	1			
BIL	Anuran	Ilium	Left			1		1		
BIL	Anuran	Ilium	Right			1		1		
BIL	Snake	Vertebra	Central	29 (1)						
BIL	Snake	Compound bone	Indeterminate	**1**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BIL	Arvicola amphibius	Mandible	Left	**1**						
BIL	Arvicolinae	Maxilla	Right	**1**						
BIL	Murinae	Mandible	Left	**1**						
BIL	Rodent	Loose tooth Upper	Left		**1**					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
BIP	Anuran	Scapula	Right		**1**					
BIP	Rodent	Pelvis	Right			**1**	1			
BIP	Snake	Vertebra	Central	11 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	I1	C	PM	M1	M2	M3
BIP	Arvicolinae	Loose tooth Lower	Left					1	**2**	
BIP	Arvicolinae	Loose tooth Lower	Right					1		
BIP	Cricetulus migratorius	Loose tooth Lower	Right					**1**		
BIP	Rodent	Loose tooth Upper	Left		1					

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ZBB	Anuran	Axis	Central	**1**						
ZBB	Rodent	Humerus	Indeterminate		**1**					
ZBB	Rodent	Femur	Right			1				
ZBB	Snake	Vertebra	Central	5 **(1)**						

Context	Taxa	Element	Side	MNE for unzoned elements	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
ZBD	Anuran	Humerus	Left			1	1			
ZBD	Anuran	Urostyle	Central		**1**	1				
ZBD	Snake	Vertebra	Central	26 (1)						
ZBD	Snake	Palate	Indeterminate	**1**						
ZBD	Snake	Ectopterygoid	Indeterminate	1						

Body Part Representation (by NISP)

	Element	No. in single specimen	7th Millennium	10th-9th Millennium	14th-12th Millennium
			NISP	NISP	NISP
Cranial	Premaxilla	2	2	2	2
	Maxilla	2	15	14	22
	Mandible	2	4	22	16
	Frontoparietal	2		4	3
	Parasphenoid	1			
	Sphenethmoid	1	2	26	10
	Pterygoid	2	5	4	5
	Squamosal	2	8	1	2
	Total	**14**	**36**	**73**	**60**
Forelimb	Clavicle	2			
	Sternum	2	2	3	3
	Scapula	2	2	24	16
	Humerus	2	7	41	9
	Radio-Ulna	2	4	11	16
	Coracoid	2	5	18	8
	Total	**12**	**20**	**97**	**52**
Axial	Vertebra	8	86	77	45
	Sacrum	1	9	23	5
	Total	**9**	**95**	**100**	**50**
Hindlimb	Urostyle	1	3	19	12
	Ilium	2	7	103	31
	Ischium	1		4	4
	Femur	2	4	14	
	Tibio-Fibula	2	6	27	9
	Total	**8**	**20**	**167**	**56**
Pes	Tarsals	4	19	3	2
	Metapodials	18	38	33	17
	Phalanges	54	16	30	12
	Total	**76**	**73**	**66**	**31**