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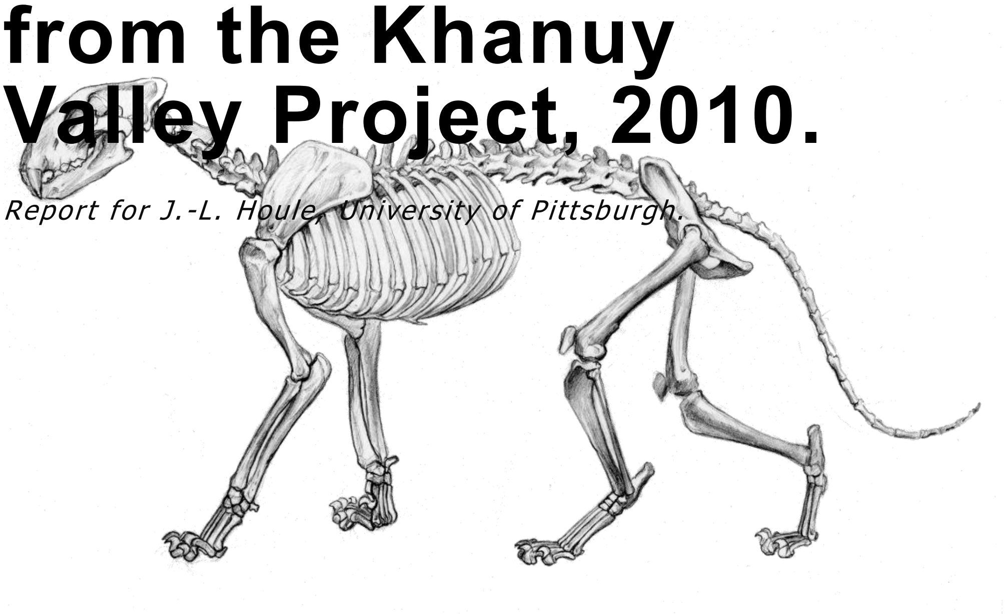
The Faunal Remains from the Khanuy Valley Project, 2010.

Report for J.-L. Houle, University of Pittsburgh.



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All images and other figures are author's own unless clearly stated otherwise.

1. Introduction

Analysis of zooarchaeological assemblages from domestic sites in Mongolia is a practice very much in its infancy. Previous work has been focused, as in this report, on the Khanuy valley, in the Arkhangai province of northern central Mongolia (Makarewicz, 2006; Viner, 2009; Broderick, 2010). This report examines the remains excavated during the 2010 field season of the Khanuy Valley Project.

Research aims and objectives include:

i. To gain information about the wild and domestic animal species represented.
ii. To gain information about the exploitation of wild and domestic animal species.
iii. To ascertain economic and seasonal strategies.
iv. To better understand the palaeoenvironment.
v. To identify changes in any or all of the above between the Xiongnu period and the preceding and subsequent phases of occupation.

2. Methods

A full account of the methods used in identification and recording of the assemblage can be found in the appendices.

The binomial name is used for all species throughout this report. Taxonomy follows Wilson and Reeder (2005) for mammals and Voous (1977) for birds. For convenience, their common (English) name is used in brackets alongside the binomial name when the animal is first mentioned, and a dictionary of all the animals mentioned is provided in the appendices. The word caprine is used when referring to an animal that may be a sheep or a goat.

All bones in the assemblage were identified by comparison with the specimens held in the reference collection of the Khanuy Valley Field Project, where possible, which continued to be assembled and improved during the 2010 field season.

In brief, all teeth were counted (maxillary and mandibular) and a pre-determined selection of skeletal parts was recorded and used in counts. Specifically, these parts are as follows: zygomaticus; occipital; supraorbital; atlas; axis; scapula (glenoid articulation); distal humerus; proximal humerus; distal radius; proximal radius; proximal ulna; carpal 2-3; distal metacarpal; pelvis (ischial part of acetabulum); distal femur; proximal femur; distal tibia; proximal tibia; calcaneum (sustentaculum); astragalus (lateral side); scafocuboid; distal metatarsal and proximal parts of the 1st, 2nd and 3rd phalanges. At least 50% of any given part had to be present for it to be recorded. The presence of large (cow or horse sized), medium (sheep or pig sized) and small vertebrae and ribs were recorded. Horncores with a complete transverse section were also recorded.

For birds, the following elements were always recorded, along the same lines outlined above for mammals: scapular (articular end), proximal coracoids, distal humerus, proximal humerus, proximal radius, distal radius, proximal ulna, proximal carpometacarpus, distal femur, proximal femur, distal tibiotarsus, proximal tibiotarsus and distal tarsometatarsus.

The pelvis and main long bones were recorded for amphibians.

Potentially diagnostic fish bones were photographed in order to prompt identification away from the field when suitable reference material was to be found.

The separation between *Ovis aries* (sheep) and *Capra hircus* (goat) was attempted on the following elements: mandible; dP_3; dP_4; M_1; M_2; M_3; distal humerus; distal metapodials (both fused and unfused); distal tibia; astragalus and calcaneum, using the criteria described in Boessneck (1969), Payne (1985; 1969); Kratochvil (1969) and Halstead, et al.(2002).

The separation between *Dama dama* (fallow deer) and *Cervus elaphus* (red deer) was attempted on the following elements: scapula; distal humerus; proximal radius; distal radius; proximal metacarpal; distal metacarpal; distal tibia; astragalus; calcaneum; proximal metatarsal; distal metatarsal and first phalanx, using the criteria described in Lister (1996).

Wear stages were recorded for P_4, dP_4, M_1, M_2, and M_3 of *Bos* (cattle), caprines and *Sus* (pig), both isolated and within mandibles. Tooth wear stages follow Grant (1982) for *Bos*, Bull and Payne (1982) for *Sus* and Payne (1973; 1987) and Jones (2006) for caprines.

A mammal bone epiphysis is described as “fusing” once spicules of bone have formed across the epiphyseal plate, joining epiphysis to metaphysis, but while some ‘gaps’ are still visible between the epiphysis and diaphysis. An epiphysis is described as “fused” once these gaps along the line of fusion have disappeared. Fusion stages follow Moran and O’Connor (1994) and Zeder (2006). Bird bones with ends that are incompletely ossified were recorded as “juvenile”. Where mammal bones were fused, or fusing, and bird bones were not juvenile specimens, metapodial measurements were taken according to Payne (1969), measurements for *Sus* teeth were taken following Payne and Bull (1988), whilst all other measurements taken followed the criteria laid out by von den Driesch (1976).

Equus sp. (horse) bones and teeth are aged according Silver (1969) and Levine (1982).

The bones from this site are presently kept in storage at the National Museum of Mongolia.

3. Results

The overall condition of the assemblage was highly fragmentary, with just 108 fragments (3.11%) from the domestic assemblage being identifiable under the protocol (Figure 1). This assemblage consists of those remains excavated from MAB and MAC, which is kept separate from the assemblages excavated at the monumental sites KYR1 and KYR 119 throughout this report. Fragments from MAC and MAB showed signs of being root damaged, burnt or calcined. Generally speaking, those bones from MAC showed greater damage by weathering and root etching than did those from MAB (Figure 2). Ratios of burning, in particular, were noted as being similar to those recorded from a modern day winter campsite in the same area (Figure 3), the similarity being slightly greater for MAC than for MAB (Figure 4).

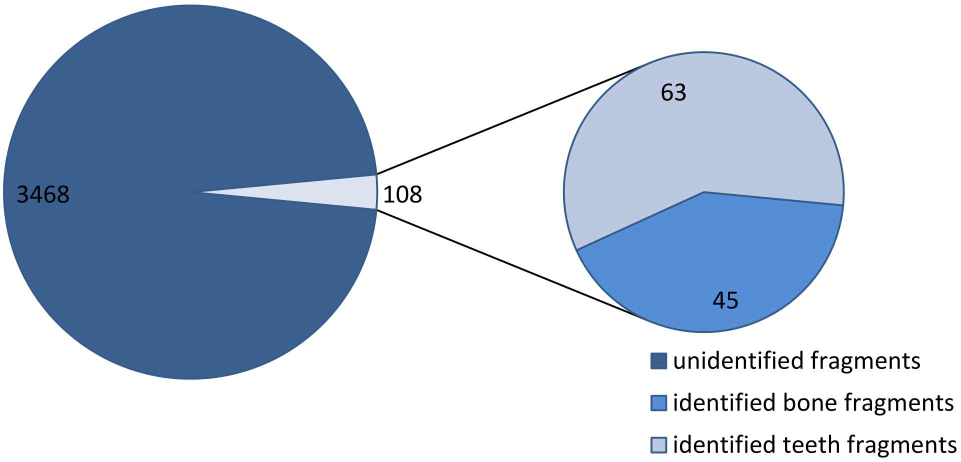

Figure 1: NISP (Number of Identified SPecimens) as proportion of total assemblage from domestic sites (MAB and MAC).

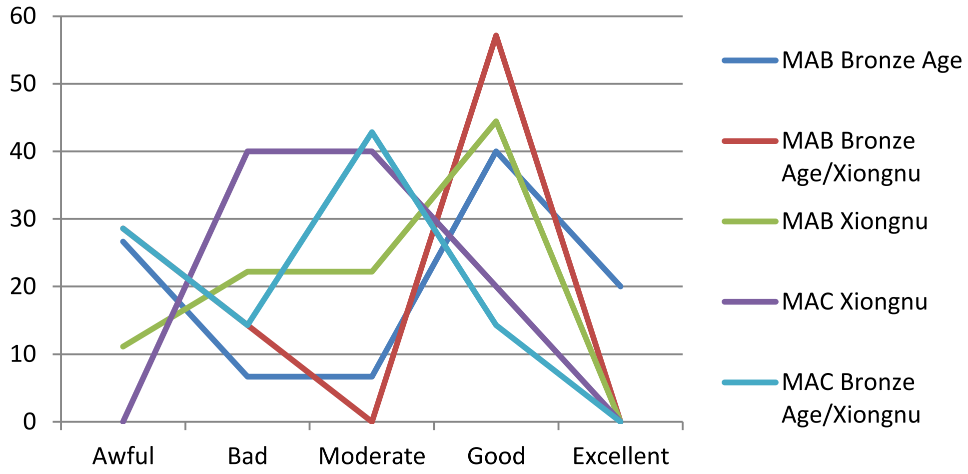

Figure 2: Preservation condition of countable elements from domestic sites, expressed as a percentage of the total recorded in the "bones" database for each site.

The NISP from the monumental sites (KYR1 and KYR 119) was much lower, despite coming from a much larger assemblage, representing just 9 fragments from a total of 5,302 (0.17%). These fragments were almost ubiquitously calcined (Figure 3), a pattern significantly different from that observed at the two domestic sites (Figure 4).

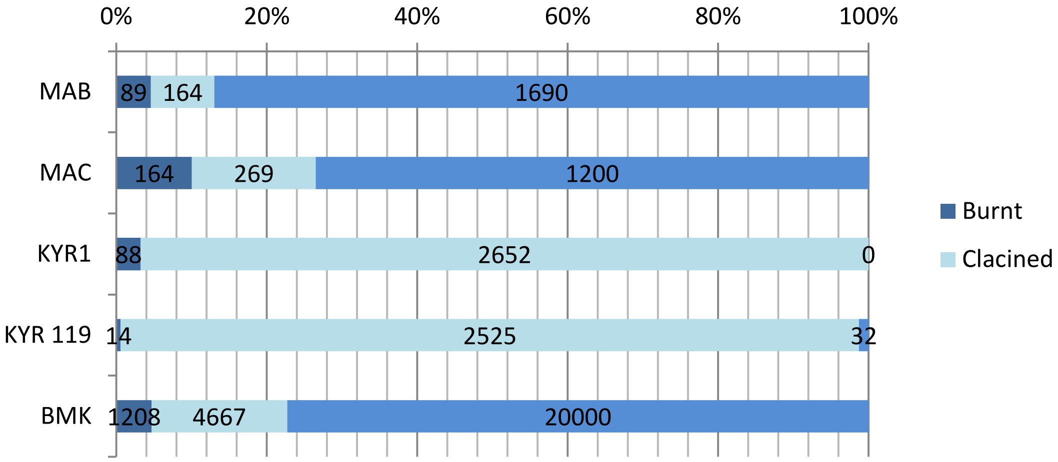

Figure 3: Ratios of burning (low intensity, "burnt" and high intensity, "calcined") for each site shown against ratios from the modern day winter campsite of BMK (BMK data from Broderick, 2011).

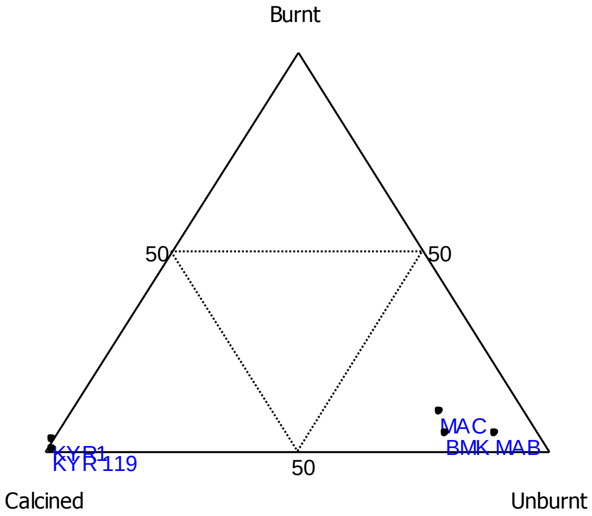

Figure 4: Tri-polar plot for percentages of burnt, calcined and unburnt fragments, including the modern day winter campsite of BMK (BMK data from Broderick, 2011).

In order to extract the largest dataset possible from the assemblage, and so increase the statistical validity of interpretations, as much effort was made as possible to obtain information from those fragments not countable under the protocol, but instead assigned to the 'fragments' section of the database (see Appendix 2: Recording Protocol). These fragments cannot be used for fine resolution analytical units such as MNI, since they may represent duplicates, but can be included in more coarse analysis, such as NISP. It was possible to speciate some of these 'non-countable' elements and by adding them to the 'countable' elements it is possible to increase the NISP figures for MAC and MAB to 6.29% of the assemblage (Figure 5). This represents a significant improvement over the base figure here and over previous zooarchaeological analyses in the region (Broderick, 2010; Makarewicz, 2006; Viner, 2009). It is these revised figures that will be used through the remainder of this report.

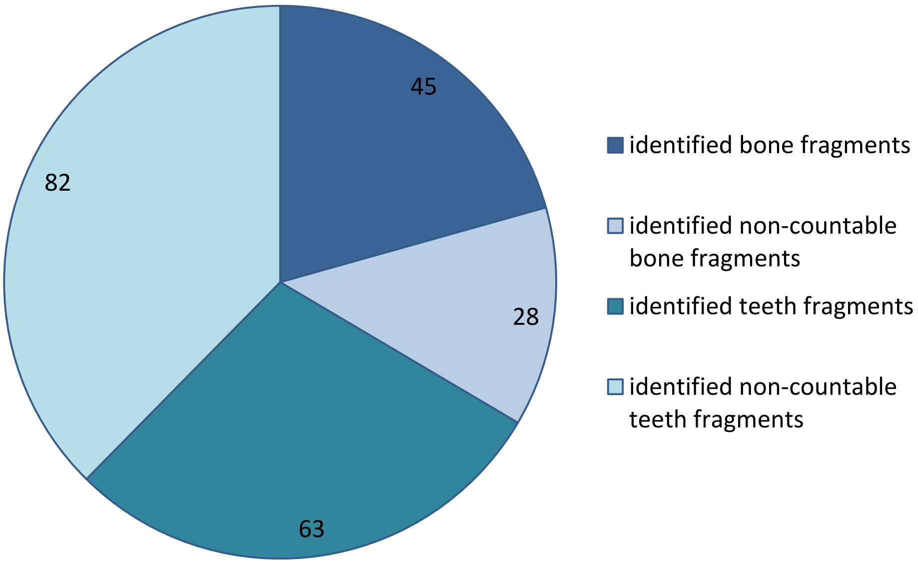

Figure 5: Revised NISP figures ('countable' plus 'non-countable' elements) for domestic sites (MAB and MAC).

The effect on the monumental sites (KYR1 and KYR 119) is less dramatic, increasing the NISP figure by just one individual (present at KYR 119).

3.1. Results from the domestic sites (MAB and MAC)

All contexts at MAB and MAC were routinely sieved using 6mm gauze. MNI figures for all grouped assemblages are so low as to be meaningless, never exceeding 2 for any given species on any particular site in one period, and are not used in this report. They are, however, included for reference in the appendices (Appendix 3: MNI Figures).

3.1.1 The Bronze Age Assemblage

The specimens identified from the Bronze Age layers at MAB (in the present day summer campsite zone (Houle et al., 2008)) provide a total NISP of 53 (Figure 6), 0.27 of the total NISP (Figure 5). This figure can be neatly divided into small, medium and large mammals, birds and fish (Figure 6**Error! Reference source not found.**) in which the medium and large sized mammals are represented by domesticated, or relatives of domesticated, species and the small mammals are represented by wild species – with the exception of *Capreolus pygargus* (Siberian roe deer) as a wild medium mammal. The domestic mammals account for 0.83 of the total Bronze Age assemblage from MAB. The Bronze Age assemblage for MAC (in the present day winter campsite zone (Houle et al., 2008)) consisted of a single specimen of *Bos sp*.

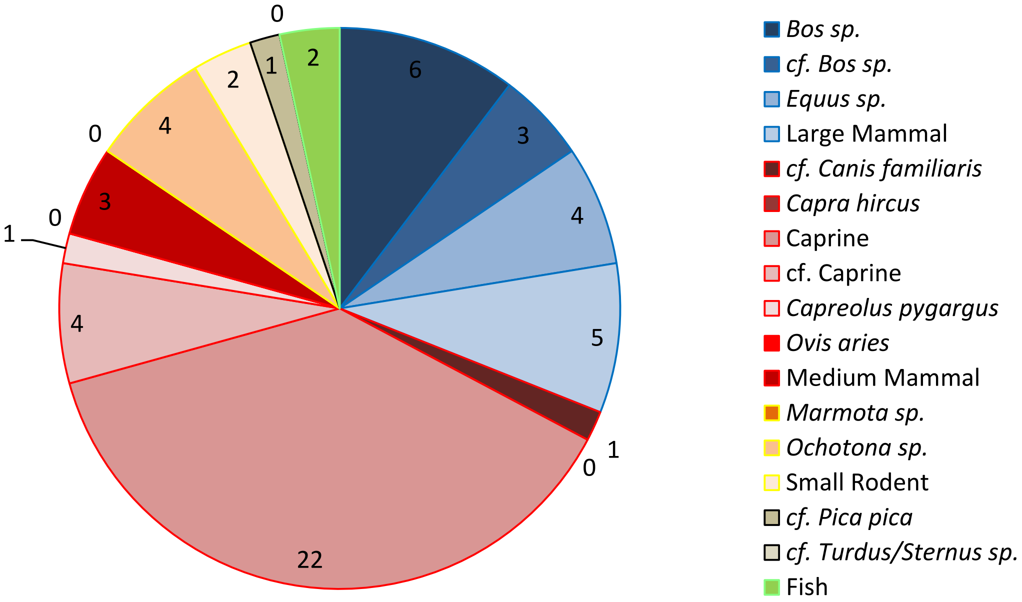

Figure 6: Species representation, by NISP, for Bronze Age layers from MAB.

Of the eighteen large mammal specimens identified in the assemblage from the present day summer campsite area, six were *Bos* sp. and a further three were cf. *Bos* sp., four were *Equus* sp, (Figure 6). It was not possible to speciate a further five specimens, which were recorded simply as "Large Mammal". These unspeciated bones came from a single deposit of 5 ribs in MAB12 (A2), which were noted as having been broken when fresh. It was also noted that they were associated with a *Bos* sp. tooth, at the time of excavation. A *Bos* sp. humerus, from MAB12 (B2) was broken into three pieces and had an FFI of one. It was also possible to record an FFI for two further specimens of *Bos* sp.: a metatarsal from MAB11 (B2) (FFI = 3) and a cf. *Bos* sp. metapodial also from MAB11 (A3) (FFI = 6).

A cf. *Bos* sp. 2nd phalanx was recorded from MAB15 (A3) which, though heavily abraded, showed signs of a burden/traction related pathology (lipping). *Equus* sp. remains comprised only teeth, of which it was not possible to determine any ageing information It was possible to record a wear stage of 'g' from a *Bos* sp. M1/M2 – the same tooth mentioned above as being found in association with the ribs – representing an age at death of 2-5 years.

Of the 30 specimens identified as medium mammals in the assemblage, 22 were caprines and a further 4 were cf. caprine (Figure 6). In addition to three further specimen identified as non-specific "Medium Mammals" (one of which had a helical fracture observed), a 1st phalanx from MAB12 (B3) was recognised as being *Capreolus pygargus* (Siberian roe deer). cf. *Canis familiaris* (dog) was also identified from MAB14 (A1), where a highly worn maxillary first molar was recovered.

A second molar, of a caprine, was recovered from MAB11 (B2) which was at wear stage 9A, which would translate to an age at death of 2-7 years. A caprine humerus was recovered from MAB15 (C3) which showed an FFI of 3 and exhibited signs of carnivore gnawing. Three caprine astragali of sufficient preservation to permit biometric analysis were recovered from MAB15 (C2), MAB12 (C2) and MAB11 (B2) respectively; these are plotted in Figure 7.

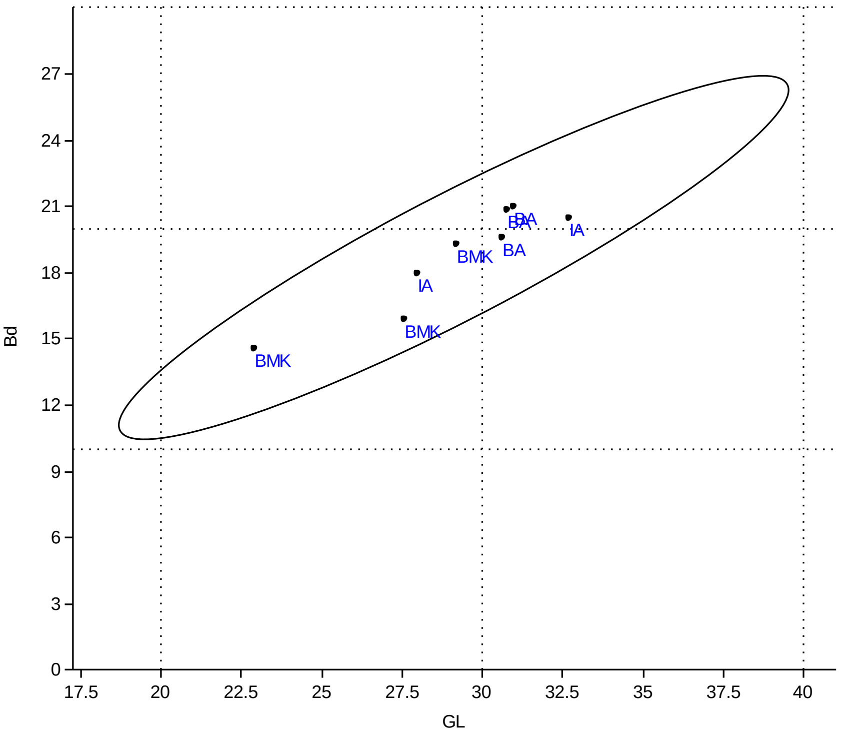

Figure 7: Caprine astragali plots of greatest breadth at distal end (Bd) against greatest lateral length (GL) from Bronze Age (BA), Xiongnu (IA) and modern (BMK) samples from the Khanuy valley, circle drawn at 1 SD (BMK data from Broderick, 2011).

Of the wild resources recovered, one of the fish bones (a vertebra from MAB11 (B3)) was later identified to the family *Salmonidae* (salmonid) with the aid of a laboratory reference collection and photographs. The single bird specimen, cf. *Pica pica* (magpie), was a phalanx recovered from MAB15 (B1) which had clearly been burnt. Among the small mammal remains, a cranium and right mandible of *Ochotona* sp, (pika) were recovered from MAB12 (B1) and a right mandible of a small rodent from MAB12 (C3) which were intact, so permitting measurements of the tooth row; these were 8.1, 7.7 and 4.7mm, respectively.

Of the unidentified specimens recovered from this period, a helical fracture was observed on a further specimen and two possible worked bones were recovered from MAB13 (B2).

3.1.2 The Bronze Age/Xiongnu assemblage

The specimens identified from the mixed Bronze Age/Xiongnu layers at MAB provide a total NISP of 26 (Figure 8), 0.12 of the total NISP (Figure 5). This figure can be neatly divided into small, medium and large mammals, (Figure 8) in which the medium and large sized mammals are represented by domesticated, or relatives of domesticated, species and the small mammals are represented by wild species. The domestic mammals account for 0.77 of the total Bronze Age assemblage from MAB.

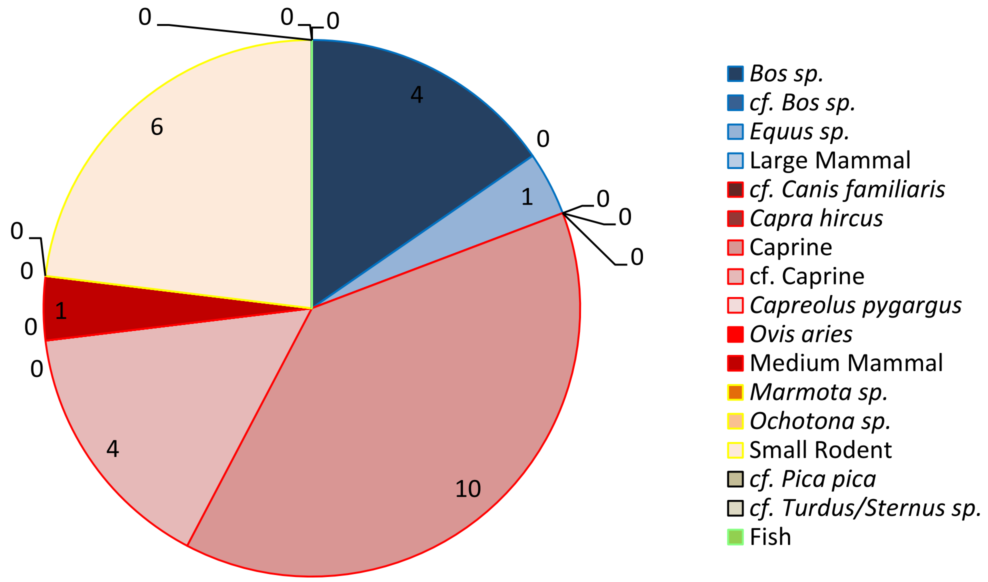

Figure 8: Species representation, by NISP, for Bronze Age/Xiongnu layers from MAB.

The specimens identified from the mixed Bronze Age/Xiongnu layers at MAC provide a total NISP of 9 (Figure 9), 0.04 of the total NISP (Figure 5). This figure consists of medium and large mammals, all of which are domesticated, or relatives of domesticated, species (Figure 9).

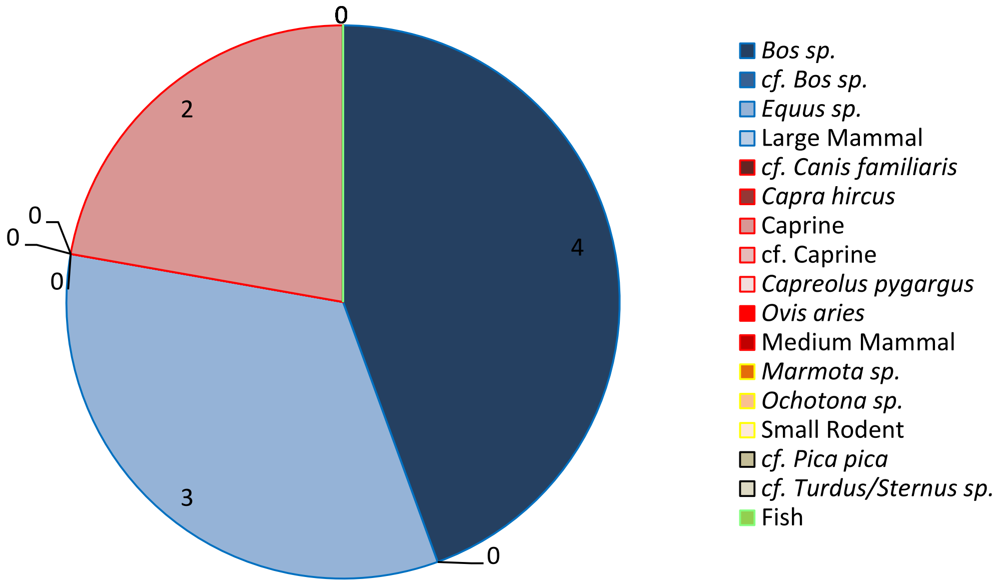

Figure 9: Species representation, by NISP, for Bronze Age/Xiongnu layers from MAC.

Large mammals in the Bronze Age/Xiongnu assemblage from MAB were *Bos* sp. (n=4) and *Equus* sp. (n=1). Of 15 medium mammal specimens recorded in the assemblage, 10 were caprine and a further 4 were cf. caprine (Figure 8). It was possible to record a wear stage for a caprine dp4 from MAB13 (B3) (23L) and a caprine M2 from MAB13 (A3) (9A). This would translate to ages at death of approximately 13-30 months and 2-7 years, respectively. An unfused distal cf. caprine metapodial was recorded from MAB13 (B3), whilst FFI values of 5 and 3 were recorded for a cf. caprine tibia (MAB12 (A1)) and a caprine proximal metacarpal (MAB15 (B3)) respectively. In addition to the identified specimens, seven unidentifiable specimens from this period at MAB were noted as having helical fractures (three from MAB13 (B3), one from MAB13 (C1), two from MAB14 (B2) and one from MAB11 (A1).

6 small rodent remains were also recorded in the Bronze Age/Xiongnu assemblage from MAB (Figure 8) including a cranium and right mandible from MAB13 (C4) and MAB13 (B3) which were intact, so permitting measurements of the tooth row; these were 6.3 and 7.7 and respectively.

Large mammals accounted for the greater part of the Bronze Age/Xiongnu assemblage from MAC, where *Bos* sp., *Equus* sp. and caprines were all noted as present (Figure 9). An *Equus* sp. M3 was found at MAC10 (B2) with calculus and an *Equus* sp radius was recovered from MAC12 (A3) with an FFI of 2, in addition to a chop mark. The caprine remains consisted of two tibias, one from MAC13 (B1) with an FFI of 5 and one from MAC12 (A3) with an FFI of 6. An additional helical fracture was noted on an unspeciated specimen from MAC13 (B1).

3.1.3 The Xiongnu assemblage

The specimens identified from the Xiongnu layers at MAB provide a total NISP of 48 (Figure 10), 0.22 of the total NISP (Figure 5). This figure can be neatly divided into small, medium and large mammals, and birds (Figure 10) in which the medium and large sized mammals are represented by domesticated, or relatives of domesticated, species and the small mammals and birds are represented by wild species. The domestic mammals account for 0.73 of the total Bronze Age assemblage from MAB.

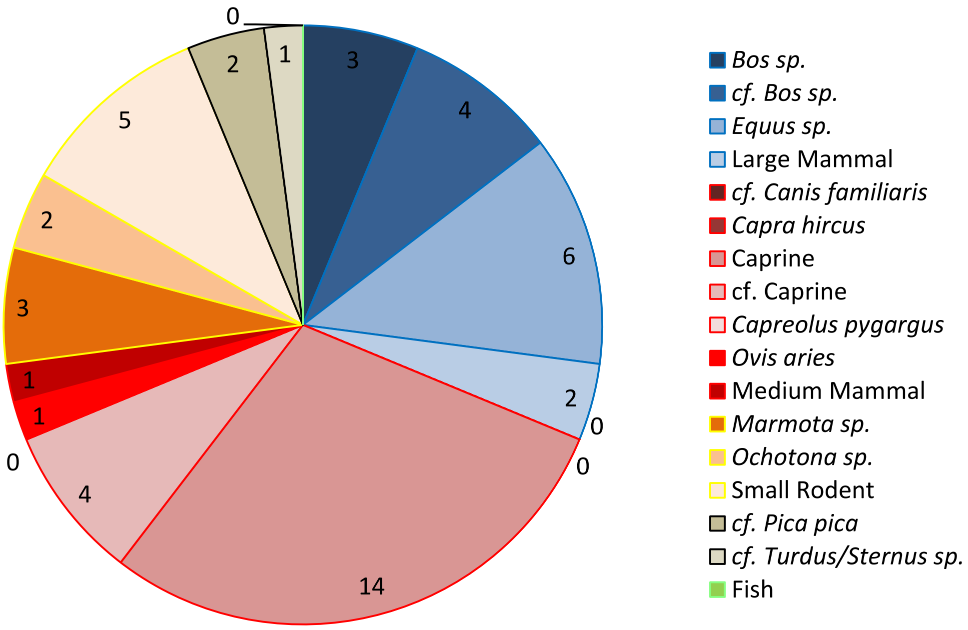

Figure 10: Species representation, by NISP, for Xiongnu layers from MAB.

The specimens identified from the Xiongnu layers at MAC provide a total NISP of 62 (Figure 11), 0.28 of the total NISP (Figure 5). This figure can be neatly divided into small, medium and large mammals (Figure 11) in which the medium and large sized mammals are represented by domesticated, or relatives of domesticated, species and the small mammals are represented by wild species. The domestic mammals account for 0.89 of the total Bronze Age assemblage from MAB.

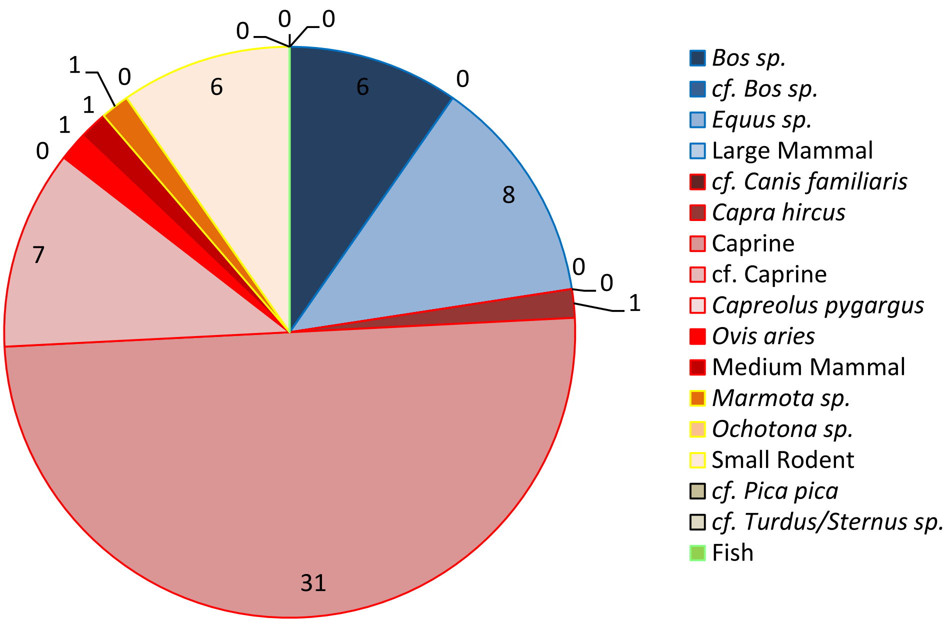

Figure 11: Species representation, by NISP, for Xiongnu layers from MAC.

Of the fifteen large mammal specimens identified in the assemblage from the present day summer campsite area, three were *Bos* sp. and a further four were cf. *Bos* sp., six were *Equus* sp, (Figure 10). It was not possible to speciate a further two specimens, which were recorded simply as "Large Mammal". These unspeciated bones were a humerus from MAB13 (B1) and a radius from MAB15 (A2), both of which were noted has having helical fractures.

Of the 10 specimens identified as medium mammals in the assemblage, 14 were caprines, a further 4 were cf. caprine and another was *Ovis aries* (Figure 10). This specimen was a maxillary M1 recovered from MAB15 (C3). Mandibular caprine teeth were recovered from MAB13 (C1) and MAB14 (B1), these were an M1/2 and an M2, both at wear stage 9A, giving ages at death of approximately 1-7 and 2-7 years, respectively. Two caprine astragali of sufficient preservation to permit biometric analysis were recovered from MAB15 (C3) and MAB11 (A2) respectively; these are plotted in Figure 7. A third caprine astragali was also recovered from MAB15 (B2) which showed signs of having been digested.

A rib from a medium mammal was recovered from MAB12 (A1) which showed signs of having been broken when fresh and also featured a cut mark. A further, unidentified, specimen from MAB11 (C1) also featured a cut mark and six other unidentified specimens from Xiongnu MAB showed signs of helical fracture.

A small rodent mandible of sufficient preservation to obtain a tooth row measurement was recovered from MAB13 (B2), this was recorded as 4.0mm.

Of the fourteen large mammal specimens identified in the assemblage from the present day winter campsite area, six were *Bos* sp. and eight were *Equus* sp, (Figure 11).

Of 42 specimens identified as medium mammals in the assemblage, 31 were caprines, a further 7 were cf. caprine and additionally both *Ovis aries* and *Capra hircus* were identified (Figure 11). These specimens were a maxillary M1 recovered from MAC10 (C1) and a right mandible from MAC13 C2, respectively. This latter specimen could assigned an age at death, on the basis of tooth wear and eruption, of 22-30 months. Four other caprine teeth of sufficient preservation to provide a wear stage were recovered:

- M_3, 11G (age at death >42 months), MAC11 (C3)
- M_2, 11A, (age at death 68-84 months) MAC12 (B1)
- P_4, U (age at death 22-30 months), MAC13 (B2)
- M_1, 12A (age at death 42-84 months), MAC13 (C2)

In addition to these cranial elements, a digested caprine cuboid was found at MAC10 (C3) and a distally fused caprine humerus with an FFI of 2 was found at MAC12 (A2). Another medium mammal specimen showing signs of helical fracture was found at MAC10 (C2) and two further unidentified specimens showing signs of helical fracture were also found.

A small rodent mandible of sufficient preservation to obtain a tooth row measurement was recovered from MAC10 (C3), this was recorded as 6.0mm.

3.1.4 The Assemblage from other contexts

A number of contexts contained mixed ceramic material, and so were not possible to date to any specific period. Most of these contain later, Chinese or Turkic, material, however and so it is likely that these contexts date from after the Xiongnu period.

Those identifiable specimens from MAB consisted of one large mammal, two caprines and one *Marmota* sp. (marmot), representing .02 of the total NISP (Figure 5). Those identifiable specimens from MAC consisted of one unspeciated large mammal, one *Bos* sp., three *Equus* sp. And three caprines, representing .04 of the total NISP (Figure 5).

The *Bos* sp. specimen was a mandibular P_4, from a Xiongnu/Chinese context located in MAC13 (A1) which had a wear stage of g, indicating an age at death of 41-50 months. Additionally, three unspeciated fragments from MAB were noted as showing signs of helical fracture, two of these were from Bronze Age/Xiongnu/Turkic contexts, and one from a Bronze Age/Turkic context.

3.2. Results from the monumental assemblage

Although NISP figures have already been given for the two monumental sites, the proportions of NISP v. total assemblage are not directly comparable between the two sites, due to different recovery strategies. KYR1 was routinely sieved using

3mm gauze, so minimising the risk of losing material, where as specimens were collected from KYR 119 by hand, without any sieving. Identifiable specimens are generally towards the larger of the recovered specimens from the sites, however, and the extremely fragmentary, calcined nature of both sites has, in any case, been demonstrated (Figure 3).

Three identifiable specimens were recovered from KYR1, all of them from stone circle 2. These were all calcined specimens identified to caprine and consisted of a fusing proximal metapodial (Figure 12), a distal metapodial and a 1st phalanx, (Figure 13).

Figure 12: Caprine metapodial, shown next to two month old Ovis aries (from the Khanuy Valley Project reference collection) (cm scale).

Figure 13: Caprine 1st phalanx, shown next to two month old Ovis aries (from the Khanuy Valley Project reference collection), proximal articulation on left, distal on right (cm scale).

Calcined caprine phalanges were also recorded among the material from KYR 119; a first phalanx from stone circle 3 and two second phalanges from both stone circle 2 and stone circle 4. Further to this, a medium mammal radius was recorded from stone mound 1, also calcined, making a total NISP of six for the site.

Among the unidentified specimens, a definite cut mark was observed on a specimen from KYR1 stone circle 1, with further possible cut marks observed on specimens from KYR 119 stone mound 1 and stone circle 2. An unfused diaphysis, of unknown element or species, was also recorded from KYR1 stone circle 2.

4. Interpretation

Several burrowing species were identified within the assemblage. The firm identification of burrowing species in archaeological assemblages is fraught with difficulty, for obvious reasons. The potential for intrusion of these species is great and they also often have a severe impact upon the artefactual and stratigraphic record (Dunwell and Trout, 1999).

To be consistent, these animals have to all either be included or discounted in the analysis, since the reasons for discounting them should apply to all. Given that the soil in the Khanuy valley is highly compact (Broderick, personal observation) it is anticipated that any burrowing action and resulting bioturbation should be clearly visible and noted during excavation, furthermore, it is likely to result in mixed contexts. Given that no evidence for bioturbation was attached to the context information, and that the contexts analysed here have been dated on the basis of their ceramic artefact typology, burrowing species have been included in the interpretation.

As shall be discussed below, some at least, have been demonstrated to be in the zooarchaeological record through human agency, whilst others have clearly argued cases for close habitation with humans in the context of the environment. Thus, although some may be intrusive, it is assumed that most are not.

4.1 Ecology and Environment

The wild mammals recognised in this report were identified to the genus *Ochotona,* to *Marmota* sp., as small rodents or as *Capreolus pygargus*. Of the birds, *Pica pica* was firmly identified and a further specimen was identified more loosely as a passerine, most probably a small member of the genera *Turdus/Sturnus* (thrushes and starlings). Of other vertebrates, a fish of the family *Salmonidae* was recognised.

Of those small mammals identified only as small rodent, those providing tooth row measurements from Xiongnu MAC and Bronze Age/Xiongnu MAB are most likely to be *Tamias sibiricus* (Siberian chipmunk). These are the smallest sciurids occurring in the general region today, with the Khanuy valley being just south of their present known distribution, and preferring a wooded habitat (Batsaikhan et al., 2010, 96-97). A find of similar size, 5.8mm, from the modern day winter campsite of BMK (Broderick, 2011) would seem to indicate that its modern range does extend this far however, probably restricted to the patches of woodland occurring in the hills. 5.8mm (mandibular) corresponds to the lowest value recorded by Allen for this species in Mongolia, while the other measurements are medians (Allen, 1940, 691). The presence of *Tamias sibiricus* at MAC would fit with this model of distribution, but its inclusion in the assemblage from MAB is a little more difficult to explain. Palynological studies from the recent past in Mongolia are still rare, but work in the nearby Khangai mountains indicates that there may have been a period of deforestation, perhaps related to increased aridity, around 1700-1500BP (Tarasov et al., 2004). If true, this data may be complementary in explaining the range shift of *Tamias sibiricus* on a local scale.

Other tooth row measurements taken from small rodents in the assemblage can be fairly confidently assigned to the *Sciuridae*, on the basis of their dental formulae, and yet their measurements are much smaller even than *Tamias sibiricus*, the smallest sciurid present in the region today. At present this data is unsatisfactory, belying interpretation and perhaps demanding a second examination of the original material.

Ochotona are a genus of primitive lagomorphs supremely adapted to wide open environments, owing to the situation of their eye sockets, which enables them to perceive threats from above, such as raptors, more easily than many other small vertebrates (Allen, 1938, 524). There are thought to be thirty different species of *Ochotona* extant in the world today (Chapman and Flux, 2008, 2), two of which are known to inhabit the general region of the Arkhangai province in Mongolia - *Ochotona dauurica* and *Ochotona alpina* (daurian pika and alpine pika) (Batsaikhan et al., 2010, 74-77). Tooth row measurements obtained from specimens from MAB of 8.1mm (maxillary) and 7.7mm (mandibular) both fall within the range for specimens of *Ochotona dauurica* from Mongolia published by Allen (1938, 552) and considerably below the standard for *Ochotona alpina* (Allen, 1938, 532). Accordingly, it is assumed that all those specimens identified in this report belong to the species *Ochotona dauurica*.

The presence of *Ochotonidae* in Asian ecosystems is crucial to their well-being, as they often form the base of animal food chains, being highly fecund small to medium sized herbivores (Smith et al., 1990, 15), and engineer their environment to their own benefit and, inadvertently, to the benefit of other species. Populations of *Ochotona dauurica* can fluctuate wildly, with up to 90% mortality per year, due to the effects of predation, disease and food availability, in years where populations are high, they may account for up to 60% of the diet of some of the larger raptors (Smith et al., 1990, 14-16). It is the preferred prey of *Otocolobus manul* (Pallas's cat) (Ross et al., 2010) and may also make up a significant proportion of the diet of *Mustela eversmanni* (steppe polecat), which is known to be present in the Akhangai province (Batsaikhan et al., 2010, 233), although this relationship is poorly researched (Smith et al., 1990, 16).

Ochotona dauurica usually inhabits damp, low lying regions of the steppe which are subject to periodic flooding (Smith et al., 1990, 29). The species lives in pairs, but in overlapping territories; communal burrows may cover up to 35m^2, whilst population densities of up to 300 per hectare have been recorded (Smith et al., 1990, 29-30). *Ochotona* generally have a high body temperature which enables them to survive extreme cold environments, but renders them weak in hot environments (Yang, 1990).

The architecture of *Ochotona dauurica* (haystacks and burrows) may also support a number of other herbivores, including other lagomorphs as well as rodents and birds, in particular *Oenanthe isabellina* and *Pyrgilauda davidiana* (isabelline wheatear and Père David's snow finch) are both known to nest in *Ochotona dauurica* burrows (Smith et al., 1990, 16). The burrow systems also serve to increase biomass and prolong growth seasons for plants in the immediate vicinity, as *Ochotona dauurica* loosens and improves soil (Smith et al., 1990, 16-17, 29-30).

There are 14 species of *Marmota* sp. extant in the world today (Barash, 1989, 5), of which one is known to inhabit the general area of the Arkhangai province today – *Marmota sibirica* (Siberian marmot) (Batsaikhan et al., 2010, 82-83). This is the only species to occur widely in Mongolia today and the assumption is made here that those remains identified to *Marmota* sp. are *Marmota sibirica*. Like *Ochotona daurica*, *Marmota sibirica* is known to be a keystone species (Murdoch et al., 2009, 431), assisting in soil renewal, influencing plant communities and having several other animals make use of their architecture, including *Vulpes corsac* (corsac fox) (Murdoch et al., 2009).

Marmota sp. are adapted to periglacial conditions, hibernating during extreme cold spells and droughts (Barash, 1989, 8), they shun woodland and instead prefer grassland environments (Barash, 1989, 12).

Pica pica is widely distributed in the old world and is often associated with man, scavenging off rubbish and other food (Mullarney et al., 1999, 330). They can gather in large flocks of up to 25 individuals (Mullarney et al., 1999, 30) and such large flocks have been observed in the Khanuy Valley today (Broderick, 2011).

Salmonidae are a family of pelagic and freshwater fish, 11 species of which are native or endemic to Mongolia (Froese and Pauly, 2010). Of these, four are known to exist in the Selenge drainage system:

- *Brachymystax lenok* (lenok)
- *Thymallus arcticus* baicalensis (arctic grayling)
- *Coregonus migratorius* (omul)
- *Hucho taimen* (taiman)

Of the domestic species identified, *Ovis aries* is also a species which prefers open pasture (Squires, 1975; Harris and Yalden, 2008, 625). A wide variety of breeds have been developed since its original domestication, some of which can survive extremes of temperature (Squires, 1975). *Capra hircus* prefers dry ground and is a species descended from one common in Central Asia (Harris and Yalden, 2008, 630).

Equus is almost exclusively a grazing genus, and neither *Equus Caballus* nor *Equus Prezwalski* make use of browse, instead, their diet is dominated by grasses and sedges, which they can access even through snow (Salter and Hudson, 1979; Harris and Yalden, 2008, 558). As such, they are well adapted to extreme cold temperatures but can also survive in hot climates provided that there is enough forage and water (Salter and Hudson, 1979).

Of the non-domestic larger mammals, Capreolus *pygargus* prefers a forest habitat (Batsaikhan et al*.,* 2010).

4.2 Economy and Human Interaction

Owing to their small size, *Ochotona* are rarely utilised directly in any human economies, however, large numbers of *Ochotona* were caught in Russia up until the mid-twentieth century for their fur, which was used to make felt (Smith et al., 1990, 17, 29).

Ochotona dauurica, in common with other *Ochotona*, makes haystacks for subsistence during the winter, these can be as large as 5kg per animal, and are used by larger herbivores in winter, when the tops of the haystacks may still be visible above the snow (Smith et al., 1990, 16). It has been observed that some Mongolian herdsmen preferentially graze their livestock near large populations of *Ochotona dauurica* for this reason (Loukashkin (1940) in Smith et al., 1990, 16).

In China (and, briefly, in Russia), *Ochotona dauurica* has been seen as a pest due to perceived competition for grazing with domestic livestock, although it has been suggested that any competition for grazing may only be a reality when grasslands are already overgrazed by domestic livestock and that population control of the species may be best achieved through lowering stocking densities of livestock (Smith et al., 1990, 17-18, 29-30). Recent work pertaining specifically to *Ochotona dauuria* in Mongolia, however, has suggested a negative correlation between populations and livestock overgrazing (M. Komonen et al., 2003). The use of their haystacks for domestic livestock, as suggested above, would very likely have a similar negative impact on their population (removal of haystacks causes population decline over winter (Zhong et al., 2008)).

Marmota sibirica is present in the Xiongnu and later assemblages at MAB (Figure 10), while one specimen is present in the Xiongnu assemblage from MAC (Figure 11). Cutmarks on a *Marmota* sp. tibia from Xiongnu phase MAB, found in previous phases of excavation (Broderick, 2010) clearly demonstrate its utilisation by human populations. Today, Marmota sibirica is hunted in the summer months, for its meat and for its fur (Broderick, 2011). Taken together these two facts may imply a similar use of *Marmota sibirica* as a seasonal resource in the Xiongnu period.

Marmota sibirica is also known to commonly harbour fleas carrying the plague virus *Yersinia pestis* (Biggins and Kosoy, 2001, 909), a zoonotic disease commonly fatal to humans (Krauss et al., 2001, 218). Indeed, spread of this disease from Mongolia has sometimes been blamed for the Black Death in Mediaeval Europe (e.g. Slack, 1989). The potential presence of this disease, together with the potential for small to medium carnivores which could attack young livestock, probably argues for habitation sites occurring some distance from *Marmota sibirica* colonies.

The simplest explanation for the presence of fish on an archaeological site is always human agency, and there is nothing here which would suggest otherwise. Fish is today a taboo food in Mongolia and it is not known when this first developed, with some attributing it to Buddhism (Blunden, 2008, 208) although a link to shamanic beliefs has also been suggested (Broderick, 2011). The evidence here would suggest that the taboo was not enforced in the Bronze Age Khanuy Valley. *Thymallus arcticus baicalensis* can grow up to 35cm long (Kottelat, 2006), *Coregonus migratorius* can grow up to 56cm in length and is today an important food source around Lake Baikal (Dulmaa, 1999). *Brachymystax lenok* can grow up to 70cm long and is today an important game fish (Dulmaa, 1999) and *Hucho taimen* can reach 200cm in length and is today probably the most important sport fish for Mongolian tourism (Dulmaa, 1999; Blunden, 2008, 210).

Of the birds found on the site, although they might conceivably have been deliberately caught, for consumption or other reasons, it is considered more likely that they entered the assemblage through accidental inclusion. Although a carbonised phalanx, such as that of *Pica pica* found at Bronze Age MAB, is often associated with cooking, *Pica pica* is particularly associated with sites of human habitation (Mullarney et al., 1999, 330) and modern day site maintenance practices present serious issues of equifinality for the zooarchaeologist. These practices involve the burning of all fallen livestock and refuse (Broderick, 2011) and it should be noted that the ratios of burning in the archaeological assemblages from domestic sites is comparable with that from modern day campsites (Figure 4).

When discussing ratios of burning at the sites, it should be noted that there is a higher proportion at MAC than at MAB (Figure 3) and that MAC is more similar to the modern day winter campsite assemblage than MAB (Figure 4). Since burnt bone will survive longer than unburnt, when undisturbed, it may be anticipated that this proportion would increase with time, moving it still closer to MAC and further from MAB. It has already been stated that MAC is located in the present day winter campsite zone and MAB in the summer – this evidence points to further support for a similar pattern of occupation in the past.

Bos sp. was present at MAB and MAC in all periods except post Xiongnu MAB. It was also the most numerous large mammal, by NISP, on both domestic sites in the Bronze Age, but falls behind *Equus* sp. in the subsequent phases. In many ways, this is contrary to what might have been expected, since *Bos* sp. has been a very rare find in Bronze Age Mongolian assemblages before now, which had led to the belief that it may be a new, exotic animal in this period (Houle, 2010). In the Khanuy valley today, *Bos* sp. are slaughtered in small numbers when first moving to the winter campsite; at this point the animals are in peak physical condition after the summer grazing and so slaughtering then maximises the meat yield (Broderick, 2011)). The meat can then be preserved for storage throughout the ensuing winter. Slaughtering the animals after arrival at the winter campsite, rather than before leaving the summer campsite can probably be explained by a variation of the Schlepp effect – in essence it's much more energy efficient to make the animal carry its own meat to the winter campsite.

The origins and nature of *Bos* sp. in Mongolia are still poorly understood, two species are present in the Khanuy Valley today – *Bos grunniens* and *Bos Taurus* – but no method has yet been devised for distinguishing between their skeletal remains. The presence of a possible traction related pathology on a *Bos* sp. phalanx at Bronze Age MAB is of real interest, since it would indicate a domestic type. Such pathologies are generally associated with ploughing (eg. Groot, 2005; Isaakidou, 2006; Telldahl, 2005), but that seems unlikely given the context. Today the only use of *Bos* sp. for traction in the Khanuy Valley is to pull carts for the transporting of goods, and when a family moves campsite (Broderick, 2011). Although the pathological effects of such activity might be presumed to be less than for ploughing, a *Bos* sp. first phalanx with a similar pathology was also identified at the modern day campsite of BMK (Broderick, 2011).

Fracture patterns of the *Bos* sp. remains at Bonze Age MAB would also indicate that they were being utilised for marrow extraction at that time, a practice still common in the area today (Broderick, 2011; Houle, 2010). The absence of fracture (excepting two generic large mammal specimens) and butchery data for *Bos* sp. from MAC may be an artefact of the generally harsher taphonomy present on the site (Figure 2).

Equus sp. was present in all phases at both domestic sites, except for Bronze Age MAC and post-Xiongnu MAB, in the Xiongnu period it was the most numerous large mammal, by NISP, and the second most numerous animal overall (Figure 10; Figure 11). The M3 recovered from Bronze Age/Xiongnu MAC would indicate that the animal was at least two years of age at death (Levine, 1982). This tooth also had a build-up of calculus, which forms in adulthood (Waldron, 2009, 240) and begins to form in the front teeth of *Equus* sp. before the rear teeth (Hillson, 1986, 302), it therefore seems likely that the horse in question was much older than two years. In the Khanuy valley today, horses are slaughtered at 2-3 years of age for their meat (Broderick, 2011), elsewhere in Mongolia, the Khalkha also slaughter their horses for meat at this age (Levine, 1990, 730), this represents a recent development however, following a culturally acquired preference for more tender meat, and traditionally horses would have been slaughtered for meat by the Khalkha at 14-15 years of age, following the end of their useful (working or breeding) lives (Levine, 1990, 730-731). Either interpretation would seem acceptable based on this information. From the same site and period, evidence for butchery and marrow extraction of *Equus* sp. was recorded, compatible with the modern day large mammal exploitation strategy practised in the area described above.

Caprines were the largest part of the assemblage overall. Both *Ovis aries* and *Capra hircus* have been demonstrated to be present in the Khanuy Valley by at least the Xiongnu period (Figure 10; Figure 11). Today, *Capra hircus* is a valuable resource, due to the high price fetched for its fleece, while *Ovis aries* is primarily kept for its meat (Broderick, 2011), this is most likely a recent development however, and the presence of both species is probably better read as a risk minimising strategy to cope with an ever changing environment.

Caprines are most commonly slaughtered at the summer campsites in the Khanuy Valley today (Broderick, 2011), and it’s important to note that their presence at MAC does not necessarily contradict this pattern. It is sometimes easy to confuse a dead animal with a slaughtered animal in zooarchaeological reports, but the two are not the same thing. Caprines are today housed over winter in the Khanuy Valley, but there will inevitably be casualties every year. Fallen stock is usually burned on the edge of the site as soon as weather conditions allow (Broderick, 2011). It’s interesting to note in this context that the only recorded butchery of caprines occurred at MAB.

Similarly, it’s interesting to note that the Xiongnu assemblage from MAB had by far the greatest number of fresh bone breaks, generally associated with marrow extraction. It seems likely that MAC was only occupied during the Xiongnu period, a phenomenon that may have been associated with population pressure brought about through climatic deterioration (Houle, 2010). This theory is given greater credibility given the environmental data outlined above, and the increased evidence of marrow processing in this period at MAC may be related to the same phenomenon.

Where age at death estimates were available for caprines, they all broadly indicated the slaughter of adult animals on the domestic sites. The greater survivability of adult, as against juvenile, caprine bones should caution against the elevation of this interpretation however, particularly in light of the small NISP and the high degree of fragmentation. For the same reasons, it has not been possible to discern any clear pattern of element distribution within the assemblage for any species. The biometric data would appear to suggest that caprines kept in the Khanuy Valley today are of the same size as those kept in the past, and therefore of the same genetic stock, without any ‘improvement’. It’s worth noting, however, that an increased sample size may yet point to the present population being smaller than those in the past. Since this data came from astragali, their role in games in Mongolia today, and elsewhere in the past (Dandoy, 2006), is perhaps also pertinent to cultural discussions.

The presence of *Canis familiaris* has been recorded at Bronze Age MAB. This is significant, since although carnivore gnawing had been detected previously (Broderick, 2010), this is the first time that *Canis familiaris* has been found in an archaeological context in the region. Although hard to conclusively differentiate from Canis lupus (wolf), the high state of wear on the tooth, combined with signs of carnivore gnawing on a caprine humerus from the same site, would argue in favour of the former. Digested bones in the Xiongnu phase of both domestic sites would suggest the species' continuing presence in this period. Today, *Canis familiaris* is often a tolerated guard rather than a pet or hunting or herding companion (Broderick, 2011). That some hunting occurred alongside herding in the Bronze Age period can be demonstrated by the presence of *Capreolus pygargus* in the assemblage.

The high frequency of carbonized and calcined bones in the assemblage raises difficult questions for interpretation, owing to issues of equifinality. Previous analysis of this type of remain in the Khanuy valley has been interpreted as evidence of use of animal bone for fuel (Viner, 2009), however, animal bones are also burnt as means of disposing of domestic refuse, and of disposing of fallen livestock in the Khanuy valley today (Broderick, 2011). Any of these interpretations are compatible with the data, although the near ubiquity of the material probably argues in favour of some kind of combination.

4.3 Unusual activities: The interpretation of the assemblages from the monumental sites

The identification of caprines, and only caprines, among the assemblage from the monumental sites is of some worth, since although it has been known for some time that the stone circles surrounding khirigsuurs contained the cremated remains of mammals, the precise species had not previously been determined (Allard and Erdenebaatar, 2005)

Burnt bone can shrink in size by up to 20% (Shipman et al., 1984) and so although the bones recovered are roughly the same size as a 2 month old caprine held in the reference collection this does not mean that the animal remains deposited at Stone Circle 2, KYR1 were the same size in life. It was possible to reassemble a 1st phalanx from this deposit, and from other deposits in the monumental assemblage, all of which were fused. Fusion of the epiphysis to the diaphysis occurs in the first phalanx by around 12 months of age (except in the case of castrates) and, depending on which author you read, may begin as young as six months (Moran and O'Connor, 1994). The presence of an unfused diaphysis of an unknown element in the stone circle 2, KYR1 context, however, clearly indicates that the individual deposited there was a juvenile and so it seems most likely, based on this, the fused first phalanx and the size of the recovered bones, that the individual was less than a year old.

Due to the effects of shrinkage, noted above, it is widely assumed that traces of butchery are obliterated by the effects of burning on bones. In fact, however, cut marks remain largely unaffected by burning (Herrmann and Bennett, 1999; Pope and O. C. Smith, 2004) and one was clearly visible on a fragment recovered from stone circle 1, KYR1. Two further possible cut marks were observed on material recovered from KYR 119.

All of the data considered here indicates that a young caprine was butchered and its remains were burned at a high heat, before being deposited in the various contexts described (mainly stone circles, but also a stone mound at KYR 119). This is of interest since rituals involving animal sacrifice in many parts of the world frequently concern their formalised slaughter and subsequent deposition (Lauwerier, 2004, 67; Luff, 1996, 2; Popkin, in press; Wait, 1985, 244).

As for the physical nature of the assemblage, there are parallels of highly calcined material with barely anything recognisable except phalanges from Northern Europe in early prehistory (Ingrem; Ukkonen; Amundsen; pers. com.).

5. Future Work

i. Faunal analysis in Mongolia is in its infancy, and further detailed excavation and analysis is needed of animal bone assemblages from domestic/habitation sites.
ii. Further work on assemblages from monumental sites, particularly stone circles, should be carried out in order to test the interpretations made here.
iii. Higher resolution butchery recording methods would complement the use of FFI for analysing dietary preferences and stress, particularly in light of observed modern day marrow extraction methods in the Khanuy valley (Broderick, 2011).
iv. The prevalence of caprines needs to be assessed in greater detail to determine whether their domination was a persistent feature of the Bronze Age/Xiongnu economy.
v. The appearance of domestic cattle in Mongolia is an issue deserving of further research. As yet the timing of the appearance of domestic types of *Bos sp.* is unclear, and whether domesticates were allochthonous or autochthonous needs to explored.
vi. Related to this, methods need to be developed to distinguish the skeletal remains of *Bos taurus* from *Bos grunniens*. These methods should be inexpensive if they are to be widely adopted.
vii. The appearance of *Canis familiaris* in Mongolia is an issue deserving of further research. The timing of the appearance of *Canis familiaris* is unclear.
viii. The origins and appearance of the taboo on eating fish are areas which should be questioned and could be informed by further research.
ix. Further microfaunal studies would complement our understanding of the development of the Holocene environment of the region as provided by macro-scale studies by providing a micro-scale indicator.
x. Given the fragmentary character of faunal assemblages in the study area, some benefit may be derived from the application of Protein Mass Spectrometry in order to

identify bone fragments to genus level, or from histological studies or DNA analysis to identify species.

6. Conclusion

An analysis of the preferred habitats of all of the species identified as present on the sites – wild and domestic – has shown that the Khanuy valley was most probably a grassland landscape, similar to that of today. The presence of several species able to withstand extremes of temperature, together with one with a preference for periodic flooding, suggests that the Xiongnu climate may also have been similar to that of today in the Khanuy valley, with melting snow creating annually marshy areas in the valley bottom. The presence of *Tamias sibiricus* at Xiongnu MAC, in conjunction with regional palynological data, indicate that there may have been more forest at that site in the past than today.

Interpretation of the assemblage is compatible with a pastoral economy similar to that of today. Wild resources were utilized in the form of *Marmota sibrica* and *Capreolus pygargus* for their meat and/or fur, whilst livestock may have been preferentially grazed near *Ochotona daaurica* colonies (another variation on the Schlepp effect may suggest that campsites were deliberately sited near these colonies for proximity of better grazing, hence their presence on the sites). The dominance of caprines and *Equus* sp. throughout the assemblage, suggests a herd structure similar to that of many pastoralists in the Khanuy valley today. The economic role and introduction of *Bos* sp. and *Canis familiaris*, in particular, are deserving of further research in this respect.

The assemblages from the monumental sites were made up exclusively of (probably juvenile) caprines, which had been butchered before being burnt at a high temperature and then deposited in the ground.

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Appendices

Appendix 1: Dictionary of animals referred to in the text

Binomial (Latin) name	English name	French name
Bos grunniens	yak	yak
Bos taurus	domestic cow	vache domestique
Brachymystax lenok	lenok	truite lenok
Canis familiaris	dog	chien
Capra hircus	domestic goat	chèvre domestique
Capra sibirica	Siberian ibex	ibex
Capra/Ovis	caprine	mouton ou chèvre
Capreolus pygargus	Siberian roe deer	chevreuil de Sibérie
Coregonus migratorius	Baikal omul	omoul
Equus caballus	domestic horse	cheval domestique
Equus ferus przewaslkii	Przewaslki's horse	cheval de Przewalski
Hucho taimen	taimen	taimen
Mammalia	large mammal	mammifère grand
Mammalia	medium mammal	mammifère de taille moyen
Marmota sibirica	Siberian marmot	marmotte de Sibérie
Mustela eversmanni	steppe polecat	putois des steppes
Ochotona alpina	alpine pika	pika de l'Altaï
Ochotona daaurica	Daurian pika	pika de Daourie
Oenanthe isabellina	isabelline wheatear	traquet isabelle
Otocolobus manul	Pallas's cat	chat de Pallas
Ovis aries	domestic sheep	mouton domesitque
Passeridae	songbird	oiseau chanteur
Pica pica	magpie	pie
Pyrgilauda davidiana	Père David's snow finch	niverolle de David
Rodentidae	small rodent	rongeur petit
Salmonidae	salmonid	salmonidé
Tamias sibiricus	Siberian chipmunk	tamia de Sibérie
Thymallus arcticus baicalensis	Arctic grayling	ombre arctique
Vulpes corsac	corsac fox	renard corsac

Appendix 2: Recording Protocol

This system is based on a modified version of that outlined by Davis (1992). A number of revisions have been made which reflect the specific research aims of the current project and that will efficiently explore its characteristics. The elements and zones listed below have been chosen based on a number of criteria including:

1) potential for identification to skeletal element and species by specialists of varying experience
2) survivability
3) potential for providing information on the age and/or sex of an animal
4) potential to provide useful measurements.

The system is based on three main database structures, one for teeth, one for bones recordable under the protocol (countable elements) and one for all other fragments (non-countable elements).

Non-countable elements (fragments) are those specimens which are not used for any high-resolution quantitative analysis and include identifiable but partial bones and all other elements or parts of elements which are not included in the list of regularly recorded teeth and bones (see below). As much information as possible is recorded for these specimens in the comments field including, where possible, attribution to species, genus, family (for fish and bird) or Large mammal (Cervus/Bos/Equus size), Medium mammal (Capreolus/Ovis/Sus size), Small mammal (Oryctolagus/Felis size) or Rodent.

Countable elements (bones and teeth) are recorded when at least 50% of the articulation or of the occlusal surface is present.

Amphibian bones are recorded when either end of the following bones is present: humerus, radioulna, femur and tibiofibula. The acetabulum is also recorded.

A Fracture Freshness Index is recorded for all countable elements, which follows the criteria laid out in Outram (2001; 2002).

For a description of how measurements are taken see Albarella and Davis (1996), Davis (1992) and von den Driesch (1976). The following measurements are taken:

TEETH

Equids: L_1, W_a and W_d (as in Davis 1987) (only teeth which can be positioned, i.e. we know which tooth it is) (W_d is only taken on molars)
Cattle: dP_4 W, dP^4 W, M^1W, M^2W, M^3W, M_1W, M_2W, M_3L and M_3W
Caprine: dP_4W, M_1W, M_2W, M_3L and M_3W
Pig: dP^4 (L,WP), M^1, M^2 & M^{12} (L, WA,WP), M^3 (L,WA,WC), dP_4 (L,WP), M_1, M_2 & M_{12} (L,WA,WP), M_3 (L,WA,WC, WP), H.
Carnivores: P_4, M_1 (L & W), P_1-M_3L (canids), P_3-M_1L(felids), P_2-M_3L (canids), P_1-P_4 L (canids), P_2-P_4L (canids), M_1-M_3L (canids), H.

BONES

Horncores and antlers: min and max diameter of the base, greatest length (only bovids)
Atlas: H, BFcr (only for pig)
Scapula: mammals SLC
Humerus: mammals = GLC, BT (ungulates), Bd (all other mammals), HTC, SD

birds = GL, SC, Bd
Radius: mammals = GL, SD (when GL is taken)
Metacarpal: cattle = GL, SD, BatF, Bd, a, b, 3, 6.
caprines = GL, SD, Bd, a, b, 1, 3, 4, 6.
pig = GL
cervids = GL, SD, Bd, 3.
horse = GL, SD, Bd, Dd
Pelvis: mammals = LAR (LA)
Femur: mammals = GL, SD (when GL is taken), DC
birds = GL, Lm, SC, Bd, Dd
Tibia: mammals = GL, Bd, Dd, SD (ant-post, when GL is taken)
birds = GL, La, SC, Bd, Dd.
Astragalus: bovids and cervids = GLl, GLm, Bd, Dl
pig = GLl, GLm
carnivores = GL
equids = GH, GB, BFd, LmT
Calcaneum: mammals = GL, GD
Metatarsal: cattle = GL, SD, BatF, Bd, a, b, 3, 6.
caprines= GL, SD, Bd, a, b, 1, 3, 4, 6.
cervids = GL, SD, Bd, 3, 6.
pig = GL
birds = GL, SC, Bd.
horse = GL, SD, Bd, Dd
Phalanx 1: equids = GL, Bp, Dp, SD, Bd, Dd.

Additional measurements may be taken, and are included in the “comments” field when recorded.

The sheep/goat distinction is attempted on the following elements:
horncore
dP_3, dP_4, M_1, M_2 & M_3
permanent lower molars
Humerus
Metacarpal
Tibia
Astragalus
Calcaneum
Metatarsal

The frog/toad distinction is attempted on the pelvis.

LIST OF FIELDS FOR THE THREE DATABASE STRUCTURES:

Teeth

ID = automatically generated specimen record number
SITE
YEAR = year of excavation
BOX = box number
CTX = context
CAT # = catalogue number
COL = type of collection
EL = maxilla or mandible
LJ=loose tooth or jaw
SIDE
TAX = taxon
I1
I2
I3
I (=I/C in ruminants)
dI1
dI2
dI3
dI/dC

C
dC
P1
P2
P2L_1
P2Wa
P2Wd
P3
P3L_1
P3Wa
P3Wd
P4
P4L (L_1 in equids)
P4Wa (W in carnivores)
P4Wd
P
dP2
dP3
dP4
dP4L
dP4W
M1
M1L (L_1 in equids) (C in cattle upper tooth)
M1WA (W in caprines and carnivores) (Wa in equids)
M1WP (Wd in equids)
M1hyp
M2
M2L (L_1 in equids) (C in cattle upper tooth)
M2WA (W in caprines) (Wa in equids)
M2WP (Wd in equids)
M2hyp
M3
M3L (L_1 in equids) (C in cattle upper tooth)
M3WA (W in bovids) (Wa in equids)
M3WC (Wd in equids)
M3hyp
M12
M12WA
M12WP
M12hyp
M
P/M
P1/M3 L (P3/M1 L in felids)
P2/M3 L
P1/P4 L
P2/P4 L
M1/M3 L
H

Comments

Bones
ID = automatically generated specimen record number
SITE
YEAR = year of excavation
BOX = box number
CTX = context
CAT # = catalogue number
COL = type of collection

PRES = preservation
EL = anatomical element
SIDE
TAX = taxon
FUSP = prox fusion
FUSD = dist fusion
FFI = Fractrure Freshness Index
BUTCH = butchery
BURN = burning
GNAW = gnawing
GL (=GLl in astrag.) (=GH in equid astragalus) (=GLC in humerus) (=H in atlas)
Bd (=GB in equid astragalus) (= BT in humerus) (=BFcr in atlas)
Dd (=Dl in astrag.) (=BFd in equid astragalus) (=3 in metapodials) (=DC in femur) (=GD in calcaneum)
HTC (=LmT in equid astragalus) (=GLm in astragalus) (=6 in metapodials)
LAR
SD (=SC in birds) (=SLC in scapula)
Lm (=La in tibiotarsus)
BatF
a
b
1
4
Comments

Fragments
ID = automatically generated specimen record number
SITE
YEAR = year of excavation
BOX = box number
CTX = context
CAT # = catalogue number
COL = type of collection
Ver L = large vertebra
Ver M = medium vertebra
Ver S = small vertebra
Rib L = large rib
Rib M = medium rib
Rib S = small rib
Comments = recording of all additional discernible information, including species and element

CODES
COL (=type of collection):
HC = hand collected
CS = from coarse sieving
FS>10 = from fine sieving (>10mm fraction)
FS>5 = from fine sieving (>5mm fraction)
FS<5 = from fine sieving (<5mm fraction)

PRES (=preservation)
A = awful
B = bad
M = medium
G = good
E = excellent

ELEM (=anatomical element):
U = unknown
X = maxilla
N = mandible
OC = occipital
ZY = zygomaticus
SU = supraorbital arch
AT = atlas
AX = axis
SC = scapula
CO = coracoid (prox end)
HU = humerus dist
OTHU = humerus prox
RA = radius dist
OTHRA = radius prox
UL = ulna
C3 = carpal 3 or 2+3 (=carpal 2+3 - i.e. capit-trapez.- in bovids and cervids; carpal 3, distal row - i.e. capit. - in equids, pig and carnivores)
MC1 = metacarpal (=carpometacarpus, prox end, in birds)
MC2 = 1/2 metacarpal
MCIII = third metacarpal (pigs/carnivores)
MCIV – fourth metacarpal (pigs/carnivores)
PE = pelvis (acetabulum, ischial part)
FE = femur dist
OTHFE = femur prox
PA = patella
TI = tibia dist (=tibiotarsus in birds)
OTHTI = tibia prox
FI = fibula (prox)
AS = astragalus
CA = calcaneum
SCU = scafocuboid (bovids & cervids) or scafoid (equids) or cuboid (pigs and carnivores)
MT1 = metatarsal (=tarsometatarsus in birds)
MT2 = 1/2 metatarsal
MTIII = third metatarsal (pigs/carnivores)
MTIV – fourth metatarsal (pigs/carnivores)
MP1 = metapodial
MP2 = 1/2 metapodial
P1 = phalanx 1
P2 = phalanx 2
P3 = phalanx 3
HC = horncore or antler
SH = Shell
OTH = all the others (specify element in comments)

L/J:
L=loose tooth
J=Jaw
A jaw is defined as a tooth having adjacent to it at least another half tooth/alveolus or an equivalent length of bone

Hypoplasia:
P=present (one line)
PP=present (two or more lines)

TAX (=taxon):
B = *Bos*
O = *Ovis/Capra*
OVA = *Ovis aries*
CAH = *Capra hircus*
S = *Sus*
CEE = *Cervus elaphus*
DAD = *Dama dama*
CAC = *Capreolus capreolus*
EQ = *Equus*
EQC = *Equus caballus*
EQA = *Equus asinus*
CAF = *Canis familiaris*
VUV = *Vulpes vulpes*
FEC = *Felis catus*
MUN = *Mustela nivalis*
MUP= *Mustela putorius*
MUE = *Mustela erminea*
MUX = *Mustela erminea/nivalis*
LE = *Lepus*
LEE = *Lepus europaeus*
ORC = *Oryctolagus cuniculus*
LAG = Lagomorphs
CAS = *Castor*
RA = *Rattus*
RAR = *Rattus rattus*
RAV = *Rattus/Arvicola*
APO = *Apodemus*
MUM = *Mus musculus*
SMU = Small *Murinae*
ART = *Arvivola terrestris*
CLG = *Clethrionomys glareolus*
SRO = Small rodent
LRO = Large rodent
ERE = *Erinacaeus europaeus*
TAL = *Talpa*
SOA = *Sorex araneus*
SMI = Small *Microtinae*
CD = *Cervus/Dama*
DC = *Dama/Capreolus*
CB = *Cervus/Bos*
CV = *Canis/Vulpes*
OCC = *Ovis/Capra/Capreolus*
GNP = *Gallus/Numida/Phasianus*
GP = *Gallus/Phasianus*
GN = *Gallus/Numida*
GAG = *Gallus gallus*
ANA = *Anas*
ANS = *Anser*
SCR = *Scolopax rusticola*
PEP = *Perdix perdix*
PUP = *Puffinus puffinus*
PHC = *Phalacrocorax carbo*

BUB = *Buteo buteo*
MIM = *Milvus milvus*
FAL = *Falco* sp.
ACN = *Accipiter nisus*
PL = *Pluvialis* sp.
PLA = *Pluvialis apricaria*
PLS = *Pluvialis squatarola*
VAV = *Vanellus vanellus*
GAN = *Gallinago gallinago*
COL = *Columba*
TU = *Turdus/Sturnus*
CO = *Corvus* sp.
COM = *Corvus monedula*
COF = *Corvus frugilegus/corone*
COC = *Corvus corax*
PIP = *Pica pica*
GAR = *Garrulus glandarius*
PSF = *Passeriformes*
AMP = *Amphibia*
RAN = *Rana* sp.
BUF = *Bufo bufo*
TES=*Testudinidae*
URS= *Ursus* sp.
FAC = *Falco columbarius*
CTC = *Coturnix coturnix*
LU = *Lutra* sp.
MEM = *Meles meles*
NUA = *Numenius arquata*
GAL = *Galliformes*
STV = *Sturnus vulgaris*
CIR = *Circus* sp.
LA = *Lagopus* sp.
STV = *Sturnus vulgaris*
MES = *Mergus serrator*
TUI = *Turdus iliacis*
ALA = *Alauda arvensis*
STE = *Sterna* sp.
STS = *Sterna sandvicensis*
FISH = Fish
MAR = *Marmota* sp.
OCH = *Ochotona* sp.
BUU = *Buccinum undatum*
F-S = *Salmonidae*
When the identification is uncertain a question mark is put at the end (e.g. CEE? B?)

FUS (=fusion):
F = fused
G = fusing
H = fused/fusing
UD = unfused diaphysis
UE = unfused epiphysis
UX = unfused diaphysis + epiphysis
J = juvenile (for birds)

BUTCH (=butchery):
P = chopped
T = cut(s)
S = sawn
PT = chopped + cut(s)
SP = sawn + chopped
TS = cut(s) + sawn
"blank" = absent or not recordable

BURN (=burning):
S = singed
B = burnt
C = calcined
"blank" = absent or not recordable

GNAW (=gnawing):
C = gnawed by carnivores
D = partially digested
R = gnawed by rodents
CR = gnawed by carnivores and rodents
"blank" = absent or not recordable

I1, I2, I3, I, dI1, dI2, dI3, dI, C (other than pig), dC , P1, P2, P3, P, dP2, dP3, P/M, M:
P = present
"blank" = absent

C (pig):
M = male
F = female
AM = male alveolus
AF = female alveolus
P = present
"blank" = absent

P4, dP4, M1, M2, M3, M12(=M1 or M2):
wear stage
P = present, but wear stage not recordable (or not recorded)
"blank" = absent

Measurements:
All in tenths of millimetres.

Appendix 3: MNI Figures

MAB, Bronze Age:

Bos sp.	*cf. Bos sp.*	*Equus sp.*	Large Mammal	Fish
1	0	1	0	1
cf. Canis familiaris	*Capra hircus*	Caprine	cf. Caprine	*Capreolus pygargus*
1	0	2	0	1
Ovis aries	Medium Mammal	*cf. Pica pica*	*cf. Turdus/Sternus sp.*	
0	0	1	0	
Marmota sp.	*Ochotona sp.*	Small Rodent		
0	1	1		

MAB, Bronze Age/Xiongnu:

Bos sp.	*cf. Bos sp.*	*Equus sp.*	Large Mammal	Fish
1	0	1	0	0
cf. Canis familiaris	*Capra hircus*	Caprine	cf. Caprine	*Capreolus pygargus*
0		1	1	0
Ovis aries	Medium Mammal	*cf. Pica pica*	*cf. Turdus/Sternus sp.*	
0	0	0	0	
Marmota sp.	*Ochotona sp.*	Small Rodent		
0	0	1		

MAB, Xiongnu:

Bos sp.	*cf. Bos sp.*	*Equus sp.*	Large Mammal	Fish
1	0	1	0	0
cf. Canis familiaris	*Capra hircus*	Caprine	cf. Caprine	*Capreolus pygargus*
0	0	1	1	0
Ovis aries	Medium Mammal	*cf. Pica pica*	*cf. Turdus/Sternus sp.*	
1	0	1	1	
Marmota sp.	*Ochotona sp.*	Small Rodent		
1	1	2		

MAB, Others:

Bos sp.	*cf. Bos sp.*	*Equus sp.*	Large Mammal	Fish
0	0	0	0	0
cf. Canis familiaris	*Capra hircus*	Caprine	cf. Caprine	*Capreolus pygargus*
0	0	1	0	0
Ovis aries	Medium Mammal	*cf. Pica pica*	*cf. Turdus/Sternus sp.*	
0	0	0	0	
Marmota sp.	*Ochotona sp.*	Small Rodent		
1	0	0		

MAC, Bronze Age:

Bos sp.	***cf. Bos sp.***	***Equus sp.***	**Large Mammal**	**Fish**
1	0	0	0	0
cf. Canis familiaris	***Capra hircus***	**Caprine**	**cf. Caprine**	***Capreolus pygargus***
0	0	0	0	0
Ovis aries	**Medium Mammal**	***cf. Pica pica***	***cf. Turdus/Sternus sp.***	
0	0	0	0	
Marmota sp.	***Ochotona sp.***	**Small Rodent**		
0	0	0		

MAC, Bronze Age/Xiongnu:

Bos sp.	***cf. Bos sp.***	***Equus sp.***	**Large Mammal**	**Fish**
1	0	1	0	0
cf. Canis familiaris	***Capra hircus***	**Caprine**	**cf. Caprine**	***Capreolus pygargus***
0	0	1	0	0
Ovis aries	**Medium Mammal**	***cf. Pica pica***	***cf. Turdus/Sternus sp.***	
0	0	0	0	
Marmota sp.	***Ochotona sp.***	**Small Rodent**		
0	0	0		

MAC, Xiongnu:

Bos sp.	***cf. Bos sp.***	***Equus sp.***	**Large Mammal**	**Fish**
1	0	1	0	0
cf. Canis familiaris	***Capra hircus***	**Caprine**	**cf. Caprine**	***Capreolus pygargus***
0	1	2	0	0
Ovis aries	**Medium Mammal**	***cf. Pica pica***	***cf. Turdus/Sternus sp.***	
1	0	0	0	
Marmota sp.	***Ochotona sp.***	**Small Rodent**		
1	0	2		

MAC, Others:

Bos sp.	***cf. Bos sp.***	***Equus sp.***	**Large Mammal**	**Fish**
1	0	0	0	0
cf. Canis familiaris	***Capra hircus***	**Caprine**	**cf. Caprine**	***Capreolus pygargus***
0	0	0	0	0
Ovis aries	**Medium Mammal**	***cf. Pica pica***	***cf. Turdus/Sternus sp.***	
0	0	0	0	
Marmota sp.	***Ochotona sp.***	**Small Rodent**		
0	0	0		