AUROCHS HUNTERS: THE ANIMAL BONES FROM BLICK MEAD

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1. INTRODUCTION

The site of Blick Mead has attracted an unusual degree of interest. In addition to its intrinsic importance as a Mesolithic site, its location less than two kilometres east of Stonehenge and its temporal overlap with the massive Mesolithic posts in the Stonehenge carpark mean that it is the earliest settlement site in the region of the monument (e.g. Parker-Pearson et al. 2015). The site has provided an animal bone sample of modest size but great importance. Faunal remains reveal much about the socio-economic basis and cultural practices of their time. Very few Mesolithic faunal assemblages are known from Britain, so any new discovery greatly advances our understanding of the period. In the following report we do two things. First, we present a zooarchaeological analysis of the material; the most remarkable aspect of this is the high proportion of aurochs (*Bos primigenius*), so far unequalled at any other Mesolithic site in Britain and the near continent. Second, we present a stable isotopic analysis of aurochs teeth. We thus aim not only to get a better understanding of the site and its inhabitants, but also of the life of the extinct ancestor of modern domestic cattle, by focusing on their diet and migratory habits.

The current excavations at Blick Mead began in 2005. Mesolithic remains have been discovered in Trenches 19, 22 and 23. The assemblages of struck flint and burnt stone are considerably larger than those at most other Mesolithic sites in Britain (Jacques, this volume), and indicate a substantial Mesolithic occupation at the site. The quantity of flint suggests that this was a home-base used over many years. The radiocarbon dates from six animal bone and tooth enamel fragments, which span the period between 7596-7542 cal BC and 4846-4695 cal BC, reinforce the suggestion that the site marks a 'persistent place' in the landscape (Jacques, this volume).

Parts of this assemblage were initially examined, and its importance understood, by the late Tony Legge. We dedicate this study to his memory.

2. ZOOARCHAEOLOGICAL ANALYSIS

2.1 Introduction and methodology

A total of 2430 fragments of animal bone were recovered from Blick Mead. Prior to October 2012 the site was not sieved, and hand collection was used to retrieve the remains. However, upon the first significant discovery of Mesolithic material in Trench 19, all of the spoil from Layer 59, the sealed Mesolithic deposit, was sieved, as were the Mesolithic contexts from Trenches 22 and 23 (Jacques, this volume). Layer 59 was divided into nine 1m^2 squares (Contexts 59A, 59B, 59C, 61, 62, 63, 65, 66 and 67) to allow the distribution of the finds to be examined. Contexts 77 and 92 were also part of this sealed deposit and any remains found in the spoil heap from this layer were recorded as Context 64 (Jacques, this volume). All of the finds were washed. Layer 59 sits below the water table; it is described as being dark brown, viscous, silty clay. The remains were concentrated in the southern corner of this layer with 907 fragments coming from Context 77 alone (Figure 1). 65, 16 and 48 fragments came from Trenches 22, 23 and 24 respectively. Table 1 lists the Number of Identified Specimens (NISP) of the assemblage. Despite the wide range of the Mesolithic radiocarbon dates (see above), there was no stratigraphic reason to subdivide the animal bones into chronolgical sub-units. All the bones are therefore treated as a single assemblage, but it must be remembered that they span some 3000 years.

The fragments were identified by BR under the supervision of PR-C using the Durham University reference collection. Where possible, they were identified to element and species, the level of epiphyseal fusion was noted and, if the element was not complete, the part present was also recorded. They were not recorded by identifiable zones. Side was also recorded, as were any interesting features such as cut or gnaw marks. Tooth wear stage was recorded following the method of Grant (1982). If it was not possible to identify the element, fragments were recorded as either Bone Fragment or Tooth Fragment. Ribs and vertebrae, with the exception of the atlas (cervical vertebra 1) and the axis (cervical vertebra 2), were recorded as only as Bone Fragments. Each fragment was given an individual record number. Only 27 of the identifiable fragments were sufficiently well preserved to have measurements taken. Measurements follow von den Driesch (1976).

The preservation of the bones was very poor, most fragments being very small and highly eroded; this is typical for chalk environments with water percolating through them. The total weight of all the fragments was 9.353kg, with an average fragment weight of 3.8g. 91 fragments, most of which were unidentifiable, show evidence burning. All save one of these burnt fragments, which is unstratified from Trench 22, came from Trench 19. Excluding two of these fragments, which were unstratified, all were recovered from contexts 77 and 92, both of which are part of the sealed Mesolithic layer.

Some bone fragments from the southern corner of Trench 19 were a blue/green colour. This has been seen at other sites including a context from San Josecito Cave, Mexico. In this case, Robels et al (2002) identified diagenetic trace elements in the bone, including copper, strontium and zinc. They postulated that a series of physical and chemical diagenetic processes led to the transfer of particular metal ions into the bone, resulting in a change in its colour (Robels et al. 2002). It is possible that a similar process happened at Blick Mead. All the fragments were recovered from context 77.4 in Trench 19, which is close to the spring, so it is thought that the colour change was caused by the minerals and *Hildenbrandia rivularis* algae. These algae are known to turn red-oxidised flint magenta pink upon contact with the air (Jacques this volume).

Fragment 1316, a metatarsal of roe deer (*Capreolus capreolus*), has an iron cylinder concreted to its interior surface. Fragment 1317, an unidentified fragment, has evidence of being in contact with the iron on fragment 1316. Both fragments were from context 77.5 in Trench 19. The iron on the bones may have been caused by natural precipitation from the soil (Vicky Garlick 2014, pers. comm.).

2.2 Results

271 bone fragments were identified (Table 1). Twelve of these, unidentifiable morphologically, were identified using ZooArchaeology by Mass Spectrometry (ZooMS) by Sophy Charlton at York University. Of these, ten were aurochs, one was wild boar, and one was either red deer or elk. Eight further fragments were analysed using ZooMS; five were identified as terrestrial herbivores of unknown species, and three were unidentifiable (Charlton in press).

2.2.1 Aurochs, *Bos primigenius*

Aurochs remains make up 57% of the identifiable assemblage, totalling 155 fragments. A few domestic cattle bones were recovered (see below). Four further fragments were identified as probably aurochs; although visually relatively small, they were regarded as not small enough to be classified definitively as domestic. They were recovered from context 67 in Trench 19, from where many aurochs fragments were identified, so it was concluded that these fragments too are likely to be aurochs.

Aurochs were found in all four trenches. The majority, 133 (85%), came from Trench 19. Thirteen (8%) were recovered from Trench 22, nine (3%) from Trench 23 and two (1%) from Trench 24. These proportions are the same as those of the total fragments recovered from each trench, suggesting that the aurochs remains were evenly spread across the whole site. Within Trench 19 most are concentrated in the south, closest to the spring (fig. 1). 92 of the fragments (70% of the fragments from Trench 19) came from the sealed Mesolithic deposit; three of the fragments came from Contexts 75 and 76 which were underneath Layer 59.

Almost all aurochs body parts were represented, with the foot and ankle bones comprising the majority of the assemblage (Table 2). The Minimum Number of Individuals (MNI) was calculated in the simplest possible way, by taking the fewest number of elements from a single side that through side-by-side comparison could be determined to have come from different carcasses. The aurochs MNI was calculated to be four, based on three adult-sized left proximal metatarsals, as well as one unfused distal metapodial epiphysis from a neonate or very young individual. The Minimum Number of Elements (MNE) was also calculated with the most common elements being 1st and 2nd phalanges with eight and fourteen elements recovered respectively. Ten of the fragments refit, including two 1st phalanges, a 3rd phalanx, a naviculocuboid and a metacarpal; they were counted in the bone count as separate fragments but were counted as single fragments in the MNI.

Aurochs were the only animal from Blick Mead showing any signs of butchery. Five aurochs fragments exhibited cut marks (fig. 2). The proximal end of a left metacarpal has quite deep chop or gouge marks (fig. 2A), as does the proximal end of a left radius. The coracoid process of a right scapula has two deep cut marks (fig. 2B), and a calcaneum also has cuts. The fifth fragment, no. 1119, has a flint fragment embedded in it (fig. 2C). This is an aurochs 2nd phalanx recovered from Context 77.4 in Trench 19. The small fragment of flint is on the distal lateral side. A scalpel was used to carefully remove the remaining soil from around the flint, to see if it was only adhered to the bone by mud. This proved not to be the case, so the phalanx was X-rayed in an attempt to determine whether the flint penetrated the bone. Conventional X-rays were taken by Vicky Garlick of the Durham University Conservation Laboratory, and digital radiographs by Tina Jakob of the Durham University Archaeology Department. Although it was determined that the flint fragment did not penetrate the bone, there was evidence of compression of the bone under the flint. This was apparently caused by the flint impacting the bone. This is shown in fig. 3D, the area of the bone under the flint appearing as a brighter white than the rest. An arrow strike would probably have caused a more penetrating injury, so hunting seems unlikely to have been responsible. Evidence from an aurochs from Mullerup in Denmark suggests that the torso would have been the main target when hunting an aurochs (Leduc 2014). The Blick Mead example is therefore interpreted as resulting from butchery, the tip of a flint knife breaking off in the bone.

Fourteen aurochs bones were sufficiently well preserved for measurements to be taken (Table 3). Two of these were complete astragali. They are of similar sizes, and one is left and the other is right, so it is possible that they may be from the same individual. Distal breadth (Bd) could be taken on both, but only one (no. 1120) was sufficiently well preserved to allow greatest lateral length (GLl) to be taken accurately. The level of erosion on specimen 1120 suggests that the actual GLl is likely to be at least 10mm longer than the measurement that could be taken. Fig. 3 plots both astragali, compared to those from Denmark (Degerbøl and Fredskild 1970) and Star Carr (Legge and Rowley-Conwy 1988). The actual measurement on specimen 1120 from Blick Mead is plotted, along with an estimate based on the trend line from the Star Carr and Danish aurochs; the true measurement is expected to fall on the line between the two points. Aurochs are sexually dimorphic, the males being larger than the females, and two size groupings are visible in fig. 3. Both Blick Mead specimens fall into the larger group and are thus clearly male. Aurochs teeth are not sexually dimorphic, but the lengths of the two M3s, 45.3 mm and 45.8 mm (table 3) fall well above the largest British domestic cattle (see e.g. Rowley-Conwy and Owen 2011, 335). The other measurements all fall into the established aurochs range published by Degerbøl and Fredskild (1970).

2.2.2 Domestic cattle, *Bos primigenius taurus*

Five *Bos* teeth from Blick Mead were visually quite small. Four of these came from Trench 24: three from Context 103 and one from Context 101. These are the upper contexts of Trench 24, where the other bones of domestic animals were found (see below). They are therefore thought to be later intrusions into the Mesolithic layers, and were accordingly identified as domestic cattle (Table 1). The remaining fragment, a lower right M3, was found, unstratified, in Trench 19. This specimen measured 36.5 mm in length, well below the aurochs range and in the Neolithic domestic range (Rowley-Conwy and Owen 2011, 335).

2.2.3 Red deer, *Cervus elaphus*

Red deer were the second most common species found at the site comprising 17% of the total identifiable assemblage. 46 fragments were recovered (listed in Table 2). Four more fragments: two metacarpal fragments, a possible humerus and a tooth fragment, were classified as possibly red deer based on size. A further two fragments: a 2nd phalanx, and a morphologically unidentified fragment determined by ZooMS, were also classified as either red deer or elk (*Alces alces*). These six uncertain fragments are not included in the element count (Table 2).

Red deer were not recovered from Trench 24, and only two fragments each were discovered in Trenches 22 and 23. The remaining forty-two fragments were found in Trench 19 and, like the aurochs, were concentrated in the southern corner of the trench, with 16 fragments retrieved from the combined Context 77. A further four fragments were recovered from context 67, which is the most southern corner of Layer 59. Most of these are from the limbs, the majority being foot and ankle bones. The MNI for red deer was calculated as 2, the number of left calcanei, left magnums and left naviculocuboids.

Four of the Blick Mead red deer could be measured (Table 3). One of these was an astragalus. While the separation between the sexes is less clear than in aurochs, males still tend to be larger than females (Legge and Rowley-Conwy 1988). The Blick Mead individual is noticeably smaller than many of the Star Carr individuals, which suggests that it came from a female (fig. 4A). One red deer scapula was also measurable. Scapula is problematic because various factors influence size. Age is one: the bone grows markedly *after* fusion, when the bone appears to be adult (Legge and Rowley-Conwy 1988, Rowley-Conwy 2013 fig. 15.6). Among full-grown adults however the males are once again larger than the females (Rosvold et al. 2014, Legge and Rowley-Conwy 1988). Most of the animals from Star Carr were adult. The Blick Mead scapula is so small in comparison that it is likely to come from a female (fig. 4B).

2.2.4 Elk, *Alces alces*

Five fragments were identified as elk (listed in Table 4). These comprised four first or second molars, of which three were upper and one was lower, and a distal tibia. A metapodial fragment was also identified as possibly elk. All of these remains were from the Mesolithic layer in Trench 19, including the two fragments classified as elk or red deer (see above), or were unstratified.

2.2.5 Roe deer, *Capreolus capreolus*

Eight fragments were identified as roe deer (listed in Table 4). All except one, a left lower P4 from Context 90 in Trench 23, were from Trench 19. Within trench 19 six of the seven fragments were from Context 77 and one was from Context 92, both of which are in the sealed Mesolithic layer. All of the bones in the assemblage are limb bones, predominantly hind limb bones: femur, tibia, astragalus, metatarsal and 2nd phalanx; or teeth, two left lower P4s and a right upper first or second molar. This means that the MNI for roe deer is 2, based on the two lower left P4s. The MNI here is the same as the MNI at Three Ways Wharf in Uxbridge, despite over 200 fragments being identified as roe deer or of roe deer size there (Rackham and Pipe 2011).

2.2.6 Wild boar, *Sus scrofa ferus*

Twenty three fragments, 9% of the assemblage, were identified as wild boar (listed in Table 4). All were recovered from Trench 19. Nineteen came from the sealed Mesolithic layer; of the remaining four fragments, two were unstratified and the other two were found in Contexts 75 and 79. Context 79 is described as a possible Mesolithic deposit (Jacques this volume). The MNI of wild boar has been calculated as 3, based on the number of right astragali. This is relatively high considering the small number of bones found.

2.2.7 Domestic pig, *Sus scrofa domesticus*

Five fragments of *Sus scrofa* were so small that they are believed to be of domestic size. One of these was a lower left M3 with a WA of 16.6mm; this falls within the range of 13.9 - 17.5mm for domestic pigs from Durrington Walls (Albarella and Payne 2005). Four of these fragments were recovered from Trench 19 and one from Trench 24. Three of them: a scaphoid, a lower M3, and a 1st lateral phalanx, were recovered from Context 67; and a lower M3 was discovered in Context 77.2. Both of these contexts were part of the sealed Mesolithic layer. It is of course possible that these are small wild boar rather than intrusive domestic pigs - it is not always possible to distinguish between them (Rowley-Conwy, Albarella and Dobney 2012). The fifth pig fragment, a lower left incisor, was from Context 101, one of the uppermost layers in Trench 24.

2.2.8 Sheep, *Ovis aries aries*, or Goat, *Capra aegagrus hircus*

Nine bones (3% of the identifiable assemblage) were identified as sheep or goat. One of these was a complete humerus, unfused proximally but fused distally, giving it an approximate age of between 10 and 36 months, based on Silver (1969). The humerus was not as chalky as the rest of the bones, and was generally much better preserved; for this reason, and the fact that sheep are not found in Mesolithic Britain (Serjeantson 2014), the bones have been interpreted as intrusive. Five of the fragments came from Trench 22 and were either unstratified or came from Context 89. The three fragments recovered from Trench 19 were found in Contexts 71 and 75 which are above the sealed Mesolithic Layer. The final fragment, a mandibular articulation, came from Context 100 of Trench 24, which is above the context where domestic cattle remains were found.

2.2.9 Hare, *Lepus* cf. *timidus*, and Rabbit, *Oryctolagus cuniculus*

A complete hare tibia was recovered from Trench 22. It was unstratified. It is very well preserved. It was similar in colour to the other bones on the site, and hare tibias are dense and hard (Pavao 1998), so we regard it as probably of Mesolithic date. The mountain hare, *Lepus timidus*, is generally regarded as the species that was present during the Mesolithic (Maroo and Yalden 2000). A rabbit ulna was recovered from Context 100 in Trench 24. This was paler in colour, and is assumed to be intrusive. Rabbits were introduced to Britain long after the Mesolithic (Sykes and Curl 2010).

2.2.10 Domestic dog, *Canis familiaris*

An upper left P4 was discovered in Context 77.5 of Trench 19. It was not considered to be intrusive. Its greatest length is 19.9 mm. Degerbøl (1933, table 19B) lists this measurement from seven prehistoric and 18 recent wolves. All of these are much larger than that of the Blick Mead specimen, the smallest being 23.3 mm. Degerbøl (op. cit., table 49) gives two measurements of domestic dogs from the Mesolithic site of Sværdborg I, of 20 and 19.7 mm respectively. Measurements of this tooth from Britain are scarce, but van Wijngaarden-Bakker (1974, 342) gives a measurement of 19.0 mm for a Beaker period dog from Newgrange in Ireland. From these measurements it seems reasonably certain that the Blick Mead specimen is indeed a domestic dog, not a wolf.

2.2.11 Bird (cf. Passeriformes)

The synsacrum of a bird tentatively referred to as a passerine was found in Context 90 of Trench 23. It is thought to be intrusive and not part of the Mesolithic assemblage.

2.3 Discussion

In the early seasons of excavation there was a bias towards larger bone fragments such as those of aurochs, elk and red deer, due to the lack of sieving. Sieving during the later seasons reduced this bias and enabled the recovery of many smaller, more ephemeral fragments such as the pig 1st lateral phalanx. This is less than 5mm long and so might have been missed during hand collection (Davis 1987).

The MNIs of all taxa are so small that it would not be meaningful to calculate the MNI percentages. The use of MNI to quantify the animal remains from archaeological sites puts too much emphasis on the chance recovery of multiples of the same fragment, particularly in assemblages where the total number of fragments is small (Grayson 1984). The weaknesses of MNI are highlighted at Blick Mead where the MNI of aurochs, 4 (from 155 fragments) is only one higher than that of wild boar – of which only 23 fragments were recovered. The MNI of red deer and roe deer are the same, 2 of each species, despite only 8 fragments of roe deer being identified compared to 46 of red deer. This disparity is highlighted to an even greater extent when the MNI of roe deer at Blick Mead and Three Ways Wharf are compared; both sites have an MNI of 2 despite over 200 fragments of roe deer being recovered from Three Ways Wharf. It is also very unlikely that only 4 aurochs were killed during the 4000 year period that Blick Mead was occupied.

The Number of Identified Specimens (NISP) as listed in Table 1 is more useful, especially in combination with the skeletal part frequencies listed in Table 2. A considerable proportion of the fragments found at the site from all of the major species, particularly aurochs, are foot and ankle bones. Taken at face value, these could suggest that Blick Mead was a kill site or hunting site rather than a home base, since the lower limbs and head are often discarded and not returned to the base camp (Legge and Rowley-Conwy 1988). In Binford’s study of Nunamiut hunting camps he noted that there was a dominance of mandibles, upper forelimbs and limb extremities, without phalanges; the parts of higher value were taken back to the base camp (Binford 1978). However, at Blick Mead the preservation in the chalky deposits was fairly poor, which may account for the high representation of the harder foot bones (Marean 1991). Furthermore, there is a high proportion of proximal hind limb bones, which suggests that Blick Mead was indeed a base camp.

3. BLICK MEAD IN ITS BRITISH AND EUROPEAN CONTEXT

The large proportion of aurochs makes the Blick Mead faunal assemblage unique both in Britain and the adjacent parts of the European mainland. Aurochs are usually a relatively minor component of Mesolithic assemblages; for example, only 16% (a total of 174 fragments) of the identifiable fragments found at Star Carr, in Yorkshire, were aurochs (Legge and Rowley-Conwy 1988).

Southern England has yielded four other Mesolithic assemblages. Their percentages of the large mammals are compared to Blick Mead in fig. 5 (top). They are all relatively small, but nevertheless large enough to reveal that Blick Mead is unique among them in its large proportion of aurochs. Cherhill comes closest, with 39% aurochs, but also has a large proportion of red deer (Grigson, in Evans et al. 1983). Faraday Road is dominated by wild boar (Ellis et al. 2003), while Three Ways Wharf (Scatter C West) is dominated by red deer (Rackham and Pipe 2011). Blick Mead, Faraday Road and Three Ways Wharf thus present the remarkable pattern of each specialising on one species. Thatcham presents a different trend, with red deer and wild boar both being relatively common (King 1962), while Cherhill has similar proportions of aurochs and red deer. Only 3% of the remains from Thatcham and Faraday Road were aurochs, and none at all were recovered in the Holocene Scatter C at Three Ways Wharf. The differences in the proportions of species found at each site suggests that different areas may have been utilised for different resources, possibly by the same band or bands of hunter gatherers.

Fig. 5 (bottom) compares Blick Mead with selected sites from Denmark, which has produced more Mesolithic animal bone assemblages than any comparable region in Europe. Ringkloster, Agernæs and Asnæs Havnemark are from the Late Mesolithic Ertebølle Culture, while Sværdborg I, Ulkestrup Lyng Øst and Lundby II are from the Early Mesolithic Maglemosian Culture. These large assemblage show little tendency to specialise on any species; only at Asnæs Havnemark does the proportion of roe deer exceed the proportion of aurochs at Blick Mead – but this may be due to the site's unique location at the end of a long, thin peninsula rather than a particular preference for the taxon. Aurochs decrease through time in Denmark, and are completely absent from Asnæs Havnemark. This site is on the island of Zealand, where aurochs were eradicated by Mesolithic hunters when the postglacial sea rose and cut this area off (Aaris-Sørensen 1980, 1999).

One site perhaps more comparable to Blick Mead is Auneau in northern France (Leduc and Verjux 2014). Like Blick Mead, this site was occupied for a long period, approximately 8200-5500 cal BC. Faunal remains have been recovered from some 70 pits, each presumably representing a separate event. Only two pits have faunal assemblages large enough to be useful in this context. Pit 34 has a NISP of 309, and shows a specialisation of roe deer, which form 87% of the bones. Pit 32 has been radiocarbon dated to c. 6800-6500 cal BC. It has 93 NISP, but significantly 53% of these are aurochs. The MNI for this species is 4, of which 2 were juvenile (Leduc and Verjux 2014).

4. ISOTOPIC ANALYSIS

4.1 Introduction and Methodology

During tooth formation and mineralisation enamel is deposited sequentially down the length of the crown: the earliest enamel formation occurs at the cusp (or tip) of the tooth, the latest closest to the Enamel Root Juncture (ERJ) or cervix (Zazzo, Balasse and Patterson 2005). The food and water consumed by the animal during the formation of each tooth affects the isotopic ratios of various elements incorporated into the tooth enamel (Towers et al. 2011). Sequential samples taken down the length of the tooth can therefore show change in isotope concentrations over the course of the tooth's formation (Bentley and Knipper 2005). These can in turn be used to reconstruct the animal's diet and mobility, though it should be borne in mind that values do not represent discrete time-slices but running averages, due to the c. 1 year maturation time of enamel (Zazzo, Balasse and Patterson 2005; Britton et al. 2009; Towers et al. 2010).

Three isotopic ratios were analysed at Blick Mead:

(1) The $\delta^{13}C$ values from a given herbivore tooth are linked to the $\delta^{13}C$ values of the plants it consumed (Towers et al. 2011). Variations in $\delta^{13}C$ can be caused by water availability, temperature, altitude and the amount of recycled CO_2 in dense low-light woodland (also known as the canopy effect) (Heaton 1999). As a ruminant shifts from pre-birth, to milk ingestion and non-rumination, and then to plant consumption and rumination in early life, $\delta^{13}C$ can change (Towers et al. 2014). However, in this study only third molars were used which form entirely after the onset of rumination and therefore these issues will not impact on the data obtained.

(2) The $\delta^{18}O$ values of a tooth are affected by the $\delta^{18}O$ values of ingested water, which may change seasonally with temperature (Balasse 2003). Oxygen isotopes can also be used to show mobility of animals and humans; this can be seen in an unexpected change in the $\delta^{18}O$ values, or from finding $\delta^{18}O$ values not consistent with the area where the remains were located (Tornero et al. 2013).

(3) Sr-87/Sr-86 can also be used to track mobility. Strontium in teeth is ingested from dietary plants, and comes from the soil in which the plants grow. Plant values reflect both the underlying geology and atmospheric deposition via rainwater (Price et al. 2002; Montgomery 2010). It is thus possible to determine the likely geology on which the plants in the individual's diet grew (Balasse and Ambrose 2002).

The different isotopes used in combination provide a better understanding of the lives of animals and humans in the past (Balasse et al. 2002; Müller et al. 2003; Britton et al. 2009). In migration studies, strontium and oxygen can be used to determine seasonality of migration and also more precise geographical origins of the individual (Britton et al. 2009). Carbon and strontium were combined to examine mobility by Balasse et al. (2002), allowing differences between coastal and inland diets to be determined; this could not have been inferred from either of the isotopes independently. Towers et al. (2011) used a variety of isotopes to get a better understanding of the seasonality and movement of Early Bronze Age cattle from two barrows at Gayhurst and Irthlingborough. This includes the only previous aurochs from Britain for which $\delta^{18}O$ and $\delta^{13}C$ intra-tooth enamel profiles have been obtained.

In order to understand of the lives of the aurochs at Blick Mead, incremental isotopic analysis was carried out on the two mandibular M3s in the assemblage: fragments 421 (hereafter referred to as BM421) and 422 (hereafter referred to as BM422). These teeth were relatively well preserved and certainly came from different individuals, since they exhibit very different levels of wear: BM421 was in early wear, while BM422 was well worn. BM 422 was directly dated to 6881±33 bp (SUERC-60917), or 5793-5723 cal BC at 1σ, or 5845-5686 cal BC at 2σ. BM421 contained insufficient collagen to be dated. We sampled two cusps from BM421: the mesial (anterior, or first) and middle (central, or second), to see whether they might produce different values. The teeth are shown before and after sampling in fig. 6.

The samples were taken in the Durham University Archaeology Grinding Laboratory by BR under the supervision of JM and KG. The cementum was removed from the outside of the buccal lobe on the medial and the middle cusps lobes of BM421, and the middle lobe of BM422, using a diamond dental burr-equipped hand-held rotary dental drill. This burr was then used to take intra-tooth samples of enamel at 2-3mm intervals from the top of the tooth down to the Enamel Root Juncture (ERJ). The burr was cleaned with acetone between each sample, and prior to use all equipment was cleaned using distilled water and acetone to prevent contamination. 24 samples were taken from the mesial lobe of BM421, 22 from the middle lobe of BM421, and 11 from BM422. The distances from the ERJ were measured using Workzone digital callipers.

Around 20mg of enamel powder was collected for each sample. These were taken across the entire width of the cusp except for the mesial lobe of BM421, where it was only possible to sample half of the cusp for the final 10 samples due to a deep crack down the centre of the lobe (see fig. 6 top right). These samples were transferred to the Stable Light Isotope Facility at the University of Bradford for further preparation and analysis for their $\delta^{13}C$ and $\delta^{18}O$ values, following a protocol modified after Sponheimer (1999) and according to established laboratory procedures (Towers et al. 2011). Between 0.5 and 2mg of enamel was added to 1.8ml of NaOCl solution (1.7% v/v) and agitated for 30 minutes. The samples were rinsed with water and spun in a centrifuge three times. The water was then removed and 1.8ml of NaOCl solution (1.7% v/v) was added for 30 minutes. The samples were centrifuged again, rinsed three times with distilled water and freeze-dried. Oxygen and carbon isotope ratios were measured using a Finnigan Gasbench II connected to a Thermo Finnigan MAT253 continuous flow isotope ratio mass spectrometer. The carbonate fraction of enamel was reacted with anhydrous phosphoric acid at 70°C releasing CO_2, from which values of $\delta^{18}O_{VSMOW}$ and $\delta^{13}C_{VPDB}$ were directly obtained using a CO_2 reference supply. They were normalised through calibration to the measured and accepted values of the NBS19 international standard and two internal standards: Merck Suprapur $CaCO_3$ and OES (ostrich egg shell). Analytical precision was determined by repeat measurement of an internal enamel laboratory standard to be ± 0.2 ‰ f(1σ) or $\delta^{18}O_{VSMOW}$ and ± 0.1 ‰ (1σ)for $\delta^{13}C_{VPDB}$.

For analysis of the Sr-87/Sr-86 ratios, three additional samples were taken from the middle lobe of BM421 from the ridges between samples BM421-41 and BM421-43, BM421-51 and BM421-53 and BM421-60 and BM421-62 (see fig. 6). These samples were sent to the Laboratory for Archaeological Chemistry at the University of Wisconsin-Madison for preparation, and then to the Isotope Geochemistry Laboratory at the University of North Carolina for analysis, using standard methodology detailed by Sjögren, Price and Ahlstöm (2009).

Water samples were taken from the Blick Mead spring and the River Avon close to the site. They were tested for their δ18O values in the Durham University Earth Sciences Laboratory. They were first filtered through a 0.45µm filter before 75nl of each sample was injected into a LGR Liquid Water Isotope Analyser. The samples were then calibrated against three stable isotope water standards supplied by IsoAnalytical. These standards had an isotopic range of ~80 ‰ in d18O. Each sample was injected ten times with the results of the first two injections rejected to avoid contamination with the previous sample. A mean of the remaining eight samples was then calculated. Each sample was repeated three times and the mean calculated. The mean $\delta^{18}O$ value for the spring water was -6.65‰ with a range of -6.72‰, to -6.55‰. The mean $\delta^{18}O$ value for the river water was -6.53‰ with a range of -6.59‰ to -6.49‰.

Unexpectedly, there was a considerable difference between the two cusps or BM421. For $\delta^{13}C$ this amounted to almost 2‰, well outside the standard error. The analyses were therefore repeated. The difference may have been caused by the larger quantities of enamel used in the first run not fully reacting with the NaOCl, and so not showing the true $\delta^{18}O$ and the $\delta^{13}C$ values (Towers 2015, pers. comm.). For the second run therefore the amount of enamel power added to the reaction was on average halved; sample BM421-15 could not be repeated due to insufficient sample remaining. The results of this second run are used below as it is more likely that these samples would have fully dissolved. The discrepancy between the two lobes is however also visible in the second run. A running average was generated to reduce the effects of anomalous results and to produce a smooth curve. All the values are listed in appendix A and B. Figures 7 and 8 show the values for oxygen and carbon isotopes respectively, with the individual values, above, and the smoothed curves created by the running averages below.

In addition to the incremental analysis of the teeth, five aurochs bone fragments from Trench 19 were sampled for bone collagen carbon and nitrogen isotope analysis. Three calcanei, an astragalus, and a naviculocuboid were sampled. Standard extraction protocols were carried out in accordance with Ambrose and DeNiro (1986); DeNiro (1985) and Longin (1971). While collagen was extracted from all of the bone fragments, only two, BM557 (the calcaneum with cut marks) and BM658 (the naviculocuboid), produced enough for bulk isotope analysis. These two samples were analysed by the University of Bradford's Light Isotope Laboratory. The results of these analyses are displayed in Table 6. The C:N ratios of both samples are between 3.22 and 3.41, which falls within DeNiro's (1985) acceptable atomic C:N range indicating low likelihood of diagenesis. The ratios themselves are in accordance with the expected values for terrestrial herbivores (Bocherens and Drucker 2003) and are in agreement with a diet from closed forest environments.

4.2 Oxygen Isotope Results

The $\delta^{18}O$ values from the two lobes of BM421 (fig. 7) are similar in absolute value, but they do not track each other; this was the case in both runs of the samples. However, both lobes produce remarkably homogeneous data sequences. This contrasts with the $\delta^{18}O$ profile from the Irthlingborough aurochs M3, which falls by more than 2‰ towards the ERJ, suggesting a summer maximum and a winter minimum. The middle lobe from BM421 is a sine curve. This shows two summer peaks towards each end of the plot, with a winter minimum in between. In domestic cattle M3 formation spans just over a year, starting around 9.5 months and finishing before 24 months (Sharma et al. 2004). The first summer peak occurs approximately a quarter of the way down the tooth, indicating that tooth formation began in spring. If tooth formation in aurochs was similar, this correlates with the birth season of May to June as described by van Vuure (2005) for the last surviving animals of this species.

The $\delta^{18}O$ values from the mesial lobe of BM421 show a rather different pattern. The highest point falls slightly before that on the middle lobe, while the lowest point falls slightly after that on the middle lobe. This may suggest a slight difference in the formation time of the two lobes. The two lobes remain within 1‰ of each other, not a significant difference given analytical uncertainty of +/- 0.4 ‰ (2 sd).

The $\delta^{18}O$ values from the middle lobe of BM422 fall between the two lobes of BM421. They track the middle lobe of BM421 with a slight offset. This suggests that this individual was either born slightly earlier in the year, or started tooth formation at an earlier point in its life (Fricke and O'Neil 1995). BM422 is significantly more worn than BM421, Grant's (1982) Stage g/h compared to Grant Stage a. The remaining portion of the tooth thus represents the summer, autumn and early winter of the animal's second year of life.

The $\delta^{18}O$ values of BM422 track those of the Irthlingborough aurochs (Towers et al. 2011), which are around 2‰ higher. The $\delta^{18}O$ values of the Irthlingborough aurochs however, have a much wider range (2‰), showing a more pronounced seasonal variation than the Blick Mead individuals.

4.3 Carbon Isotope Results

The $\delta^{13}C$ values are shown in Figure 8. The mesial lobe from BM421 remains relatively constant, with less than 0.75‰ variation, although this exceeds analytical uncertainty of +/- 0.2‰ (2sd) until about 15mm from the ERJ when it decreases sharply by over 1‰. Around 9mm above the ERJ the values flatten out. The middle lobe of BM421 is also relatively flat, staying within 1‰ throughout. However, it is considerably lower until around 8mm from the ERJ, when the two lobes come together.

The middle lobe of BM422 shows a similar pattern to the mesial lobe of BM421, becoming lower towards the ERJ. It occurs later in the formation of the tooth, the offset mirroring that in the $\delta^{18}O$ values. As such it can be explained by differences in either the time of birth or the developmental rate in the individuals. Near the ERJ the $\delta^{13}C$ values of BM422 briefly fall, a change also visible in BM421 although to a lesser extent. Like BM421, the $\delta^{13}C$ values of BM422 do not fall after the winter trough seen in the $\delta^{18}O$ profile.

The $\delta^{13}C$ values of both Blick Mead teeth differ from those of the Irthlingborough aurochs. Irthlingborough does not change in a way corresponding to the changes observed in the $\delta^{18}O$ values, despite falling towards the ERJ. Initially, as the $\delta^{18}O$ values decrease the $\delta^{13}C$ values remain constant, within 0.2‰; then they increase by 1‰ before finally falling by around 0.5‰ around 15mm before the ERJ.

Three samples used for strontium isotope analysis were also tested for $\delta^{13}C$ and $\delta^{18}O$. The $\delta^{13}C$ results are shown in Figure 8. They differ from the results produced at Bradford but remain within 1‰ of the Bradford results.

4.4 Strontium Isotope Results

The Sr-87/Sr-86 results from the three samples are listed in table 5. Variations between them are minimal: less than 0.0001 variation.

4.5 Diagenesis

One possible cause of these results is diagenesis. This has however been discounted for several reasons. Firstly, while the quantities of carbonate in the samples are higher than in modern teeth, they are not significantly high (Towers 2015, pers. comm.). In order to check this, the isotope ratios of carbon and oxygen have been plotted against the percentage of CO_3 (fig. 9). There is no correlation between either the isotope ratio or the quantity of CO_3 in the sample. This was true for both runs of the samples. A correlation might have suggested that the lower or higher isotope ratios were diagenetic, and not the result of changes in diet or climate.

The difference between the two lobes of BM421 could suggest diagenesis in this tooth, particularly given the crack down the mesial lobe. However, this lobe was not sampled across the crack: only one half of the lobe was sampled (Figure 6 top right). Furthermore, the carbon in carbonates is more resistant to diagenetic change than the oxygen (Wang and

Cerling, 1994). There are some differences between the $\delta^{18}O$ values in the two lobes from BM421. However, this is less than the difference in the $\delta^{13}C$ values between the two lobes.

The low values for the oxygen isotope ratios also suggest that diagenesis should be discounted. The teeth were recovered from a chalk environment. The $\delta^{18}O$ value for chalk is high, so any diagenetic change would increase the $\delta^{18}O$ values (Jenkyns et al. 1993). Given that the $\delta^{18}O$ values are already low, the incorporation of diagenetic chalk-derived oxygen is unlikely as this would imply the original biogenic values were even lower and more extreme.

The strontium concentrations in the main group of samples were not measured, so it is not possible to determine if they are physiologically unusually high and indicative of post-mortem addition. The age of the teeth and the crack in the mesial lobe of BM421 could suggest that diagenesis might have occurred, since the strontium isotopes are comparable with those of the chalk burial environment (Evans et al. 2010). However, enamel is considered to be considerably more resistant to strontium diagenesis than dentine or bone and is usually a reliable reservoir for biological strontium (Budd et al. 2000). The strontium isotope ratios from the teeth are therefore likely to be a true reflection of the values in life.

4.6 Discussion

Based on modern precipitation maps, the $\delta^{18}O$ values for both Blick Mead aurochs are very low. They are over 2‰ lower than the Irthlingborough aurochs, which would be expected to have a lower $\delta^{18}O$ value than the Blick Mead aurochs due to Irthlingborough's more north-easterly location (Darling et al. 2003) and because global temperatures in the early Holocene were warmer than during the Bronze Age (Roberts 2014). It is possible that the Irthlingborough aurochs tooth could have been curated and thus significantly predate the early Bronze Age barrow in which it was found. However, the Irthlingborough aurochs $\delta^{18}O$ values fall within the range of the Bronze Age domestic cattle teeth also recovered from the barrow (Towers et al. 2011), suggesting the Irthlingborough aurochs and cattle are contemporary and consistent with the region of burial. However, these expectations are based on modern $\delta^{18}O$ values for precipitation, groundwaters and surface waters, and contours, and these may have changed between the Mesolithic, the Early Bronze Age, and today. If the aurochs were drinking only from the spring at Blick Mead this would explain why the $\delta^{18}O$ results are so homogeneous, as springs fed from underground aquifers rather than directly from seasonal rainfall can average out seasonal change. It would however not explain why they are so low: the spring is thought to have formed in the early Holocene (Jacques pers. comm.), so the lower $\delta^{18}O$ values obtained cannot be explained by the aurochs drinking from a spring tapping an underground aquifer formed largely during the last glacial, and thus having a $\delta^{18}O$ value that reflects much colder temperatures. Today, the River Avon, into which the spring flows, has almost identical $\delta^{18}O$ values to the spring, i.e. -6.5‰, suggesting neither is anomalous and both contain water in line with Darling et al.'s (2003) oxygen isotope map.

When the enamel carbonate to drinking water conversion equation of Chenery et al. (2012) is applied to the $\delta^{18}O$ means, prior to the running average being applied, the resulting rainwater $\delta^{18}O$ values range from -9.2‰ and -13.7‰. Mean annual modern precipitation in Britain ranges from -4.0 ‰ to -9.0 ‰ (Darling et al. 2003), so although the higher values could be consistent with areas of eastern Scotland and northern England, values below -10.0 ‰ are clearly inconsistent with Britain today. None of the oxygen isotope ratios fall within the range for southwestern England (although it must be remembered that the Chenery et al. (2012) equation was derived from archaeological humans rather than cattle, and the two species may not have comparable metabolisms and thus may not fractionate oxygen isotopes during uptake and incorporation in a comparable manner). A possible explanation of the anomalously low $\delta^{18}O$ values is therefore that the aurochs migrated to Blick Mead after developing their M3s in a more northerly region such as Scotland. Scandinavia is even a possibility because the site was first occupied when Britain was still connected to mainland Europe. Aurochs tooth BM422 has been directly dated to too late a date for this to be a possibility. BM421 could however not be directly dated, and could therefore be early enough for a long migration to be theoretically feasible. However, it seems most unlikely.

The results from the Sr-87/Sr-86 values are consistent with the animals being local to the site (Evans et al. 2010). It is difficult to reconstruct water sources and rainfall patterns in the Mesolithic. There are areas in the UK which today have similar Sr-87/Sr-86 values and also low oxygen isotope ratios, for example around the Humber estuary. This location, however, would not explain why the $\delta^{18}O$ curves are so flat. The possibility cannot be ruled out that the aurochs could have migrated from somewhere in the now-submerged Doggerland where no Sr-87/Sr-86 or $\delta^{18}O$ biosphere data are available. Alternatively, it could have followed a migration route that never left chalk. Both oxygen and strontium isotopes could theoretically be explained by the aurochs having come from the Alpine region or the Massif Central through France, where there are areas of chalk. However, this migration also seems highly unlikely, and could only have occurred in the Early Mesolithic when there was a land bridge connecting Britain to the continent.

This discussion of the oxygen and strontium isotopes thus suggests that, while migration cannot be ruled out, it is most unlikely that the aurochs came from far away. We therefore conclude that the aurochs were most probably local. We are unable to account for the low $\delta^{18}O$ values. Perhaps the values in the spring water have changed, or alternatively the values in rainwater may have done so, since the Mesolithic.

The enamel $\delta^{13}C$ values indicate the feeding behavioural ecology of the animals. The decrease in the mesial lobe of BM421 by around 1.3‰, and the lesser decrease in BM422, could be explained by the canopy effect: under tree cover, $\delta^{13}C$ values can be reduced by up to 4‰. This is due to an increase in the recycled CO_2 under tree cover related to the amount of light reaching leaves for photosynthesis (Heaton 1999). This decrease occurs at the same time as the $\delta^{18}O$ values decrease from summer peak to winter trough, which could indicate that the animals moved into a more wooded area for the winter. It could also be explained by a dietary change, away from leaves and towards branches and bark. The animals might also have eaten acorns or other autumn fruits. Such behaviours were observed in 16th century Polish aurochs (van Vuure 2005). The decrease is small, possibly insignificant in BM422, which could indicate that the woodland into which they moved was not very dense, so the increase in the amount of recycled CO_2 was only small. There could be other causes of this variation. The age of a plant can affect its $\delta^{13}C$ values, and this would vary throughout the year, with most young plants appearing in the spring and summer (Heaton 1999). However, Donovan and Ehleringer (1992) found that the $\delta^{13}C$ of a plant increased with age; while at Blick Mead the values decreased in autumn when the plants would be older.

The middle lobe of BM421 however does not track the mesial lobe, indicating instead a relatively constant diet throughout the year. It is not currently possible to determine which lobe gives a true reflection of the diet of the animal. As a result it is not possible to draw a definitive conclusion for the $\delta^{13}C$ for BM421.

The $\delta^{13}C$ values for the Blick Mead animals are similar to those of the Irthlingborough aurochs (Towers et al. 2011). This is likely to be due to their having similarly mixed diets, obtained from a relatively dense woodland settling (Wright and Viner-Daniels 2015) despite their different locations.

The repeatable difference between the two lobes of BM421 for the $\delta^{13}C$ values are around 1‰. This is only just outside the margin of error of the samples, 0.4‰ to 2σ, and so is not significant. However, the two sample groups – measured on the same instrument, from the same samples – show a wide range of values from the same tooth. This highlights the potential for over-interpretation of results which vary by less than 1‰. We have argued that the difference is unlikely to be caused by diagenesis. The discrepancy between the results from the same lobe tested at Bradford and in Wisconsin/North Carolina is smaller: between 0.5‰ and 1‰. This further highlights the problems: the samples sent to Wisconsin were not the same as those tested in Bradford, but they were taken from the ridges between the Bradford samples and so should not be very different from them.

It is not possible to determine which $\delta^{13}C$ values give the best reflection of the aurochs' diets. The results are not different enough to suggest that there is an inherent difference between the lobes. Experiments on modern cattle teeth, with no preservational or diagenetic effects, could determine if there is an inherent difference between the lobes of the same tooth.

5 CONCLUSIONS

Our analysis of the Blick Mead animal bones make a valuable contribution to our understanding of Mesolithic diets and to the behavioural ecology of the now-extinct aurochs. The high percentage of aurochs is unique in Britain and the near continent. The poor preservation and fragmentary nature of the remains may have caused a bias towards larger animals, but the proportion of aurochs is still significantly higher than at any other site. Blick Mead appears to fit within a landscape of specialisation, with different resources utilised at different sites. We have tentatively argued that skeletal part frequency does not resemble that expected at a hunting camp. This could support the suggestion that Blick Mead was a home-base. This agrees with the conclusions from the study of lithic assemblage (Jacques this volume).

It is likely that the aurochs were non-migratory, and did not move large distances away from Blick Mead. This is based on the strontium isotope results, despite the low $\delta^{18}O$ values, and is supported by the $\delta^{13}C$ values. It is possible that the inhabitants of Blick Mead chose this location for their home-base because of its natural resources, perhaps including an unusual abundance of aurochs. The $\delta^{18}O$ results suggest that the aurochs were indeed born in spring, like their historically-recorded counterparts. The $\delta^{13}C$ results suggest that aurochs may have moved into denser woodland during the winter. Further work needs to be done to determine if there is an inherent difference between the different lobes of the same tooth, but taken together the isotopes do not suggest long-distance migration.

Acknowledgements

We would like to thank David Jacques allowing us to study this remarkable assemblage. He provided BR and PR-C with opportunities to visit the site and answered numerous questions regarding the excavation process and the stratigraphy. He and Tom Phillips provided access to the plans and sections. Thanks also go to David and the whole Blick Mead Project for providing the funding for both the isotopic analyses of the teeth and the radiocarbon dates, and for Sophy Charlton's ZooMS results. We also thank Umberto Albarella for acting as external referee; his comments and suggestions have substantially improved this paper. We also thank site custodian Mike Clarke for help with taking the water samples, Vicky Garlick and Dr Tina Jakob for the X-rays of Fragment 1119, and Jeff Veitch for his superb photos in figures 2 and 6. Lastly we thank Jim Burton for preparation and analysis of the strontium samples.

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Species	**Total**	**Trench 19**	**Trench 22**	**Trench 23**	**Trench 24**
Aurochs, *Bos primigenius*	155	139	13	1	2
Aurochs? cf *Bos primigenius*	4	4	0	0	0
Red Deer, *Cervus elaphus*	46	42	2	2	0
Red Deer? cf *Cervus elaphus*	4	4	0	0	0
Elk, *Alces alces*	5	5	0	0	0
Elk? cf *Alces alces*	1	1	0	0	0
Red Deer or Elk, *Cervus* or *Alces*	2	2	0	0	0
Roe Deer, *Capreolus capreolus*	8	7	0	1	0
Wild Boar, *Sus scrofa ferus*	23	23	0	0	0
Hare, *Lepus* cf. *timidus*	1	0	1	0	0
Sheep/Goat, *Ovis* or *Capra*	9	3	5	0	1
Domestic Cow, *Bos primigenius taurus*	5	1	0	0	4
Domestic Pig, *Sus scrofa domesticus*	5	4	0	0	1
Bird, Aves	1	0	0	1	0
Dog, *Canis familiaris*	1	1	0	0	0
Rabbit, *Oryctolagus cuniculus*	1	0	0	0	1
Total Identified	271	236	21	5	9
Unidentified	2159	2065	44	11	39
Total	2430	2301	65	16	48

Table 1. The animal bones from Blick Mead. The totals are Number of Identified Fragments (NISP).

	Aurochs (N = 155)					**Red Deer (N = 45)**				
Element	**L**	**Unsided**	**R**	**MNI**	**MNE**	**L**	**Unsided**	**R**	**MNI**	**MNE**
horn core/antler		2		**1**	**1**		1		**1**	**1**
pre-maxilla	1			**1**	**1**					
upper molar	1			**1**	**1**	1			**1**	**1**
lower M3	1		1	**2*[1]**	**2**	1			**1**	**1**
lower incisor	1			**1**	**1**					
tooth fragment		33					5	1	**1**	**1**
atlas (C1)		1		**1**	**1**		1		**1**	**1**
axis (C2)		1		**1**	**1**					
scapula			2	**2**	**2**	2			**1**	**1**
proximal humerus		1		**1**	**1**					
distal humerus	2		1	**2**	**3**	2		1	**1**	**2**
proximal radius	2		3	**3**	**4**	1		1	**1**	**2**
distal radius	1		2*[2]	**1**	**1**	1			**1**	**1**
ulna		1		**1**	**1**					
cuneiform			2	**2**	**2**		1		**1**	**1**
magnum			1	**1**	**1**	2			**2**	**2**
scaphoid		1		**1**	**1**			1	**1**	**1**
lunate	1			**1**	**1**					
unciform	1			**1**	**1**	1			**1**	**1**
metacarpal	4	3	4	**2**	**4**	1	2		**1**	**1**
pelvis	1	1	1	**1**	**2**					
proximal femur	1		3	**3**	**4**	2			**1**	**1**
distal tibia			1*[2]			2		2	**2**	**3**
astragalus	3		1	**3**	**4**	1		1	**1**	**2**
calcaneum			3	**3**	**3**	2			**2**	**2**
naviculocuboid	2		2	**2**	**2**	2			**2**	**2**
metatarsal	5*[3]	2	1	**3**	**3**	2	3		**1**	**1**
metapodial fragment		6		**2**	**5**					
1st Phalanx		8		**2**	**8**					
2nd Phalanx		14		**4**	**14**		1		**1**	**1**
3rd Phalanx		4		**1**	**4**					
sesamoid		1		**1**	**1**					
limb bone fragment		2		**1**						
bone fragment		19		**1**						

Table 2. Skeletal distribution of the aurochs and red deer bones from Blick Mead.

*[1] These teeth have been identified as coming from separate individuals based on their wear stages.
*[2] Includes one mid-shaft fragment.
*[3] Includes one fragment which was identified as possibly left.

Fragment Number	Trench	Context	Element	Fusion	Side	Measurement
AUROCHS						
421	19	59C	M3 (lower)		R	L = 45.3
422	19	59C	M3 (lower)		L	L = 45.8
727	19	77.4	humerus	F	R	SD = 43.5
2233	19	65	astragalus		L	GLl = 83.19, Bd = 59.92
1120	19	77.4	astragalus		R	BD = 68.9, GLl = ((80.6))
559	19	unstrat	metatarsal		L	BP = 51.2
1121	19	77.4	1st phalanx	F		SD = 27.6, BD = 32.8
560	19	unstrat	2nd phalanx	F		GLl = 50.5, BD = 36.8
670	19	92	2nd phalanx	F		GL = 45.4, BP = 34.0, BD = 23.6, SD = 2
1118	19	77.4	2nd phalanx	F		GL = 40.5, BP = 33.8, BD = 38.4, SD =
1119	19	77.4	2nd phalanx	F		GL = (34.9), SD = 29.5
2181	19	unstrat	2nd phalanx	?		SD = 25.4, BD = 27.6
2351	19	67	2nd phalanx	F		GLl = 49.3, Sd = 26.9, Bd= (26.7), Bp =
2361	19	67	2nd phalanx	F		GLl = 46.5, Bp = 32.6, Bd = 27.8, Sd = 2
RED DEER						
1125	19	77.4	scapula	F	L	GL = 55.5, SLC = 36.7
1	19	61	humerus	F	L	HT = 42.6
1122	19	77.4	tibia	F	L	DD = 30.7
532	19	unstrat	astragalus		L	GLl = 54.7, BD = 33.0
WILD BOAR						
1890	19	77.4	lower M1		R	L = 17.3, WA = 9.9, WP = 11.0
6	19	61	humerus	F	L	HT = 38.0
657	19	92	humerus	?	R	SD = 19.8
99	19	77.2	astragalus		R	GLl = 41.0
665	19	92	astragalus		R	GLl = (49.6)
ROE DEER						
101	19	77.2	tibia	F	R	BD = 26.9
100	19	77.2	astragalus		L	GLl = 28.9, BD = 17.7, Dl = 15.9
HARE						
634	22	unstrat	tibia	F, F	L	GL = 92.9, BP = 13.3, BD = 12.4
DOMESTIC DOG						
726	19	77.5	upper P4		L	GL = 19.9, GB = 11.9, B = (8.3)

Table 3. Measurements from bones at Blick Mead, following the definitions of von den Driesch (1976), except humerus HT, from Legge and Rowley-Conwy (1988).

	Roe Deer (n=8)				
Element	**L**	**Unsided**	**R**	**MNI**	**MNE**
lower P4	2			**2**	**2**
upper M1 or M2			1	**1**	**1**
distal femur	1			**1**	**1**
distal tibia			1	**1**	**1**
astragalus	1			**1**	**1**
metatarsal	1			**1**	**1**
2nd phalanx		1		**1**	**1**
	Elk (n=5)				
upper M1 or M2			2	**1**	**2**
lower M1 or M2		1	1	**1**	**2**
distal tibia			1	**1**	**1**
metacarpal		1		**1**	**1**
	Wild Boar (n=23)				
lower canine	1		1	**1**	**2**
lower M1			1	**1**	**1**
M3 fragment		1		**1**	**1**
lower M3	1	1		**1**	**2**
lower P4 lower		1		**1**	**1**
molar fragment		1		**1**	**1**
distal humerus	1		1	**1**	**2**
ilium	1			**1**	**1**
distal tibia	2			**1**	**1**
astragalus	1		3	**3**	**4**
calcaneum	2	1	1	**2**	**3**
2nd phalanx		1		**1**	**1**
bone fragment		1			

Table 4. Skeletal distribution of the elk, roe deer and wild boar from Blick Mead.

Sample Number	Distance from the ERJ (mm)	Sr-87/Sr-86
BMSr-1	48.78	0.708598
BMSr-2	26.14	0.708656
BMSr-3	6.34	0.708671

Table 5. Results of Sr-87/Sr-86 analysis of the Blick Mead teeth

Sample	$\delta^{13}C$	Average	$\delta^{15}N$	Average	C:N
BM557a	-23.70	-23.62	3.62	3.62	3.41
BM557b	-23.78		3.62		3.29
BM658a	-23.71	-23.74	3.82	3.81	3.27
BM658b	-23.54		3.81		3.22

Table 6. The bulk collagen results from aurochs bone samples from Blick Mead.

BM 421, Mesial lobe

		run 1					run 2				
sample	ERJ	weight mg	δ^{18}O VSMOW ‰	SD	RA	%CO3	weight mg	δ^{18}O VSMOW ‰	SD	RA	%CO3
BM421-1	52,70	2.941	23,2	0,21	23,4	6,7	0.54	22,2	0,16	22,4	6,8
BM421-2	50,90	2.927	23,5	0,16	23,3	6,6	1.72	22,6	0,11	22,2	6,6
BM421-3	48,57	2.935	23,0	0,30	23,8	5,2	1.70	21,9	0,15	22,9	6,7
BM421-4	46,63	2.848	25,0	0,26	23,6	4,8	1.73	24,2	0,11	23,1	6,8
BM421-5	43,93	3.076	22,9	0,18	24,2	5,0	1.72	23,8	0,09	23,9	6,8
BM421-6	41,74	2.739	24,7	0,07	23,7	4,7	1.72	24,4	0,13	23,7	7,0
BM421-7	40,00	2.884	23,6	0,16	24,6	5,3	1.82	23,6	0,07	24,3	6,9
BM421-8	37,85	2.878	25,4	0,16	24,3	5,2	1.60	24,8	0,10	24,1	7,1
BM421-9	35,54	2.889	23,9	0,12	24,3	5,2	1.75	23,8	0,09	24,1	7,0
BM421-10	32,96	2.739	23,7	0,18	23,5	4,8	1.72	23,9	0,05	23,7	6,7
BM421-11	30,22	2.896	22,8	0,27	23,3	4,3	1.56	23,4	0,06	23,6	6,5
BM421-12	28,34	2.665	23,4	0,28	23,2	4,0	1.76	23,7	0,07	23,4	6,1
BM421-13	26,06	2.616	23,4	0,18	23,6	5,0	1.57	23,2	0,10	23,7	7,0
BM421-14	24,12	2.671	24,1	0,14	23,8	4,8	1.81	24,3	0,08	23,6	6,6
BM421-15	22,54	2.722	24,0	0,08	23,9	4,4	**	**	**	**	**
BM421-16	19,76	2.940	23,8	0,15	23,6	4,9	1.73	23,3	0,07	23,6	6,4
BM421-17	18,03	2.626	23,2	0,17	23,2	4,7	1.75	23,1	0,07	23,0	6,9
BM421-18	15,59	2.718	22,6	0,12	23,1	5,0	1.61	22,6	0,10	23,2	6,7
BM421-19	13,44	2.791	23,8	0,29	22,8	4,9	1.72	23,7	0,07	22,9	6,9
BM421-20	11,31	2.731	22,3	0,14	22,8	5,1	1.42	22,4	0,10	22,8	6,9
BM421-21	9,17	2.674	22,6	0,19	22,4	5,9	1.65	22,3	0,06	22,4	7,5
BM421-22	7,01	2.936	22,4	0,15	22,5	5,9	1.69	22,5	0,07	22,5	8,0
BM421-23	4,45	2.803	22,7	0,10	22,7	5,4	1.78	22,5	0,06	22,7	7,5
BM421-24	2,70	2.580	22,9	0,15	22,8	6,2	1.57	23,0	0,12	22,7	8,2

BM 421, Middle lobe

		run 1					run 2				
sample	ERJ	weight mg	δ^{18}O VSMOW ‰	SD	RA	%CO3	weight mg	δ^{18}O VSMOW ‰	SD	RA	%CO3
BM421-41	50,70	2.812	22,8	0,17	23,1	5,1	1.60	22,6	0,15	22,8	7,1
BM421-42	48,78	2.874	23,4	0,25	23,2	5,3	1.73	22,9	0,09	22,9	7,3
BM421-43	46,88	2.953	23,3	0,20	23,5	5,1	1.64	23,1	0,08	23,0	7,3
BM421-44	44,15	2.941	23,7	0,11	23,5	4,9	1.58	22,9	0,13	23,0	7,2
BM421-45	41,81	2.931	23,5	0,13	23,7	5,0	1.68	23,1	0,09	23,1	6,7
BM421-46	39,81	2.997	23,9	0,09	23,7	5,1	1.67	23,2	0,11	23,2	6,8
BM421-47	37,58	2.999	23,6	0,17	23,8	4,9	1.54	23,2	0,07	23,2	6,8
BM421-48	35,39	2.717	23,8	0,15	23,5	4,9	1.62	23,2	0,11	23,3	6,4
BM421-49	33,49	2.858	23,2	0,18	23,4	4,9	1.835	23,4	0,13	23,2	6,9
BM421-50	31,08	2.561	23,2	0,32	23,2	4,9	1.544	23,1	0,11	23,1	7,2
BM421-51	28,59	2.860	23,2	0,20	23,2	5,1	1.792	22,8	0,16	22,9	7,0
BM421-52	26,14	2.904	23,2	0,24	23,1	5,1	1,579	22,7	0,08	22,7	7,0
BM421-53	24,43	2.866	22,8	0,13	22,8	4,9	1.642	22,4	0,14	22,8	7,1
BM421-54	21,63	2.949	22,5	0,18	22,9	4,1	1.775	22,5	0,08	22,5	7,2
BM421-55	19,01	2.861	23,3	0,15	22,8	4,8	1.695	22,5	0,11	22,4	7,0
BM421-56	17,04	2.595	22,6	0,33	22,8	4,8	1.747	22,1	0,09	22,3	7,1
BM421-57	14,49	2.970	22,5	0,10	22,3	4,7	1.780	22,3	0,06	22,2	7,0
BM421-58	12,33	2.611	21,8	0,12	22,2	3,8	1.765	22,1	0,07	22,2	6,8
BM421-59	10,39	2.907	22,5	0,15	22,3	5,0	1.746	22,1	0,08	22,4	7,1
BM421-60	8,29	2.953	22,6	0,32	22,5	5,1	1.741	23,0	0,04	22,5	7,3
BM421-61	6,34	3.007	22,5	0,10	22,6	5,0	1.802	22,5	0,09	22,7	7,3
BM421-62	3,79	2.902	22,7	0,26	22,6	4,9	1.642	22,5	0,12	22,5	7,1
BM421-41	50,70	2.812	22,8	0,17	23,1	5,1	1.60	22,6	0,15	22,8	7,1
BM421-42	48,78	2.874	23,4	0,25	23,2	5,3	1.73	22,9	0,09	22,9	7,3

BM 422, Middle lobe

		run 1					run 2				
sample	ERJ	weight mg	δ^{18}O VSMOW ‰	SD	RA	%CO3	weight mg	δ^{18}O VSMOW ‰	SD	RA	%CO3
BM422-1	28,45	2.651	24,0	0,37	23,2	4,7	1.643	23,5	0,10	23,5	6,8
BM422-2	25,35	2.808	22,3	0,15	23,3	4,9	1.737	23,6	0,03	23,4	7,0
BM422-3	23,03	2.697	23,7	0,25	22,8	5,0	1.535	23,3	0,05	23,5	7,1
BM422-4	20,64	2.945	22,3	0,19	23,2	5,1	1.555	23,8	0,10	23,4	7,2
BM422-5	18,06	2.729	23,7	0,17	23,3	4,9	1.761	23,3	0,15	23,5	7,1
BM422-6	16,19	2.752	23,9	0,21	23,4	4,9	1.612	23,3	0,11	23,3	7,2
BM422-7	13,55	2.784	22,6	0,06	23,3	3,3	1.814	23,2	0,09	23,2	7,4
BM422-8	11,51	2.650	23,3	0,17	23,0	5,4	1.662	23,1	0,15	23,1	7,3
BM422-9	8,67	2,732	23,2	0,05	23,1		1.627	23.0	0,10	22,9	7,4
BM422-10	6,19	2,700	22,8	0,06	22,8		1.659	22,6	0,11	22,7	7,5
BM422-11	3,12	2,968	22,4	0,07	22,6		1.791	22,5	0,13	22,5	7,7

Appendix A. δ^{18}O determinations from the aurochs teeth at Blick Mead. ERJ = distance from the Enamel-Root Junction. RA = Running Average. ** = sample too small to complete run 2.

BM 421, Mesial lobe

		run 1					run 2				
sample	ERJ	weight mg	δ^{13}C VPDB ‰	SD	RA	%CO3	weight mg	δ^{13}C VPDB ‰	SD	RA	%CO3
BM421-1	52,70	2.941	-13,3	0,12	-13,5	6,7	0.54	-13,1	0,16	-13,5	6,8
BM421-2	50,90	2.927	-13,7	0,09	-13,7	6,6	1.72	-13,8	0,05	-13,6	6,6
BM421-3	48,57	2.935	-14,1	0,09	-13,7	5,2	1.70	-13,8	0,07	-13,7	6,7
BM421-4	46,63	2.848	-13,5	0,09	-13,9	4,8	1.73	-13,4	0,06	-13,7	6,8
BM421-5	43,93	3.076	-14,2	0,08	-13,8	5,0	1.72	-13,8	0,07	-13,6	6,8
BM421-6	41,74	2.739	-13,7	0,06	-13,9	4,7	1.72	-13,6	0,11	-13,7	7,0
BM421-7	40,00	2.884	-14,0	0,08	-13,8	5,3	1.82	-13,8	0,10	-13,7	6,9
BM421-8	37,85	2.878	-13,7	0,08	-13,9	5,2	1.60	-13,7	0,05	-13,7	7,1
BM421-9	35,54	2.889	-14,0	0,07	-13,8	5,2	1.75	-13,6	0,08	-13,6	7,0
BM421-10	32,96	2.739	-13,7	0,04	-13,8	4,8	1.72	-13,4	0,06	-13,5	6,7
BM421-11	30,22	2.896	-13,7	0,04	-13,7	4,3	1.56	-13,4	0,07	-13,3	6,5
BM421-12	28,34	2.665	-13,6	0,11	-13,9	4,0	1.76	-13,2	0,05	-13,5	6,1
BM421-13	26,06	2.616	-14,3	0,04	-13,9	5,0	1.57	-13,9	0,05	-13,6	7,0
BM421-14	24,12	2.671	-13,8	0,10	-13,9	4,8	1.81	-13,6	0,05	-13,6	6,6
BM421-15	22,54	2.722	-13,6	0,07	-13,7	4,4	**	**	**	**	**
BM421-16	19,76	2.940	-13,6	0,08	-13,7	4,9	1.73	-13,4	0,07	-13,6	6,4
BM421-17	18,03	2.626	-13,9	0,06	-13,9	4,7	1.75	-13,7	0,06	-13,7	6,9
BM421-18	15,59	2.718	-14,2	0,09	-14,0	5,0	1.61	-13,9	0,10	-13,7	6,7
BM421-19	13,44	2.791	-14,0	0,10	-14,3	4,9	1.72	-13,4	0,04	-13,8	6,9
BM421-20	11,31	2.731	-14,6	0,07	-14,5	5,1	1.42	-14,2	0,05	-14,0	6,9
BM421-21	9,17	2.674	-14,8	0,08	-14,7	5,9	1.65	-14,3	0,07	-14,3	7,5
BM421-22	7,01	2.936	-14,6	0,05	-14,6	5,9	1.69	-14,4	0,06	-14,3	8,0
BM421-23	4,45	2.803	-14,5	0,07	-14,5	5,4	1.78	-14,2	0,03	-14,3	7,5
BM421-24	2,70	2.580	-14,4	0,09	-14,5	6,7	1.57	-14,4	0,07	-14,3	8,2

BM 421, Middle lobe

		run 1					run 2				
sample	ERJ	weight mg	δ^{13}C VPDB ‰	SD	RA	%CO3	weight mg	δ^{13}C VPDB ‰	SD	RA	%CO3
BM421-41	50,70	2.812	-14,3	0,07	-14,3	5,1	1.60	-14,1	0,04	-14,2	7,1
BM421-42	48,78	2.874	-14,3	0,08	-14,5	5,3	1.73	-14,3	0,06	-14,3	7,3
BM421-43	46,88	2.953	-14,8	0,09	-14,5	5,1	1.64	-14,4	0,07	-14,4	7,3
BM421-44	44,15	2.941	-14,4	0,05	-14,6	4,9	1.58	-14,5	0,04	-14,5	7,2
BM421-45	41,81	2.931	-14,4	0,05	-14,4	5,0	1.68	-14,5	0,05	-14,5	6,7
BM421-46	39,81	2.997	-14,4	0,05	-14,4	5,1	1.67	-14,4	0,07	-14,3	6,8
BM421-47	37,58	2.999	-14,3	0,04	-14,3	4,9	1.54	-14,0	0,03	-14,2	6,8
BM421-48	35,39	2.717	-14,3	0,05	-14,3	4,9	1.62	-14,3	0,04	-14,2	6,4
BM421-49	33,49	2.858	-14,4	0,07	-14,4	4,9	1.835	-14,5	0,04	-14,4	6,9
BM421-50	31,08	2.561	-14,6	0,08	-14,6	4,9	1.544	-14,6	0,05	-14,6	7,2
BM421-51	28,59	2.860	-14,7	0,09	-14,8	5,1	1.792	-14,8	0,04	-14,6	7,0
BM421-52	26,14	2.904	-14,9	0,07	-14,8	5,1	1,579	-14,4	0,06	-14,6	7,0
BM421-53	24,43	2.866	-14,8	0,05	-14,8	4,9	1.642	-14,7	0,03	-14,6	7,1
BM421-54	21,63	2.949	-14,7	0,06	-14,6	4,1	1.775	-14,8	0,06	-14,7	7,2
BM421-55	19,01	2.861	-14,2	0,15	-14,4	4,8	1.695	-14,4	0,07	-14,6	7,0
BM421-56	17,04	2.595	-14,4	0,20	-14,3	4,8	1.747	-14,5	0,05	-14,4	7,1
BM421-57	14,49	2.970	-14,4	0,08	-14,5	4,7	1.780	-14,4	0,05	-14,5	7,0
BM421-58	12,33	2.611	-14,8	0,04	-14,6	3,8	1.765	-14,6	0,04	-14,5	6,8
BM421-59	10,39	2.907	-14,7	0,07	-14,6	5,0	1.746	-14,5	0,06	-14,5	7,1
BM421-60	8,29	2.953	-14,5	0,18	-14,5	5,1	1.741	-14,2	0,06	-14,3	7,3
BM421-61	6,34	3.007	-14,4	0,07	-14,5	5,0	1.802	-14,1	0,06	-14,3	7,3
BM421-62	3,79	2.902	-14,6	0,11	-14,5	4,9	1.642	-14,5	0,06	-14,3	7,1

BM 422, Middle lobe

		run 1					run 2				
sample	ERJ	weight mg	δ^{13}C VPDB ‰	SD	RA	%CO3	weight mg	δ^{13}C VPDB ‰	SD	RA	%CO3
BM422-1	28,45	2.651	-14,1	0,19	-14,3	4,7	1.643	-14,0	0,07	-14,2	6,8
BM422-2	25,35	2.808	-14,4	0,06	-14,3	4,9	1.737	-14,3	0,06	-14,2	7,0
BM422-3	23,03	2.697	-14,3	0,03	-14,3	5,0	1.535	-14,2	0,03	-14,2	7,1
BM422-4	20,64	2.945	-14,3	0,06	-14,3	5,1	1.555	-14,2	0,06	-14,3	7,2
BM422-5	18,06	2.729	-14,4	0,05	-14,3	4,9	1.761	-14,4	0,03	-14,2	7,1
BM422-6	16,19	2.752	-14,3	0,08	-14,3	4,9	1.612	-14,2	0,07	-14,3	7,2
BM422-7	13,55	2.784	-14,3	0,08	-14,4	3,3	1.814	-14,3	0,04	-14,3	7,4
BM422-8	11,51	2.650	-14,5	0,07	-14,5	5,4	1.662	-14,5	0,02	-14,4	7,3
BM422-9	8,67	2,732	-14,7	0,04	-14,7		1.627	-14,5	0,04	-14,6	7,4
BM422-10	6,19	2,700	-15,	0,04	-14,9		1.659	-14,7	0,06	-14,5	7,5
BM422-11	3,12	2,968	-14,9	0,04	-15,0		1.791	-14,4	0,04	-14,5	7,7

Appendix B. δ^{13}C determinations from the aurochs teeth at Blick Mead. ERJ = distance from the Enamel-Root Junction. RA = Running Average. ** = sample too small to complete run 2.

Figure 1. Distribution of bone fragments in Layer 59.

Figure 2. Butchery traces on aurochs bones from Blick Mead. A: left proximal metacarpal; B: coracoid process of right scapula, arrows indicate cutmarks; C: the flint adhering to fragment 1119; D: X-ray or fragment 1119, showing compression of the bone beneath the flint. (photos A-C: Jeff Veitch; D: Tina Jakob).

Figure 3. Measurements Bd and GLl of the Blick Mead aurochs astragali, compared to those from Star Carr and Denmark. The estimated range of Blick Mead 1120 is shown as well as the actual measurement. Measurements follow von den Driesch (1976). Star Carr from Legge and Rowley-Conwy (1988, table 8). Danish aurochs from Degerbøl and Fredskild (1970, table 19).

Figure 4. Measurements of the red deer astragalus and scapula from Blick Mead, compared to those from Star Carr (from Legge and Rowley-Conwy 1988, table 7).

Figure 5. The Blick Mead animal bone frequencies compared to those from other Mesolithic sites. Percentages are calculated just from the totals of the five species plotted. Top: comparison with other southern English sites. Bottom: comparison with selected Danish Mesolithic sites (Faraday Road from Ellis et al. 2003, table 3; Thatcham from King 1962, pp. 355-361; Three Ways Wharf Scatter C West from Rackham and Pipe 2011; Cherhill from Grigson, in Evans et al. 1983, table 1; Ringkloster from Rowley-Conwy 2013 and unpublished; Agernæs from Richter and Noe-Nygaard 2003, Asnæs Havnemark from Ritchie, Gron and Price 2013; Sværdborg I from Aaris-Sørensen 1976; Ulkestrup Lyng Øst from Richter 1982; Lundby II from Rosenlund 1980).

Figure 6. The aurochs lower M3s sampled incrementally. Top: BM421. Bottom: BM422. Both are shown before and after sampling. (photos: Jeff Veitch).

Figure 7. Oxygen isotope values from the Blick Mead aurochs teeth (run 2), compared to the results from the Irthlingborough specimen. Top: actual values. Bottom: running average. Values are listed in Appendix A.

Figure 8. Carbon isotope values from the Blick Mead aurochs teeth (run 2), compared to the results from the Irthlingborough specimen. Top: actual values. Bottom: running average. Values are listed in Appendix B.

Figure 9. Comparison between the Blick Mead carbonate percentages and the oxygen (top) and carbon (bottom) values. Both runs of the samples are plotted.

Table 1. The animal bones from Blick Mead. The totals are Number of Identified Fragments (NISP).

Table 2. Skeletal distribution of the aurochs and red deer bones from Blick Mead.

Table 3. Measurements from bones at Blick Mead, following the definitions of von den Driesch (1976), except humerus HT, from Legge and Rowley-Conwy (1988).

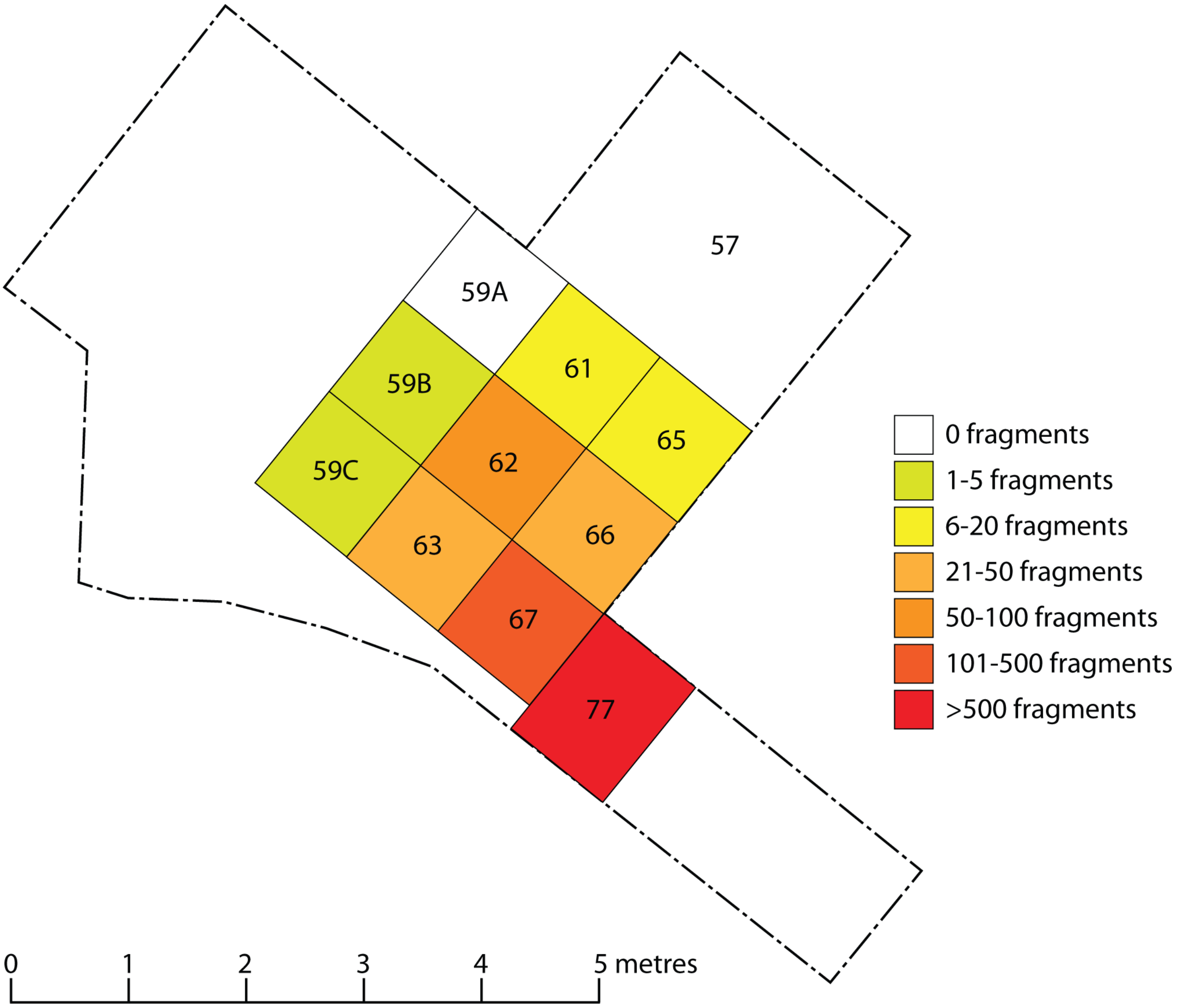
Table 4. Skeletal distribution of the elk, roe deer and wild boar bones from Blick Mead.

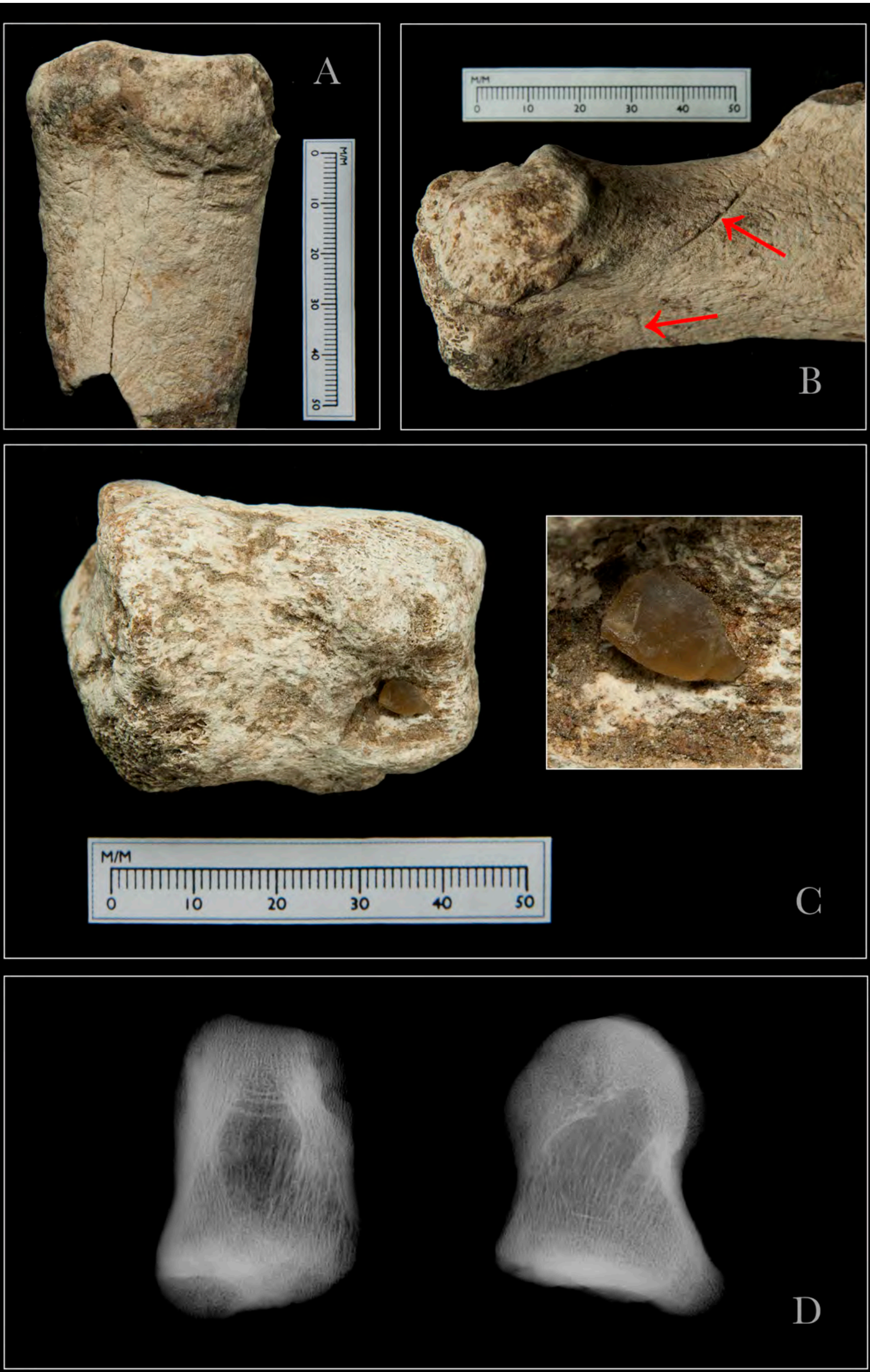
Table 5. Results of Sr-87/Sr-86 analysis of the Blick Mead teeth.

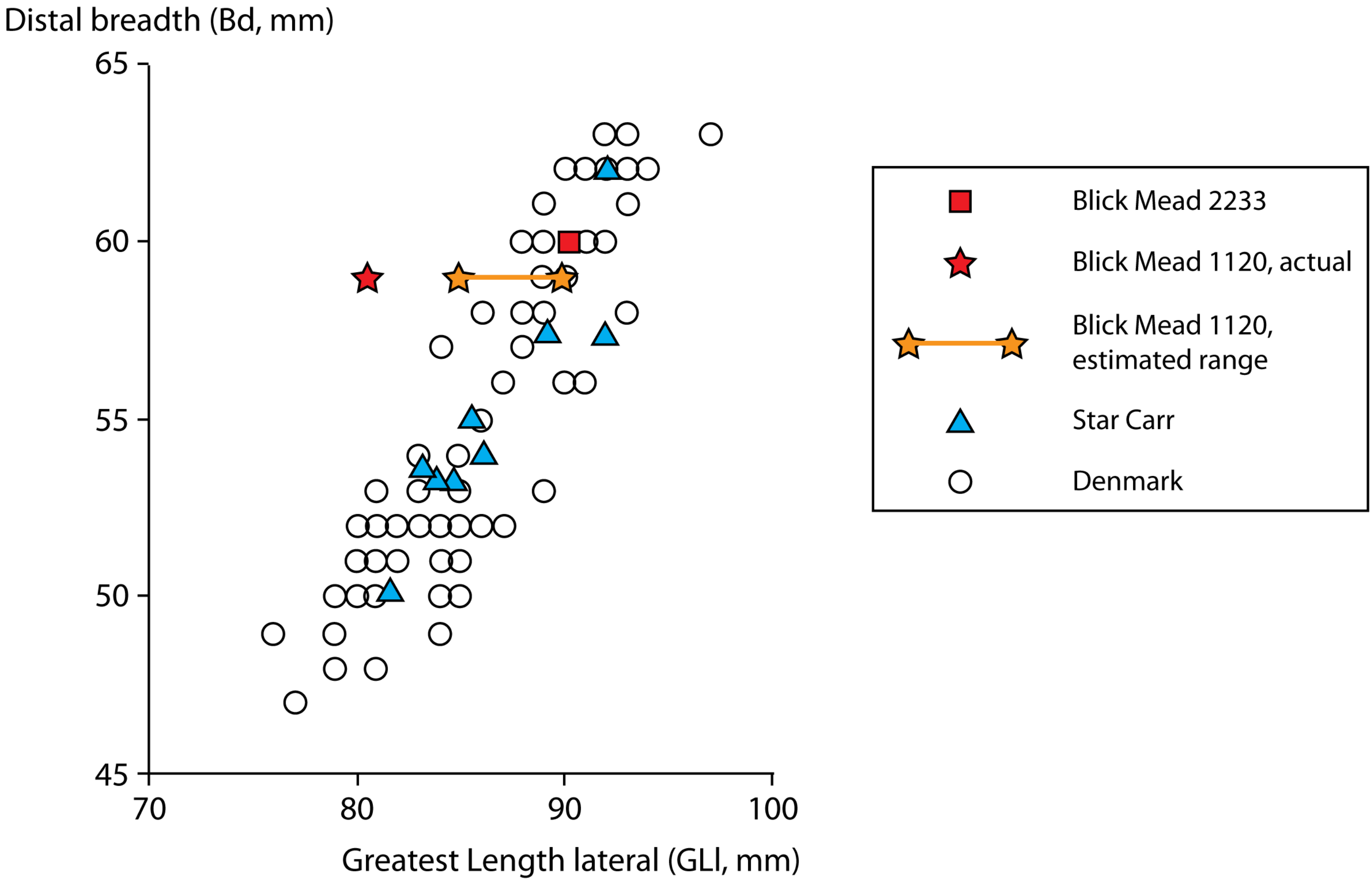
Table 6. The bulk collagen results from aurochs bone samples from Blick Mead.

Appendix A. $\delta^{18}O$ determinations from the aurochs teeth at Blick Mead. ERJ = distance from the Enamel-Root Junction. RA = Running Average.

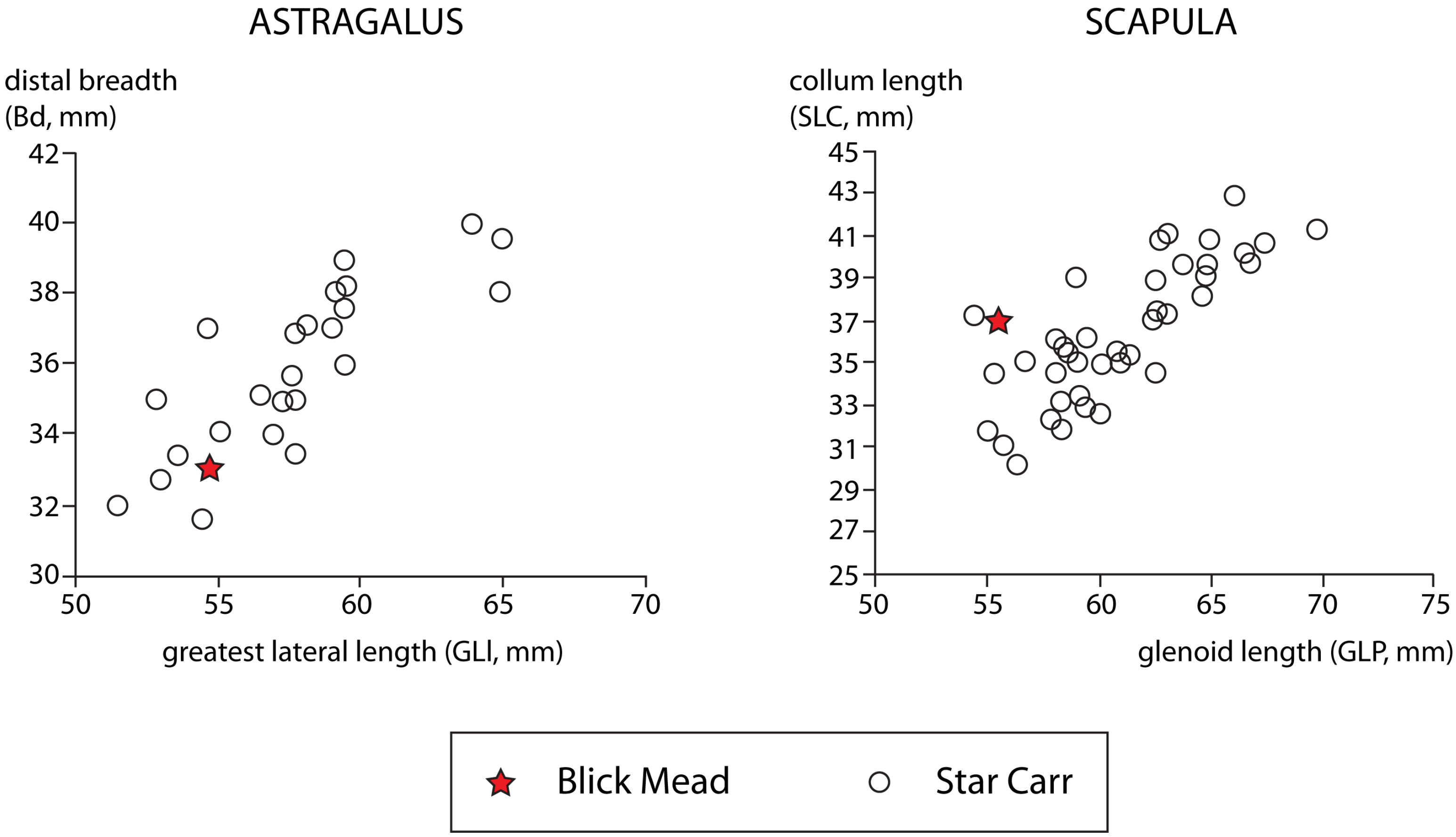
Appendix B. $\delta^{13}C$ determinations from the aurochs teeth at Blick Mead. ERJ = distance from the Enamel-Root Junction. RA = Running Average.

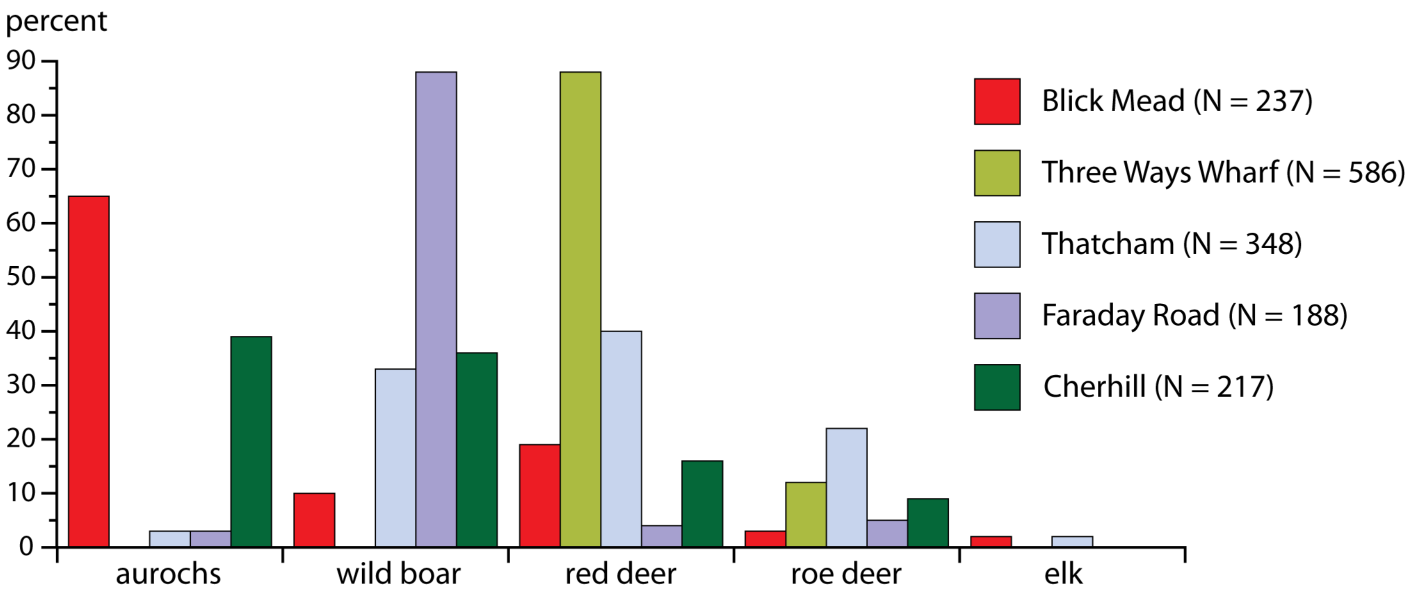

57
59A
59B
59C
61
62
63
65
66
67
77
0 fragments
1-5 fragments
6-20 fragments
21-50 fragments
50-100 fragments
101-500 fragments
>500 fragments
0
1
2
3
4
5 metres

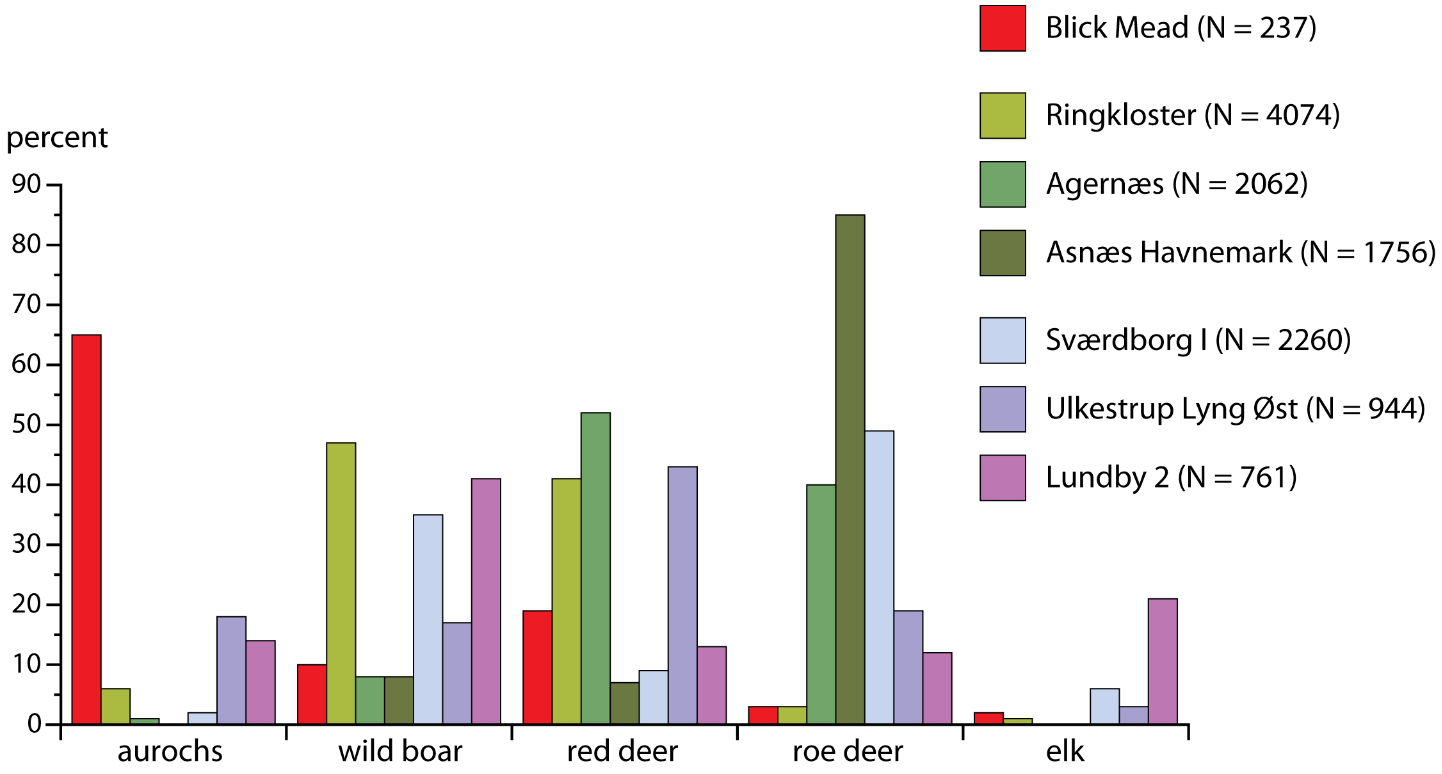

A
M/M
0
10
20
30
40
50
M/M
0
10
20
30
40
50
B
M/M
0
10
20
30
40
50
C
D



Distal breadth (Bd, mm)
65
60
55
50
45
70
80
90
100
Greatest Length lateral (GLl, mm)
Blick Mead 2233
Blick Mead 1120, actual
Blick Mead 1120, estimated range
Star Carr
Denmark


ASTRAGALUS
distal breadth (Bd, mm)
42
40
38
36
34
32
30
50
55
60
65
70
greatest lateral length (GLl, mm)
SCAPULA
collum length (SLC, mm)
45
43
41
39
37
35
33
31
29
27
25
50
55
60
65
70
75
glenoid length (GLP, mm)
Blick Mead
Star Carr


percent
90
80
70
60
50
40
30
20
10
0
aurochs
wild boar
red deer
roe deer
elk
Blick Mead (N = 237)
Three Ways Wharf (N = 586)
Thatcham (N = 348)
Faraday Road (N = 188)
Cherhill (N = 217)

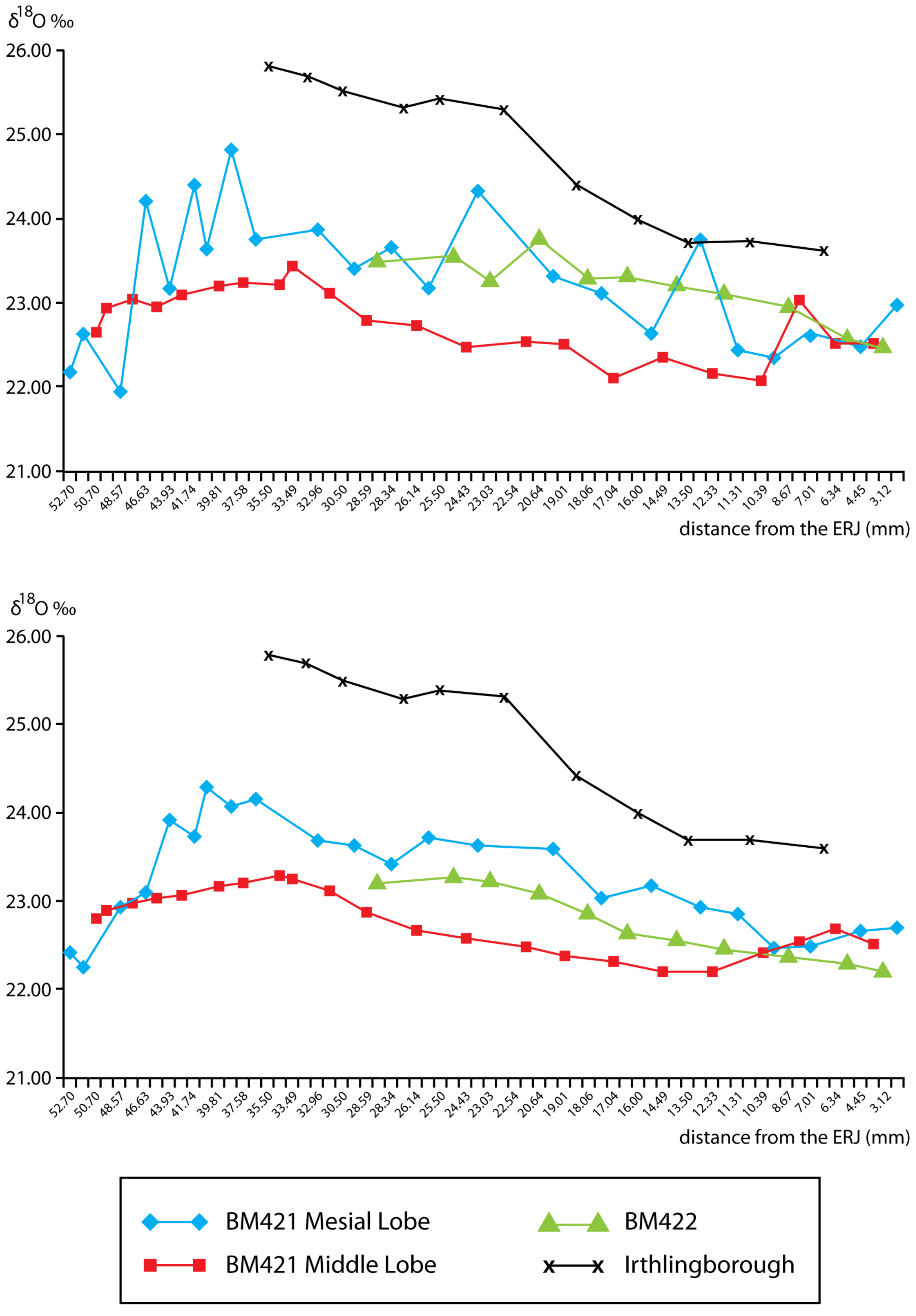

Blick Mead (N = 237)
Ringkloster (N = 4074)
Agernæs (N = 2062)
Asnæs Havnemark (N = 1756)
Sværdborg I (N = 2260)
Ulkestrup Lyng Øst (N = 944)
Lundby 2 (N = 761)
percent
90
80
70
60
50
40
30
20
10
0
aurochs
wild boar
red deer
roe deer
elk


M/M
0
10
20
30
40
50

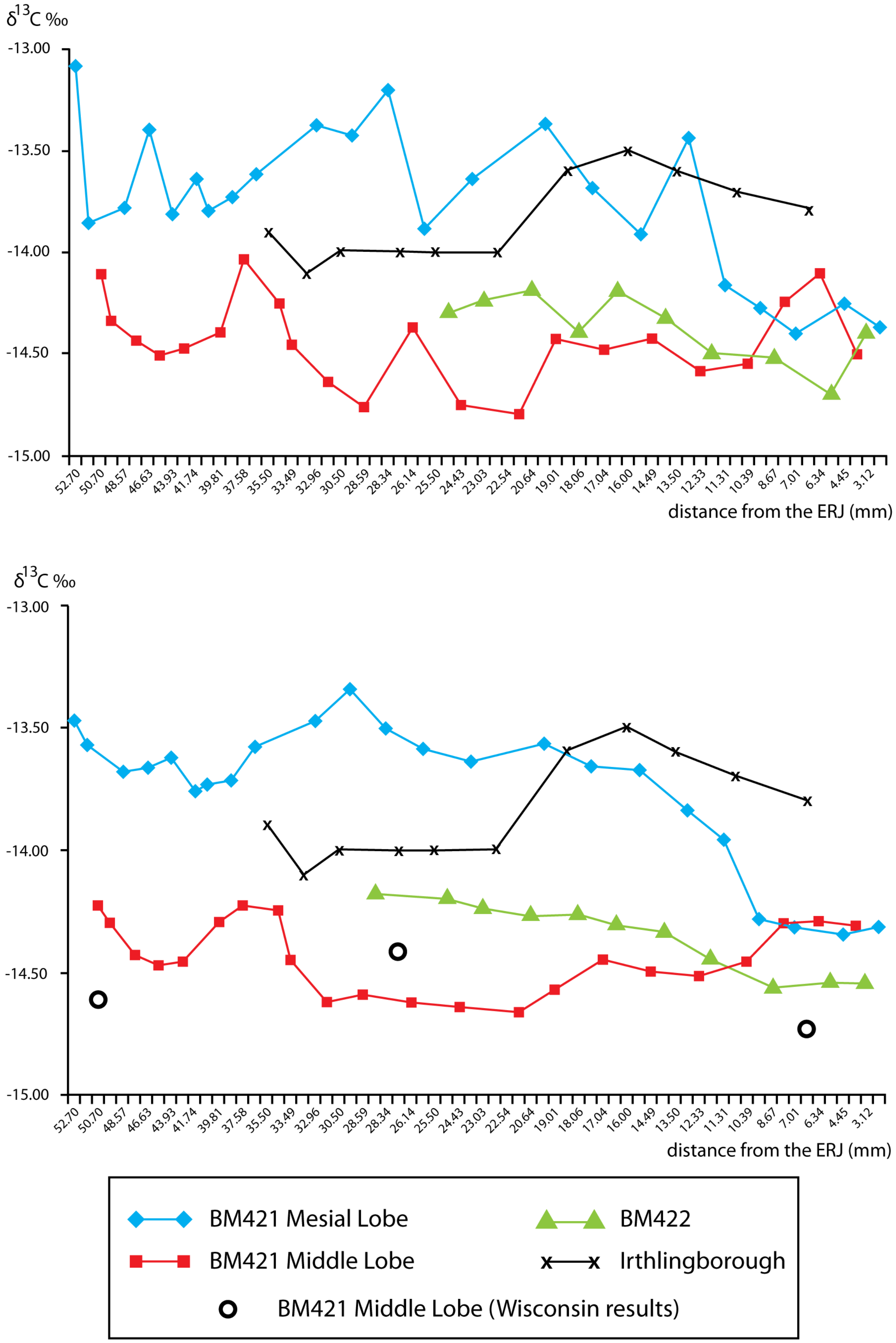

M/M
0
10
20
30
40
50

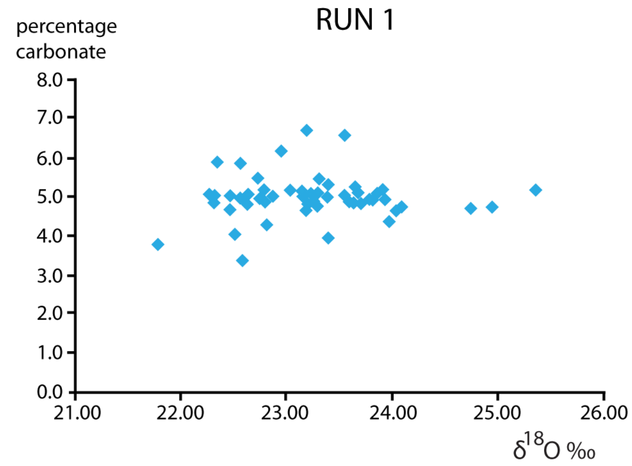

M/M
0
10
20
30
40
50

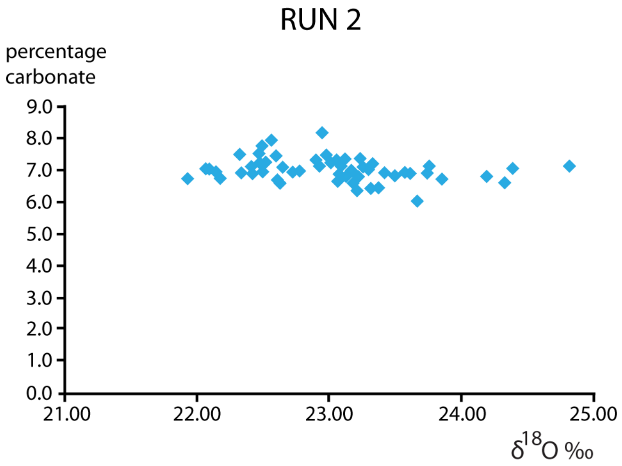

M/M
0
10
20
30
40
50



$\delta^{18}O$ ‰
26.00
25.00
24.00
23.00
22.00
21.00
52.70
50.70
48.57
46.63
43.93
41.74
39.81
37.58
35.50
33.49
32.96
30.50
28.59
28.34
26.14
25.50
24.43
23.03
22.54
20.64
19.01
18.06
17.04
16.00
14.49
13.50
12.33
11.31
10.39
8.67
7.01
6.34
4.45
3.12
distance from the ERJ (mm)
$\delta^{18}O$ ‰
26.00
25.00
24.00
23.00
22.00
21.00
52.70
50.70
48.57
46.63
43.93
41.74
39.81
37.58
35.50
33.49
32.96
30.50
28.59
28.34
26.14
25.50
24.43
23.03
22.54
20.64
19.01
18.06
17.04
16.00
14.49
13.50
12.33
11.31
10.39
8.67
7.01
6.34
4.45
3.12
distance from the ERJ (mm)
BM421 Mesial Lobe
BM421 Middle Lobe
BM422
Irthlingborough


δ13C ‰
-13.00
-13.50
-14.00
-14.50
-15.00
52.70
50.70
48.57
46.63
43.93
41.74
39.81
37.58
35.50
33.49
32.96
30.50
28.59
28.34
26.14
25.50
24.43
23.03
22.54
20.64
19.01
18.06
17.04
16.00
14.49
13.50
12.33
11.31
10.39
8.67
7.01
6.34
4.45
3.12
distance from the ERJ (mm)
δ13C ‰
-13.00
-13.50
-14.00
-14.50
-15.00
52.70
50.70
48.57
46.63
43.93
41.74
39.81
37.58
35.50
33.49
32.96
30.50
28.59
28.34
26.14
25.50
24.43
23.03
22.54
20.64
19.01
18.06
17.04
16.00
14.49
13.50
12.33
11.31
10.39
8.67
7.01
6.34
4.45
3.12
distance from the ERJ (mm)
BM421 Mesial Lobe
BM422
BM421 Middle Lobe
Irthlingborough
BM421 Middle Lobe (Wisconsin results)


RUN 1
percentage carbonate
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
21.00
22.00
23.00
24.00
25.00
26.00
δ18O ‰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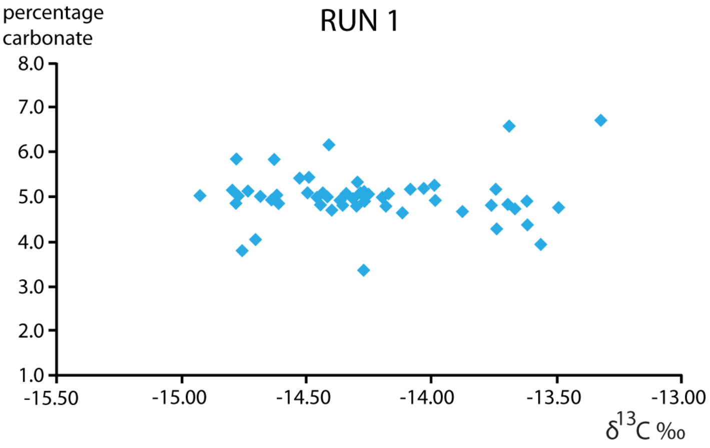
6.0
5.0
4.0
3.0
2.0
1.0
0.0
21.00
22.00
23.00
24.00
25.00
δ18O ‰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percentage carbonate
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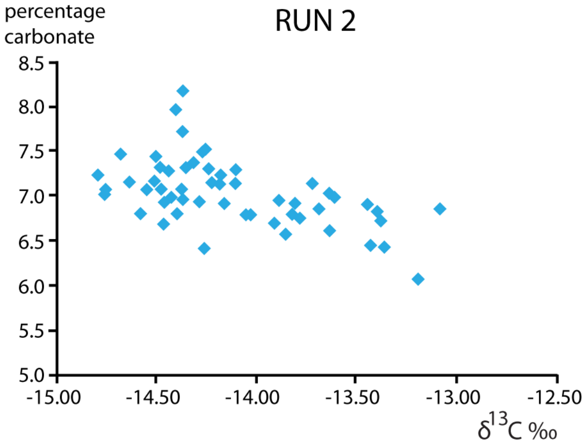
7.0
6.0
5.0
4.0
3.0
2.0
1.0
-15.50
-15.00
-14.50
-14.00
-13.50
-13.00
δ13C ‰


RUN 2
percentage carbonate
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8.0
7.5
7.0
6.5
6.0
5.5
5.0
-15.00
-14.50
-14.00
-13.50
-13.00
-12.50
δ13C ‰