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Report on the Archaeological Resolution of a Multi-Period Burial, Settlement & Industrial Site at Johnstown 1, Enfield, County Meath

Volume 7
Appendices 7-16

Licence No. 02E0462

Linda Clarke

Sept. 2004

APPENDIX 15

DENDROCHRONOLOGICAL REPORT ON TIMBER FROM JOHNSTOWN

By David M. Brown

Queens University Belfast
School of Archaeology and Palaeoecology

Dendrochronology Laboratory Report 17/2003

Dendrochronological report on a timber from Johnstown, Co. Meath

David M. Brown

Summary

A sample of a timber used as a side plank, of a trough, located in a large ditch was submitted for dendrochronological dating. Radiocarbon dating of animal bones gave dating from AD1420 to AD1640. This ditch cut an earlier ditch that returned radiocarbon dates from AD1000 to AD1240. The timber being dated by dendrochronology gave an estimated felling date range of AD1125 ± 9 years or later.

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Dendrochronological report on a timber from Johnstown, Co. Meath

1. Introduction

On the 20th October 2003 the Palaeoecology Centre received a sample from a timber plank from archaeological excavations at Johnstown, Co. Meath. Our reference number for this sample is Q10525. Examination of the sample indicated that it would be suitable for dendrochronological dating.

2. Methodology

Methods at Queens University Belfast dendrochronology laboratory in general follow those described by Baillie (1982) and English Heritage (1998). Details of the exact methods used are described below.

The slices provided were split into sections to ease measurement. The samples were then prepared while still damp. The best-looking radii was selected and prepared for measurement. A Stanley knife was used to remove rough wood on the top surface. Then using a scalpel knife with a number 26 blade a finer cleaner surface was produced. Were the wood sample was soft or needed to be made clearer a razor blade was used. A mixture of finely ground chalk and water was spread onto the prepared surface. This was to define the annual tree-ring boundaries more clearly for measurement.

The sections, which were selected for daring purposes, were measured to an accuracy of 0.01mm using a microcomputer based travelling stage. The tree-ring series obtained for each sample was plotted onto graph paper to facilitate visual comparisons was employed to search for positions where to be made between the tree-ring patterns. In addition cross-correlation algorithm CROS84 (Munro 1984) and Cros73 (Baillie and Pilcher 1973) was employed to search for positions where the tree-ring series were highly correlated. These positions were then checked visually using the plotted graphs. All the measured sequences were compared with each other and any found to match would be combined to form a site master chronology. These and any remaining unmatched tree-ring series were tested against a range of regional and local chronologies using the matching criteria: high *t* – values, replicated values against a range of chronologies at the same position, and satisfactory visual matching. Where such positions are found these provide calendar dates for the tree-ring sequence.

The tree-rings dates produced by this process initially only date the measured tree-rings present in the timber. The interpretation of these dates relies on the condition of the final rings in the sequence. If the samples end in the heartwood of the tree then a *terminus post quem* date is indicated by the date of the last ring plus an addition of the minimum expected number of sapwood rings which are missing. Where some sapwood or the heartwood-sapwood boundary is present, then a death date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. The sapwood estimates are a minimum of 10 and a maximum of 46 annual rings, where these figures indicated the 95% confidence limits of the range. These figures are applicable to oaks from Britain and Ireland. In the Belfast laboratory we us an estimated sapwood range of 32 ± 9 years. If the bark edge survives then a death date can be directly obtained from the date of the last ring.

3. Results

Sample Q10525. F1039 timber from base of ditch F556

This sample yielded 127 annual growth rings when measured. The centre or pith of the tree is present on the sample. There is no sapwood or heartwood-sapwood boundary present on the sample. The measured tree-ring series obtained from this sample was compared with a suite of both regional and local Irish chronologies. Extremely significant and consistent correlation values (t = 6.24*** *cf*. Early Medieval Irish chronology, t = 5.44*** *cf.* Cro-Inis, Co. Westmeath, t = 5.21*** *cf.* Clononan, Co. Westmeath) were found. These and other results indicate that the measured tree-ring series dates from AD967 to AD1093. The best estimated felling date range for the tree, from which this sample was taken, will be AD1125 ± 9 or later.

4. Conclusions

The measured tree-ring series produced excellent and consistent correlations values with many of the local site chronologies. The felling date for the tree is likely to be sometime in the later 12th or early 13th century. The lack of sapwood or even the heartwood-sapwood boundary means only a *terminus post quem* date can begiven.

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APPENDIX 14

WOODEN OBJECTS & MISCELLANEOUS WOOD FROM STRUCTURE F1039

By Simon Gannon

PROJECT DETAILS

Project	Wooden Objects and Miscellaneous Wood from Structure W1039
Specialist	Simon Gannon
Client	Meath County Council
Nat. Grid Refs.	27698/24047
Licence Number	02EO462
Project Date	2002
Report Date	March 2003

SUMMARY

This material was found in the fill of Structure W1039. 114 wooden items were recorded; forty six of these were artefacts, all of which were incomplete through breakage or decay. Some of these artefacts are of some importance due to their varied carpentry indicators and unknown functions. The remaining wood pieces are summarized; these were non-artefactual items such as broken branchwood or broken/ eroded pieces that had lost sufficient surface information to indicate their original status.

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List of Figures

1. Methodology

All pieces of wood were cleaned using wooden scrapers, water, and small brushes in order to reveal the natural features of the wood and any wood working indicators. A detailed record including: analysis, photograph and interpretation, was made for each item of wood. Artefactual wood was scale drawn at 1: 2 or 1:2.5.

2. Wood Objects and Miscellaneous Wood from Structure W1039

2.1 Johnstown 1

Licence Number	02EO462
Nat. Grid Ref:	27698/24047
Townland:	Johnstown
Date of Analysis:	March 2003

2.1.1 Introduction

There are a total of 114 wood items from the fill of Structure W1039. The assemblage is defined in terms of two main categories, (a) artefact wood, where there is a direct archaeological element in a piece of wood; and (b) non-artefact wood, where there is no discernable, direct archaeological element. The latter category is for all wood items that have had no retained or discernable human alteration to their natural state and includes pieces that may have been objects but have lost any surface indication due to degradation.

2.1.2 Artefact Wood Pieces

There were fort-six artefactual wood pieces recovered, these are summarized in the Catalogue below. From this list there are six items of particular interest.

W1039 1 appears to be portion of an unknown device that W1039 12 and W1039 65 were found to be a part of, see Figure 1. W1039 4 is has similarities to W1039 1 but is also of unknown function, Figure 2. These two pieces reveal a range of carpentry methods and tools; the auger is well attested in the bore-hole cuts and suggests instruments of 8 to 10 mm across at their widest. A maximum tip width of 4 mm is indicated in the broken auger hole in W1039 1 and the depth of hole cut indicates an auger of approximately 70 mm in length. The use of the chisel suggested in the carpentry of the Structure F1039 is more clearly indicated in the cuts that bridge the auger holes in W1039 1. The treenails, or dowels, preserved in both pieces have also been wedged; the one in W1039 1 has been particularly carefully made using a hard piece of well seasoned oak as a wedge. W1039 4 has a hazel nut (*Corylus avellana*) shell fragment embedded in the side of the wood; this may help in identifying the function of the piece but at least indicates a certain pressure being exerted on one of its surfaces.

W1039 32 is also worthy of note, well made and almost complete, it has a handle-like end broken near the tip, Figure 3. Several pieces were portions of structural items and may originally have been a part of Structure F1039. W1039 6 is a broken portion, possibly from a plank, with three well preserved axe marks and facets, the more complete axe cut mark is 40 mm across, Figure 4.

There are several possible stakes in the assemblage implying construction separate to the main structural elements of F1039.

2.1.3 Non-Artefact Wood Pieces

There were sixty eight non-artefact wood pieces: W1039 15, W1039 17, W1039 18-29, W1039 33-38, W1039 49-59, W1039 64, W1039 67-83, and W1039 88-106. These items were mainly branchwood, species not-determined, of various sizes, between 10 cm and 95 cm long in various states of preservation. Some of these could have been used in the construction of makeshift walls or similar, again probably separate to the Structure F1039.

2.1.4 Catalogue of wooden artefacts from fill of W1039

Number	Features	Taxa	Condition	Size: mm L × W × D	Tools used	Function interpretation
W1039 1	split & hewn, cut holes, treenail	yew	incomplete	490×230×100	axe, auger, chisel, mallet & wedge	unknown device
W1039 2	possible object: roundwood	n.d	broken ends	560× 80× 50	possibly axe	unknown
W1039 3	split, cut hole	n.d	broken surfaces	420×120× 90	axe, auger, chisel	unknown
W1039 4	split & hewn; cut holes and surfaces	yew	broken end	400×110× 90	axe, auger, chisel, mallet & wedge	unknown device
W1039 5	roundwood, cut end	n.d	broken end	360× 75× 55	axe	stake
W1039 6	radial, split & hewn, cut end	oak	broken surfaces	630×170× 60	axe, mallet & wedge	structural: plank
W1039 7	boxed heart, split & hewn	oak	broken & eroded	380×240×210	axe, mallet & wedge	structural
W1039 8	radial, split & hewn, notch	oak	broken & eroded	450×160×130	axe, mallet & wedge	structural
W1039 9	radial, split & hewn, facets	oak	broken end	740×130× 60	axe, mallet & wedge	stake
W1039 10	radial, split & hewn	n.d	broken & eroded	360×105× 40	axe, mallet & wedge	stake
W1039 11	tangential, split & hewn	oak	broken ends	500×150× 45	mallet & wedge	off-cut
W1039 12	radial, split & hewn, cut hole	yew	broken surfaces	470×110× 50	axe, auger, mallet & wedge	part of W1039 1
W1039 13	radial, split & hewn	oak	broken surfaces	310×200× 38	axe, mallet & wedge	stake
W1039 14	radial, split	oak	broken surfaces	290× 75× 20	mallet & wedge	stake
W1039 16	radial	oak	broken & eroded	280× 80× 15	unknown	off-cut
W1039 30	tangential, split & hewn	oak	broken ends	150×130× 58	axe, mallet & wedge	structural
W1039 31	split & hewn, treenail	yew	broken surfaces	180× 50× 60	axe, auger, mallet & wedge	part of device
W1039 32	squared, split & hewn	ash	broken	530× 70× 40	axe, mallet & wedge	implement
W1039 39	radial, split & hewn	oak	broken surfaces	240×120× 50	axe, mallet & wedge	off-cut
W1039 40	radial, split & hewn	oak	broken surfaces	390×120× 50	axe, mallet & wedge	structural
W1039 41	radial, split & hewn	oak	broken surfaces	480× 70× 80	axe, mallet & wedge	stake
W1039 42	radial, split & hewn	oak	broken surfaces	560×130× 70	axe, mallet & wedge	structural
W1039 43	radial, split & hewn	oak	broken surfaces	270× 90× 30	axe, mallet & wedge	off-cut
W1039 44	radial, split	oak	broken surfaces	340× 90× 30	mallet & wedge	off-cut
W1039 45	quartered, split & hewn	oak	broken & eroded	330×190×150	axe, mallet & wedge	structural

Catalogue of wooden artefacts from fill of W1039 continued

n.d : species not determined.

Number	Features	Taxa	Condition	Size: mm L × W × D	Tools used	Function interpretation
W1039 46	radial, split & hewn	oak	broken & eroded	160×180×100	axe, mallet & wedge	structural off-cut
W1039 47	radial, split & hewn	n.d	broken surfaces	150×160× 30	axe, mallet & wedge	structural: plank
W1039 48	radial, split & hewn	oak	broken & eroded	280×150× 40	axe, mallet & wedge	structural: plank
W1039 60	roundwood, cut end	n.d	broken end	170× 40× 40	axe	unknown
W1039 61	roundwood, slant cut end	n.d	broken end	260× 45× 45	axe	stake
W1039 62	roundwood, cut end	n.d	broken end	455× 50× 50	axe	unknown
W1039 63	roundwood, cut end	n.d	broken end	136× 35× 25	axe	unknown
W1039 65	split & hewn, cut hole	yew	broken	110× 55× 35	axe, auger, mallet & wedge	part of W1039 1
W1039 66	tangential, split & hewn	n.d	broken surfaces	180× 150× 50	axe, mallet & wedge	structural: plank
W1039 84	roundwood, cut end	n.d	broken	620× 65× 50	axe	stake
W1039 85	split & hewn	n.d	broken end	410× 120× 56	axe, mallet & wedge	stake
W1039 86	squared, split & hewn	ash	broken ends	100× 50× 40	axe, mallet & wedge	implement
W1039 87	tangential, split & hewn	oak	broken surfaces	370× 110× 40	axe, mallet & wedge	structural off-cut
W1039 107	boxed heart, split & hewn	oak	broken surfaces	530× 290×240	axe, mallet & wedge	structural
W1039 108	radial, split & hewn	oak	broken surfaces	540× 110×120	axe, mallet & wedge	structural
W1039 109	radial, split & hewn	oak	broken surfaces	340× 100×110	axe, mallet & wedge	structural
W1039 110	radial, split & hewn	oak	broken surfaces	160× 140× 90	axe, mallet & wedge	structural
W1039 111	radial, split & hewn	oak	broken surfaces	200× 120× 90	axe, mallet & wedge	stake
W1039 112	radial, split & hewn	oak	broken surfaces	200× 90×100	axe, mallet & wedge	stake
W1039 113	split & hewn	oak	broken surfaces	1400×310×120	axe, mallet & wedge	structural: plank
W1039 114	radial, split & hewn	oak	broken surfaces	840×160×170	axe, mallet & wedge	structural: plank

APPENDIX 13

STRUCTURE F1039-ARCHAEOLOGICAL WOOD ANALYSIS

By Simon Gannon

PROJECT DETAILS

Project	Structure F1039: Archaeological Wood Analysis
Specialist	Simon Gannon
Client	Meath County Council
Nat. Grid Refs.	27698/24047
Licence Number	02EO462
Project Date	2002
Report Date	January 2003

SUMMARY

This subrectangular structure was discovered at the bottom of a large, partially excavated ditch, at approximately 2 metres below ground level. The remains of the structure consisted of several floor planks and three side walls, with a maximum preserved length of 4.1 metres, 2.96 metres width and a maximum preserved depth (wall height) of 0.5 metres. The floor planks and timber walls were roughly *in situ* and most had undergone substantial decay and breakage, few retaining the greater part of their original surfaces. The analysis covers the carpentry methods used in the construction of Feature 1039, the processes of degradation and preservation of the structure, interpretation of its possible function and the relationship of its materials to original woodland sources.

CONTENTS

1. Methodology

All the timbers and loose pieces of wood were cleaned using wooden scrapers, water, and small brushes in order to reveal the natural features of the wood and any wood working indicators. A detailed record including: analysis, photograph and interpretation, was made for each item of wood. Structural timbers were scale drawn at 1:10, where unusual items or features were found these were drawn at scale 1: 2. The interpretation of the wood in terms of the technology represented is based on replication of ancient wood working in experimental archaeology and on literature sources.

2. Sunken wooden structure: Feature 1039

2.1 Johnstown 1

Licence Number	02EO462
Nat. Grid Ref:	27698/24047
Townland:	Johnstown
Date of Analysis:	February 2003

2.1.1 Introduction

F1039 comprised a wooden rectangular structure excavated from two trenches either side of a baulk (Figure 1; Plates 1 and 2). Considerable degradation of the wood meant that most of the structural elements only remained intact before excavation.

In this text the term 'timber' is used in the specific sense of construction size material such as beams and planks and 'wood' is used as a general term.

2.1.2 Production of the timber: conversion and carpentry methods

Typically, where wood has been visibly sectioned along the structure of medullary rays (emanating from the pith), the indicated type of conversion is radial, where sectioned by crossing that structure, the type indicated is tangential. Sectioning in a radial fashion would suggest the use of hammers, wedges and axes in most circumstances. Tangential sectioning is usually the preferred method of people using saws, it is easier to produce wide planks this way and, conversely, it is difficult to saw a log radially. Tangential sections can also be achieved by using wedges and axes. In this structure the evidence points to tool use exclusive of the saw as well as a preference for radial sectioning.

Once the trees had been selected, in this case oaks, axes would have been used for felling and de-branching. The bark would have been removed and the wood from the tree would have been utilised while green, i.e. when it was still unseasoned. Large portions of seasoned oak would have been too difficult to cut with the tools of the time.

In the production of the floor planks W1101a, W1101b, W1101c, W1101d, splitting along the medullary rays was indicated (Figures 2,3,4,5). Wedges and hammers would have been used to split the log lengthways along its radial axes. The process starts with an initial v-cut made in the top of the horizontal log using an axe, into this cut a wedge would be placed and then hammered down. On the opposite side of the log and further along the length of the log more cuts would have been made in a roughly straight line and other wedges inserted and hammered down, creating a long split. By this means the log would have been split in half along its length and the half logs could then have been split again. Slim wedges of timber were produced, as in the floor planks of Feature 1039, by splitting off quarter, eighth, sixteenth and even thirty second radial sections. These timbers were cut to length by axe/adze as seen in the well preserved end of timber W1101a (Plate 5). To make flat, finished surfaces, these lengths of timber were then hewn along their length by axe or adze as in timber W1039b (Figure 6).

To produce the main side wall timbers, W1039a (Figure 7), a boxed heart conversion, and W1039c (Figure 8), a possible boxed heart conversion, the four round ‘corners’ of the log would have been removed, the large slices being split away by wedge and hammer, the remainder by axe or adze to produce a simple squared length of log. A substantial notch was cut into the side of W1039c, probably using an axe, perhaps to facilitate lifting or dragging the timber by rope.

Timbers W1039b and W1101a were converted tangentially (Figure 6 and Figure 2, respectively). Here, wedges were inserted across from each other in a roughly level plane splitting off an oblong section of wood.

The production of a tangential split along the length of a log is usually more painstaking than a radial split. Many small wedges must be inserted to facilitate a split that cuts across, rather than exploits, the main lines of structural weakness in a healthy tree. At this site they may have had a large log allowing them to obtain a tangentially split plank or two and then several useful radial splits from the remainder. The process can also start with a thick radially split section, which is then split tangentially. Tangential sectioning without the use of saws has been found at sites as early as the Neolithic, for example, the Sweet Track, England dating to 3807/3806 BC (Orme 1982, Hillam *et al* 1990).

2.1.3 Preservation

Much of the structural characteristics of F1039 are only recorded by photographs and drawings made before the timbers were removed because of the substantial extent of degradation.

The structure had been preserved by deposition of soil and the effect of water logging, which partially excluded oxygen. Water was also probably the key element in the degradation of the wood, it seems likely that ground water was present in the lower portion of the structure during the period of use and, with the timbers also being open to the air; there would have been accelerated decay due to the effect of expansion when wet and shrinkage when drying. Degradation would have been made worse if the people using the structure also walked and worked on the timbers while they were wet.

The preservation of the timbers in the structure is also relatable to the type of conversion used to produce the individual timbers. The wall plank at the front, W1039b, and the floor plank, W1101a, were two of the most degraded timbers in the structure and were converted tangentially where the splitting of the wood utilizes lines of separation that are more antagonistic to the integral strength of the wood.

2.1.4 Construction and structural elements

The first part of the structure to be put in place was the floor, made from planks each approximately 2.9 meters long, varying in width from 20cm to 60cm and in thickness from 5cm to 10 cm (Figures 1,2,3,4,5). Five of these are indicated, if the wood floor originally extended the full length of the wall timbers there would have been several more. As the plan drawings show there were no wall or floor planks found at the southwestern end of the structure and it was not possible to distinguish whether they had definitely existed or not. The long side wall beams were laid on top of the floor planks, using large oblong sectioned timbers. The more preserved beam portion, W1039a, was 2.93m long, 34cm wide, and 20cm thick, the opposite beam W1039c probably being of similar dimensions before erosion and breakage (Figures 1,7,8). Timber W1039a had a partially preserved through-cut rectangular hole at one end which could have held a stave, securing the timber to the ground underneath or perhaps holding a wall plank or upright in place (Plate 6). This hole could have been started off with axe cuts but would probably have been cut using an auger to bore out two or more corner holes in the timber before cutting out the bulk of wood with a chisel. No further rectangular holes were found in the beams, although these could have existed before severe degradation of the timbers. It is also possible that the mortise like hole in W1039a functioned in a prior use of the timber.

Timber W1039b, 55cm wide, 12 cm thick and originally perhaps 2.5m long; made up the eastern wall but was severely degraded, only the northeastern third surviving excavation intact. This timber was laid against the northeastern ends of the parallel beams and had a notch cut to fit over the side wall timber tenon on the northeastern side with a likely similar arrangement on the southeastern side (Figure 9; Plates 3 and 4 respectively). The surviving notch was wedged from the outside, keeping W1039b in place, probably until backfilled, this heavy timber having an angled cut on the bottom making it inclined to fall outward. Another large slanting notch had been cut into the top of this timber 80cm back from the corner, but for an unknown purpose. This timber was probably the key element in the structure, its dimensions determining the layout of the other timbers. Overall, this timber is the most likely to have been reused from a previous structure.

2.1.5 Choice of timber and woodland relationship

All the structural components of F1039 were of oak. A large portion of substantial structural timber in Ireland during the past would have been of oak, from the two native species, *Quercus petraea* and *Quercus robur*. The popularity of oak is partly due to its widespread growth and the strength and durability of its wood: it has a greater resistance to rot in the ground than most other species (Rackham 1982). Oak is also relatively easy to cut and shape when unseasoned and can be split more effectively than other available hardwoods, Ash (*Fraxinus excelsior*) for instance, a native species also producing a hardwood does not split as well (*cf.* Arnold 1982).

The long timbers found in structure F1039 were straight grained and knot free suggesting a woodland interior origin for the trees as opposed to growing on their own in a field or at the edge of a wood. Trees growing near other trees in a wood tend to grow up straight and tall, with limited branching, in their desire for light at canopy level.

2.1.6 Carpentry tools used

Splitting wedges and mallets/ hammers would have been necessary for the work detailed above and these would have been made of wood in most cases. The wedges would have been made of seasoned hardwood, of oak or ash for example, and would have been valued tools kept and reused over a period of months or years until they broke under the pressure of being hammered into the grain of many trees. The mallets/ hammers used to strike the wedges would also have been made of seasoned wood in the handle, and the head in most cases. Mallets and wedges are mentioned in ancient Irish writings. *Corpus iuris hibernici* (seventh or eighth centuries *AD* law-texts) describes the *forchae,* or mallet, as being the implement used to drive stakes into the ground and *ngend* is the rustic ogham word for a wedge (Kelly 2000). Both these tools would have had a limited lifespan and when broken may often have been thrown into a fire. Partially as a consequence of these processes such pieces are rare archaeological finds.

Metal axes would have been necessary during felling, debranching and probably in debarking. In practice though, debarking is effectively achieved by using a spade and running it under the bark at an angle. Cutting wood to length, hewing to flatten planes and to generally shape the wood would have been done using axes, or adzes in some cases. Axes are generally more useful than adzes because they can be used to cut at more diverse angles.

In this structure the preserved axe/adze cut marks indicate the use of a distinctly curved blade with a cutting edge of approximately 80mm and the probable use of another straight bladed axe/adze of approximately 60mm edge. The 80mm blade indicated would seem to correlate with a large axe known from ancient Irish texts as a *bíaíl, Corpus iuris hibernici* and *Críth Gablach* (early eighth century *AD* law-text), described in Kelly (2000). The smaller blade indicated may correlate with a *tál,* a small bladed adze described in *Corpus iuris hibernici,* or perhaps with an *eipit,* which was probably a small axe (*Corpus iuris hibernici* and *Críth Gablach*) also assessed by Kelly (2000). Other metal tools would have included the auger and the chisel, as used in the cutting out of slots in the timber W1039a. This auger is probably equivalent to the *tarathar,* described in *Corpus iuris hibernici* (Kelly 2000).

2.1.7 Function of the structure

There are various possibilities of function for this structure but the present lack of dating evidence from the relevant contexts prevents a considered appraisal. This section will therefore be completed at a later date. Please see note on text re. sampling in post script.

2.1.8 Conclusions

Conclusions are also withheld pending the possibility of obtaining dates.

Please see note on text re. sampling in post script.

2.1.9 Recommendations

The value of the wood from F1039 in terms of conservation is partly dependant on any relevant date obtained, inherently though, the pieces are not of sufficient quality or unusual enough to warrant great interest and are not obviously worthy of conservation.

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APPENDIX 12

SPECIES IDENTIFICATION OF CHARCOAL SAMPLES FROM JOHNSTOWN 1

By Ellen O' Carroll

Species Identification of Charcoal Samples from Johnstown 1, Enfield, Co. Meath. (02E0462)

ELLEN OCARROLL

November 2003

1. Introduction

Twelve charcoal samples were submitted for analysis. The charcoal was sent for species identification prior to ^{14}C dating and also to obtain an indication of the range of tree species, which grew in the area, as well as the utilization of these species for various functions. Wood used for fuel at pre-historic sites would generally have been sourced at locations close to the site. Therefore charcoal identifications may, but do not necessarily, reflect the composition of the local woodlands. Larger pieces of charcoal, when identified, can provide information regarding the use of a species. The charcoal was excavated from a series of features, which included three smelting pits (**F**553, **F**1105 & **F**558), a pit (**F**912), a hearth (**F**1149), the spreads, **F**554 & **F**768 (these spreads sealed the enclosure ditch F4, phase 2), and a kiln (**F**996). Another spread **F**17, a circular pit (**F**820), a refuse pit (**F**30) and an oval shaped kiln (**F**639) were also sampled for charcoal analysis.

2. Methods

The process for identifying wood, whether it is charred, dried or waterlogged is carried out by comparing the anatomical structure of wood samples with known comparative material or keys (Schweingruber 1990). The identification of charcoal material involves breaking the charcoal piece so as a clean section of the wood can be obtained. This charcoal is then identified to species under an Olympus SZ3060 x 80-zoom stereomicroscope. By close examination of the microanatomical features of the samples the species were determined. The diagnostic features used for the identification of charcoal are micro-structural characteristics such as the vessels and their arrangement, the size and arrangement of rays, vessel pit arrangement and also the type of perforation plates.

3. Results

Table 1: Results from charcoal identifications at Johnstown 1

Context No. & feature type	Sample no.	Species	Weight & Comment
F553, Large smelting pit	227	Ash *(Fraxinus excelsior)*	32 grammes
F1149, Hearth	511	Alder (*Alnus glutinosa*)& clay	145 grammes
F554, Spread that sealed enclosure ditch F4 (phase 2)	535	Oak (*Quercus sp.*)	84 grammes
F996, Kiln	378	Ash	23 grammes
F768, Spread that sealed enclosure ditch F4 (phase 2)	369	Alder (*c.* 2 g.), Oak (34 g.) and *Pomoideae (*c.* 2g.)	38 grammes
F17, Charcoal spread containing fragments of burnt timbers	Grid c	Large oak pieces with a small amount of alder and *Prunus*	A sample of just alder and *Prunus* has been bagged separately for dating
F820, Circular pit	342	Mostly alder with a small amount of willow	
F912, Irregular shaped pit	Grid d	All oak	
F30, Refuse pit	78	All oak	27g
F558, Smelting pit	447	All oak	56g
F639, Oval shaped kiln	376	Oak and pomoideae	2 g of oak & 39g of pomoideae
F1105, Smelting pit	447	All oak	20g

*Pomoideae (apple type) includes crab apple, wild pear, hawthorn and mountain ash.

4. Discussion

There are six species types present in the charcoal remains. The range of species identified from the features excavated at Johnstown 1 includes large (oak & ash) and smaller (alder, willow & pomoideae) trees and some scrub (*Prunus* spp.).

Ash (*Fraxinus excelsior*) was exclusively selected for use in the kiln (**F**996) and the smelting pit (**F**553). This is not surprising as ash charcoal is considered to be excellent fuel and its charcoal is held in high esteem. The peoples who were using the smelting pits and the kiln were aware of the qualities of ash charcoal and specifically selected this tree for that purpose. It is a native species preferring lime-rich freely draining soils. It is not a very durable timber in waterlogged conditions but has a strong elastic nature. It is easily worked and lends itself well to a range of different requirements like the turning of wooden bowls.

Alder (*Alnus glutinosa*) was identified from the hearth (**F**1149), the circular pit (**F**820) and the two spreads (**F**768 & **F**17). Alder appears too have been selected as kindle for burning and was therefore not a specifically selected species for a specific function. The kindle was probably collected close by to the site. Alder is a widespread native tree and occurs in wet habitats along streams and riverbanks. Alder also grows regularly on fen peat. It is an easily worked and split timber and does not tear when worked. Alder is commonly identified from wood remains associated with wet/boggy areas.

Oak was the most prevalent species identified from the spreads (**F**554, **F**768), that sealed the enclosure ditch F4 (phase 2), which may indicate that, an oak palisade/posts or similar type of structure stood in the enclosure ditch and was burnt down? Oak was also identified from the two smelting pits **F**558 & **F**1105, the pit **F**912, the refuse pit **F**30, the kiln **F**639 and the charcoal spread containing burnt fragments of timbers **F**17. The widespread use of oak for industrial processes such as smelting has been demonstrated by the author at other metal working sites throughout Ireland. Oak makes good firewood when dried and will grow in peat when conditions are dry. Throughout all periods of prehistory and history oak has been used for structural timbers. The oak identified suggests that there was a supply of oak in the surrounding environment. Oak also has unique properties of great durability and strength. Sessile oak (*Quercus petraea*) and pedunculate oak (*Quercus robur*) are both native and common to Ireland. The wood of these species cannot be differentiated based on its microstructure. Penduncculate oak is found on heavy clays and loams particularly where the soil is of alkaline pH. Sessile oak is found on acid soils often in pure stands and although it thrives on well-drained soils it is also tolerant of flooding (Beckett 1979, 40-41). Both species of oak grow to be very large trees (30-40m) and can live to an age of about 400 years. The oak could have been selected from mixed woodlands nearby.

A small amount of pomoideae was identified from the spread (**F**768) and the majority of sample no. 376, the kiln (**F**639), was also identified as pomoideae. Pomoideae includes apple, pear, hawthorn and mountain ash. It is impossible to distinguish these wood species anatomically but as wild pear is not native and crab apple is a rare native species to Ireland it is likely that the species identified from Johnstown 1 are hawthorn or mountain ash (rowan) (Nelson 194-200, 1993). Hawthorn (*Crataegus*) is native, and is found in many hedgerows throughout Ireland. Mountain ash (*Sorbus aucuparia*) is also a common tree to Ireland growing particularly well in rocky and hilly mountainous places. The species identified from Johnstown 1 is more likely to be hawthorn and may have grown in the enclosure ditch.

A small amount of *Prunus* was identified from the charcoal spread containing burnt fragments of timbers **F**17. The genus *Prunus spp.* includes *Prunus spinosa* (blackthorn), *Prunus avium* (wild cherry) and *Prunus padus* (bird cherry). Wood of the genus *Prunus* can be difficult to differentiate microscopically. Wild cherry and blackthorn are more common in Ireland than bird cherry. There is very little archaeological evidence for the use of cherry wood in Ireland although the wild cherry tree is commonly found in many hedgerows (Nelson 1993, 167). It is a very durable wood and is as strong as oak. Blackthorn *(Prunus spinosa)* is a thorny shrub found in woods and scrub on all soil types. In a woodland situation it is more likely to occur in clearings and at the woodland edges.

A small amount of willow was also identified from the circular pit **F**820. Willow (*Salix* spp.) is native to Ireland and can be found both in a tree and shrub form. They generally favour wet conditions. According to Webb (1971, 160-2) thirteen species of willow are found growing wild in Ireland, of which eight are certainly native. The wood of *Salix* trees and shrubs cannot be differentiated to species on the basis of anatomical features.

5. Conclusion

A total of six species were identified from sites investigated. The ash and oak were collected and used in the smelting pits and the kiln. This is not surprising as both ash and oak charcoal are considered to be excellent fuel. It is difficult to attribute a function to the other species identified at the site although the oak identified from the enclosure ditch may have been associated with a wooden type structure or posts. As indicated in the results above oak was not exclusively used as raw material in the kiln. Pomoideae and ash were identified in larger quantities from the material excavated from the kiln. Alder and willow were collected as kindle for use in the hearth, the pits and spread. It is likely that the small fires were kindled with twigs and small branches, which grew in the local environment while the oak and ash, were brought to the area from nearby woods.

The oak and ash point to the presence of woodlands and indicate that open conditions did not prevail throughout the Johnstown 1 area. The oak and particularly the ash would have grown in drier conditions preferring free-draining soils and nutrient-rich clays although oak will grow on wet soils during drier periods. Alder and willow indicates wetter conditions while the hawthorn/mountain ash and *Prunus* are indicative of those species, which may have grown locally in hedgerows or as scrub nearby to the sites.

Radiocarbon dating:

All of the charcoal samples represent the inner part of a tree of unknown age and it was not possible to tell from identification how much larger, if at all, the whole piece was. As a result the old-wood effect may need to be taken into consideration when ^{14}C dates are returned (Warner 1979, 159-172). This is particularly true in the case of oak as it can grow to an age of 300 to 400 years. The samples identified could be of a more recent date than the rings represented on the sample. There is no problem sending the oak for ^{14}C dating it's just to take into account that the date returned may (but not necessarily) be out by three hundred years or so. This is a problem for the medieval periods but not so much in the pre-historic period. I would therefore advise you to send the shorter living species identified from the site for ^{14}C dating. These would include the alder, *Prunus*, pomoideae, willow and ash.

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APPENDIX 11

ANALYSIS OF PLANT REMAINS

By Penny Johnston

Analysis of the Plant Remains
Johnstown 1
Co. Meath

Licence Nos. 02E0462

By
Penny Johnston
Margaret Gowen and Co. Ltd.

For
Archaeological Consultancy Services Ltd.

28th March 2003

Illustrations

Tables

1. Introduction

This report details the archaeobotanical analysis of samples from Johnstown in Co. Meath, where a complex archaeological site was excavated by Archaeological Consultancy Services Ltd. as part of the M4 Kinnegad-Enfiled-Kilcock Motorway Scheme. The site included several phases of enclosures, burials, settlement and industrial/craft activity. The results from the analysis of charred seeds which were extracted from archaeological deposits are presented below.

2. Methodology

The soil samples were delivered to the laboratory already processed by Archaeological Consultancy Services Ltd. Identification was carried out using a low-powered binocular microscope (magnification X4.8 to X56). Identification results are presented in Table 1 below. Taxonomic order is based on Scannell and Synnott (1987), apart from cereals and grasses, which are listed first. The common name is used for most types of plant, following the nomenclature used by Scannell and Synnott (1987). Where a plant is mentioned for the first time in the text, the scientific name follows in brackets. Both scientific and common names are listed in the tables of results.

3. Johnstown 02E0462: plant remains

3.1 Fourteen samples were examined for macro remains (seeds in particular). The majority of the seeds were preserved by carbonisation, however, in some samples from the enclosure ditches F124 and F556, waterlogged seeds were also retrieved. The preservation method has implications for the manner in which the plant remains are interpreted: carbonisation generally has a direct link to human activity, whereas waterlogging will occur dependent on local environmental conditions, be they the result of nature, or of human interference (such as digging a ditch that cuts the water table, thereby providing a waterlogged environment for plant material to accumulate and be preserved in). The seeds from each preservation category will therefore be treated separately below.

3.2

3.2.1 *Carbonised seeds*

Carbonised seeds made up the vast majority of the seeds that were retrieved from Johnstown. These were dominated by cereal grains, with oats (*Avena* species) being the most commonly identifiable cereal type, although several samples contained high quantities of indeterminate cereal grains (Cereal indet.) which could not be identified to genus or species.

The samples dominated by indeterminate grains were from F124 (S220), the enclosure ditch and F639 (S377), from a kiln. The high proportion of indeterminate grain in the ditch sample was probably due to abrasion of the plant material because of mechanical factors; ditch fills are large deposits that are frequently subjected to a high degree of mechanical activity, e.g. repeated dumping of rubbish, slumping, infilling and re-cutting (Monk 2000). This can cause degradation to the surface of plant material, and make the seeds difficult to identify. Many of the cereals were probably dumped into the ditch after they had accumulated elsewhere as rubbish, and this pattern of repeated disturbance promotes surface erosion of the plant material.

The high proportion of indeterminate grains in the kiln is probably due to high charring temperatures rather than mechanical disturbances. This assumption is based on the appearance of the grains, which are brittle as if they have been highly fired, rather than abraded due to mechanical activity. Kilns were used to dry cereals after the harvest, and date from the early historic period onwards. The purpose of drying the cereal crop is “to maintain the quality of the grains during storage to prevent the growth of bacteria and fungi and the development of insects and mites” (Bala 1997). As well as for storage, the application of heat from kilns was one of the essential stages of the malting process, and kiln drying also helped to harden grain that was intended for milling.

Modern grain drying kilns are set at temperatures appropriate to the use that the grain is to be put to: for example, when drying seed grain the temperatures should not exceed 43°C, and the set limit for malting barley (*Hordeum vulgare*) is 49°C. When grain is intended for milling, however, the temperature can be much higher, (60°-66°C is recommended for wheat (*Triticum* species), and when it needed for animal feed the temperatures are not carefully controlled (Bala 1997). These differences indicate the importance of being able to control the heat in drying chambers; presumably the medieval kiln worker was skilled in firing the kiln at controlled temperatures, depending on the end use of the grain. Indeed, the art of using drying kilns was considered important enough to be included in the education of both poor and well-to-do land-owning farmers (Kelly 1998), although it is evident that accidents were common, as most kiln sites reveal evidence of burnt grain that was lost or destroyed during firings.

When the firing of the kiln went out of control, the grains in the drying chamber were generally carbonised and therefore preserved. However, carbonisation at extremely high charring temperatures can cause distortion (Hubbard and al Azm 1990) and often makes grain from archaeological deposits difficult to identify, thus explaining the high percentages of indeterminate cereal grains in some kiln samples. Distortion normally occurs in high temperatures in oxidising circumstances, and it suggests that the fire in the kiln went entirely out of control. Most grain types become carbonised after 1.5 hours burning in oxidising circumstances at 250ºC, and at 350ºC several grains will distort to the extent that they become a "conglomerated mass" (Boardman and Jones 1990), these temperatures are considerably higher than the ideal temperatures required for drying grain.

Two samples that were rich in grains of oat were both from kiln F996 (samples 379 and 380). Oats are ideally suited to the damp Irish climate, they are one of the commonest grain types recovered from Irish sites of historic date, and it is thought that they were selected and cultivated from wild grasses in Europe from the fourth and fifth centuries onwards (Montanari 1999). Oats were coarse ground and used to make flat oat cakes, and, more frequently, they were used for porridges and gruels (Sexton 1998).

Gruels and porridges were particularly popular amongst the peasantry in the medieval period as they avoided several feudal taxes; cereals could be coarse ground at home, thus avoiding the tax that had to be paid for grinding in the mill, and the porridge or gruel could be boiled over a fire, rather than baked in an oven, the use of which may also have involved paying a fee or a tax (Mennell 1985). Oat cakes could also be produced on a small scale, within the domestic context. Sexton (1998) describes the traditional method of grinding up the oats and by a hand-mill or a rotary quern and mixing the resultant meal with butter and hot water to form a paste that was subsequently rolled out thinly and put on a griddle or a hot flagstone to bake. The oat cakes produced in this manner could be stored for several weeks and because only simple grinding and kitchen equipment was used, they were not costly to make.

As well as the rich samples from kiln F996, there were samples from kiln F639 and kiln F1005. There were not as many cereal grains in these kiln deposits as in the samples from kiln F996. Nonetheless, it is clear from the results here that barley was more common in F639 than oats, and in F1005, legumes (Legume indet.) were almost as common as cereal grains. These legumes were probably from a garden pea, which were kiln dried before storage; it was not until the seventeenth century that pulses such as peas were consumed in Ireland and Britain as fresh vegetables. Prior to this they were dried and mixed with butter and eggs to make pease pudding, which traditionally accompanied boiled bacon or pork (Hessayon 2000).

Only one sample that was not derived from an enclosure ditch or a kiln was sent for analysis. This was a sample from a pit fill (F31), which contained relatively high quantities of wheat, although the wheat type could not be determined to species. Several barley grains were also found in this feature, along with a few grains of oat and rye (*Secale cereale*). The rachis material from barley indicated that the barley type present was of the six-row variety.

One other piece of charred plant material, originally labelled as a find, (02E0462:391:1-5) was also submitted for analysis. This was not identifiable as a seed or a nut, but it is certainly charred plant material, and was probably a fruit.

3.2.2 ***Waterlogged seeds***

Three samples from enclosure ditches contained the remains of waterlogged seeds: two (S401 and S402) were from F556 and one (S125) was from F124. Although a few other seed types were present, in general these waterlogged samples were dominated by the seeds from elderberries (*Sambucus nigra*). Berries from the elder are edible, although there is no evidence to suggest that they were used as a source of food at Johnstown. It is most likely that the large quantities of seeds gathered in the ditch underneath an elder tree that was growing nearby. Elder is phosphate loving (Rackham 1986) and the accumulation of rubbish in a ditch may have encouraged its growth. This suggests that the ditch was partially overgrown for at least some of its history. However, the absence of seeds from other plants indicates that the overgrowth may have been limited.

4. Summary

4.1 In total, the plant remains from fourteen samples from six archaeological features were examined in this report. The findings demonstrated that oat was the most common cereal in the samples associated with kiln firings, and that in the enclosures where the ditches cut the water table, the seeds of elder were preserved in quite high quantities, suggesting that this shrub grew beside the ditch, or on any bank associated with it. The majority of the charred plant remains from the ditches were classified as indeterminate cereals, suggesting that there was a high degree of surface abrasion on the grains, indicative of mechanical disturbances that are common in large features, such as ditches, where rubbish and waste are frequently discarded.

Table 1: Plant Remains from Johnstown 1, Co. Meath

Context		**996**	**124**	**31**	**124**	**124**	**124**	**996**
Sample		**37B**	**72**	**87**	**112**	**125**	**220**	**376**
Triticum dicoccum	Emmer wheat						1	
Triticum cf *dicoccum*	Probable emmer wheat						2	
Triticum cf *spelta*	Probable spelt wheat						3	
Triticum durum/turgidum/aestivum	Free-threshing wheat						37	
Triticum cf *durum/turgidum/aestivum*	Probable free-threshing wheat						17	
Triticum dicoccum/ durum/turgidum/aestivum	Emmer/free-threshing wheat						6	
Triticum spelta/ durum/turgidum/aestivum	Spelt/free-threshing wheat				4			
Triticum species	Wheat species		5	17	5		220	
Triticum/Secale	Wheat/Rye grains						6	
Hordeum vulgare	Barley	7		12	2		11	1
Hordeum vulgare (6-row) chaff	Rachis internode from 6-row barley			2				
Hordeum/Avena	Barley/Oat	4		2				
Avena species	Oat species	4		5			27	38
cf *Avena* species	Possible oat grains	3					35	29
Secale cereale	Rye						2	
cf *Secale cereale*	Possible Rye grains			3			4	14
Cereal indet. grains	Indeterminate cereal grains	5	3	22	3		450	123
Chaff from indeterminate cereal	Indet. rachis material						1	
Poaceae indet.	Indeterminate grass seeds	1		5	1		16	21
Rumex cf *acetosella*	Probable Sheep's sorrel						1	
Chenopodiaceae indet.	Indeterminate goosefoot seeds						3	
Raphanus raphanistrum	Wild radish				2			

**Indicates that seeds are not charred*

Table 1: Plant Remains from Johnstown 1, Co. Meath (continued)

Context		**996**	**124**	**31**	**124**	**124**	**124**	**996**
Sample		**37B**	**72**	**87**	**112**	**125**	**220**	**376**
Rubus fructicosus	Bramble (Blackberry)					1*		
Legume indet.	Indeterminate legume seeds			5				
Aethusa cynapium	Fool's parsley					1*		
Galium cf *aparine*	Bedstraw/cleavers			1			2	
Sambucus nigra	Elder					65*		
Cyperaceae indet.	Sedge					1*		
Weed indet.	Weeds						1	

Indicates that seeds are not charred

Table 1: Plant Remains from Johnstown 1, Co. Meath (continued)

Context		**639**	**996**	**996**	**639**	**1005**	**556**	**556**
Sample		**377**	**379**	**380**	**382**	**386**	**401**	**402**
Triticum durum/turgidum/aestivum	Free-threshing wheat				1			
Triticum species	Wheat species	20				3		
Triticum/Secale	Wheat/Rye grains							
Hordeum vulgare	Barley	61	61	58	16			
cf *Hordeum vulgare*	Possible barley		29	14				
Hordeum vulgare (6-row) chaff	Rachis internode from 6-row barley	7						
Hordeum/Avena	Barley/Oat	7						
Avena species	Oat species	32	654	307	5	12		2
cf *Avena* species	Possible oat grains		122	96				
Avena cf *sterilis* floret base	Chaff from probable wild oat		1					
Avena sativa floret base	Chaff from cultivated oat		4					
Secale cereale	Rye			1				
cf *Secale cereale*	Possible rye grains		3	8		1		
Cereal indet. grains	Indeterminate cereal grains	549	84	136	10	10		
Chaff from indeterminate cereal	Indet. rachis material	1						
Poaceae indet.	Indeterminate grass seeds	6	59	24				
Polygonum lapathifolium	Pale persicaria	4	1					
Polygonum convolvulus	Black bindweed	7	4					
Rumex cf *acetosella*	Probable Sheep's sorrel		3	1				
Polygonaceae indet.	Indeterminate dock seeds	6	5					
Chenopodium album	Fat hen		1					
Chenopodiaceae indet.	Indeterminate goosefoot seeds		6					
Spergula arvensis	Corn spurrey		1					
Rubus fructicosus	Bramble (Blackberry)							3*

**Indicates that seeds are not charred*

Table 1: Plant Remains from Johnstown 1, Co. Meath (continued)

Context		**639**	**996**	**996**	**639**	**1005**	**556**	**556**
Sample		**377**	**379**	**380**	**382**	**386**	**401**	**402**
Legume indet.	Indeterminate legume seeds		1			21		
Labiate indet.	Indeterminate mint seeds		3					
Plantago species	Plantain species		5					
Sambucus nigra	Elder						8*	158*
Cirsium/Centaurea	Thistle/Knapweed							2*
Cyperaceae indet.	Indeterminate seeds from the sedge family							2*
Weed indet.	Weeds	2	2	1				1*

Indicates that seeds are not charred

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APPENDIX 10

ANALYSIS OF VERTEBRATE REMAINS (BURNT)

By Deborah Jaques

Palaeoecology Research Services

Assessment of vertebrate remains from excavations at Johnstown, Enfield, Co. Meath, Republic of Ireland.

PRS 2003/77

Assessment of vertebrate remains from excavations at Johnstown, Enfield, County Meath, Republic of Ireland

By

Deborah Jaques

Summary

A small collection of vertebrate remains (most of which were burnt) recovered from 12 features during excavations at Johnstown, Enfield, County Meath, were submitted for examination. These remains were associated with an early medieval enclosure and two burial grounds (one of which was post medieval in date).

Preservation of the burnt bone was mostly quite good, although fresh breakage damage was extensive. Identified fragments included the remains of cattle, caprovids, pig and dog. Several burnt fragments from F62 may be pieces of antler.

Little interpretation can be forthcoming, given that these remains represent only part of the vertebrate material recovered. However, most of the identified remains represented fragments associated with waste from carcass preparation (heads and lower limb elements) and food consumption.

KEYWORDS: JOHNSTOWN; COUNTY MEATH; REPUBLIC OF IRELAND; ASSESSMENT; EARLY MEDIEVAL; POST MEDIEVAL; ENCLOSURE; BURIAL SITE; VERTEBRATE REMAINS; BURNT BONE.

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14 October 2003

1. Introduction

Excavations undertaken by Archaeological Consultancy Services Limited (ACS), in advance of the construction of the new M4 Kinnegad-Enfield-Kilcok Motorway Scheme, in County Meath, Republic of Ireland, have revealed an early medieval enclosure and burial site at Johnstown, Enfield. The site, excavated between April and October 2002, appeared to be an extensive settlement, which was re-used periodically as an area for burial. The enclosure underwent three phases of modification, all of possible medieval date. Two separate burial grounds were identified, of which one was associated with the third phase of the enclosure. The other was located in an area traditionally identified as a *cillin* burial ground for unbaptised children and was dated to the post medieval period.

Vertebrate remains, most of which were burnt, recovered from twelve of the excavated features were submitted to PRS for assessment.

2. Methods

For the vertebrate remains records were made concerning the state of preservation, colour of the fragments, and the appearance of broken surfaces ('angularity'). Other information, such as fragment size, dog gnawing, butchery and fresh breaks, was noted, where applicable.

Fragments were identified to species or species group using the PRS modern comparative reference collection. The bones, which could not be identified to species, were described as the 'unidentified' fraction. Within this fraction fragments were grouped into a number of categories: large mammal (assumed to be cattle, horse or large cervid), medium-sized mammal (assumed to be caprovid, pig or small cervid) and totally unidentifiable.

3. Results

Bone submitted for analysis was recovered from 12 features, including ditches, pits, spreads, a kiln and a hearth. No information on recovery, e.g. whether by hand collection or from sieved samples, was provided.

Table 1 details the numbers of fragments recovered, their weight and some general notes about each group of bones. Preservation of the bones was, on the whole, good, although most were damaged by fresh breakage. As a result of this damage, fragments were typically less than 35mm in any dimension. Larger fragments (to 70mm) were noted in the assemblages from F1, F4, F17 and F124, however. Most of the remains were burnt or scorched, with the exception of a small proportion of the fragments from F4, F55, F124, F879 and F1154.

Few fragments could be identified to species, mainly because of extensive fragmentation, but also because of the absence of fragments with morphologically distinctive features. Species identified included the remains of cattle, sheep/goat, pig and dog, whilst many fragments represented both large and medium-sized mammals. The texture of some of the burnt fragments from F62 suggested that these fragments may have been antler.

Generally, the skeletal elements for the major domesticates were those that would be associated with primary butchery waste (e.g. cranium, isolated teeth, meatpodials and phalanges).

4. Discussion

The vertebrate remains submitted for assessment formed a very small assemblage for which the dating was rather tentative. Few fragments could be identified and none could provide age-at-death or biometrical data. The remains examined for this report are likely to represent refuse from the butchering and jointing of carcasses and the consumption of food. More detailed interpretation is not possible, given that order vertebrate remains were recovered from the same features.

Table 1: Bone recovered from at Johnstown. Key= No. of frags=Number of fragments; Wt=weight; Size of frags=Size of maximum dimensions

Feature	**Grid**	**Feature Type**	**No. frags.**	**Wt (g)**	**Size of frags**	**Notes**
F1	C	Topsoil	33	23	to 40mm most less than 20mm	All fragments burnt, all animal –includes large mammal shaft fragments, ?caprovid shaft fragment (juvenile individual), and other medium-sized mammal bones.
F4	D	Enclosure ditch (2nd phase)	44	72	To 70mm most less than 35mm1	Most fragments burnt 97 unburnt). Ten of the fragments join to form a portion of a large mammal proximal tibia shaft fragment, cow upper molar, ?pig fibula fragment, medium-sized mammal rib frgaments
F17	C	Spread	1	13	55mm	Burnt large mammal pelvis fragment
F55	C	Hearth	28	17	To 40mm	Most fragments burnt (2 unburnt). Rather variable collection-most fragments are calcined. Possible juvenile

Feature	Grid	Feature Type	No. frags.	Wt (g)	Size of frags	Notes
						pig scapula fragment, rest include medium-sized mammal shaft fragments. Two large mammal shaft fragments.
F62	C	Shallow depression	10	3	Less than 25mm	All fragments burnt. Small unidentified fragments, damaged by fresh breakage. Possibly burnt antler fragments.
F124	B	Enclosure ditch (3rd phase)	5	9	To 60mm	Most fragments burnt. Two fragments join and were identified as a caprovid femur shaft. Also present was one large mammal shaft fragment and 2 very small completely unidentified fragments.
F124	C	Enclosure ditch (phase 3)	33	40	To 70mm	Most fragments scorched or burnt. Remains of distal articulations of two cattle metapodials. Also isolated dog tooth (P4). Large mammal rib and shaft fragments and medium-sized mammal rib fragments.
F124	D	Enclosure ditch (phase 3)	20	17	To 40mm most less than 20mm	3 fragments unburnt, remainder calcined and quite brittle. Pig cranium fragment and several unidentified skull fragments.
F556	E	Ditch	1	2	14mm	1 (burnt) large mammal shaft fragment
F768	D	Spread	21	7	Less than 25mm	All fragments burnt and unidentified. Likely to represent medium-sized mammals.
F876	E	Kiln	10	5	Less than 35mm	2 fragments burnt, 8 unburnt. Preservation poor. All

Feature	Grid	Feature Type	No. frags.	Wt (g)	Size of frags	Notes
						probably represent medium-sized mammals. 6 fragments join to form medium-sized mammal femur shaft.
F912	D	Pit	5	6	Less than 25mm	Fragments of pig upper molar accounts for three of the fragments. Medium-sized mammal shaft fragment and 1 unidentified fragment. One fragment burnt.
F996	H	Kiln	7	2	Less than 15mm	All fragments burnt. Six unidentified, 1 pig second phalanx.
F1154	B	Pit	13	9	Less than 35mm	2 fragments scorched, 3 calcined and 8 unburnt fragments. Two large mammal shaft fragments, rest unidentified but representing smaller mammals.

Acknowledgements

The author is grateful to Rachel Sloane of ACS for providing the material and the archaeological information.

APPENDIX 9

BIRD & OTHER ANIMAL BONE FROM JOHNSTOWN CO. MEATH

By Sheila Hamilton-Dyer

Johnstown 1, Enfield, County Meath
Bird and other Animal Bones

S. Hamilton-Dyer

2 May 2003

1. Introduction

A small group of bird and other unidentified bone was submitted for analysis from excavations at a medieval enclosure and burial site, resulting from work on the M4. The bones were obtained by hand collection during excavation.

2. Methodology

Species identifications were made using the author's modern comparative collections. All fragments were identified to species and element where possible. Recently broken bones were joined and have been counted as single fragments. Measurements follow von den Driesch (1976) and are in millimetres unless otherwise stated. Archive material includes metrical and other data not presented in the text and is kept on paper and digital media.

3. Results

On examination the 134 fragments were derived from 127 individual bones. The condition of the bone is generally good and most of the bones can be identified to taxon. Remains of birds and mammals are present, but no fish.

4. Bird bones

At least fourteen taxa are represented in the 56 bones. At 27 bones domestic fowl is the most frequent, all the other taxa are represented by four bones or less (table 1). Several corvids are present, raven is easily distinguished on grounds of size, the others are more difficult. One bone from F566 is a good match for magpie, the others are of rook or crow. These two species are very close in morphology but have different lifestyles, crows like ravens are mainly carrion feeders while rooks feed on invertebrates and new-sown crops. All of these corvids can be perceived as pests, and the same is likely to apply to the buzzard. The single bone of a smaller, sparrow-sized, passerine may be of an incidental, perhaps a cat kill, although like most birds it is edible. More small passerines and other small taxa might have been recovered if sieving had been undertaken. The other taxa (heron, wild or domestic goose, teal, partridge, snipe, woodcock, corncrake and pigeon) are more likely to represent food remains. The pigeon bones are large and likely to be of woodpigeon rather than the domestic pigeon or other species.

The sample is small but the anatomical distribution is as expected, the larger and most sturdy limb bones are well represented and the smaller and most fragile elements absent. One of the fowl bones, a femur, is pathological with new bone growth and a sinus mid-shaft, presumably from an infection of the medullary cavity (photo). At least one of the other fowl bones is from a hen before or during the laying period as the shaft is filled with medullary bone for egg production (Driver 1982).

Both pre-Norman and later medieval dates are given by RC dating for some of the features. Most of the bones were recovered from F4 and F124, 19 and 18 respectively and account for ten of the fourteen taxa. Unfortunately even these bone samples are very small and the other features produced four bones or less. It is, therefore, not possible to adequately compare the data from the two period groups. It can be noted, however, that domestic fowl bones are present in F4 as well as in later deposits and that there is a relatively high species diversity in both groups. Previous research has indicated that pre-Norman and native settlements tend to have a wide variety of species, including raptors and corvids, whereas at Norman sites domestic poultry and game dominate (Hamilton-Dyer forthcoming).

5. Mammals

Amongst the bird bones were 71 mammal bones of at least nine taxa. These have been submitted in archive form for incorporation into the main mammal analysis, some short notes only are included below.

F124 grid D.

Pine marten radius. Although now rare this cat-like mustelid was formerly a relatively common mammal throughout Britain, including Ireland (Yalden 1999). It can be regarded as vermin, particularly regarding young poultry, and also as a fur provider.

Lagomorph bones were identified from F4 and F556. These are of very immature animals and difficult to identify. For F4, considering the early medieval date, these would be expected to be of leverets rather than rabbits. The possibility of intrusive remains cannot be ruled out, however, as the rabbit is a burrowing animal and the young may die below ground. Rabbit would be acceptable for F556 and, indeed, this bone is a better match for an immature rabbit than a very young leveret.

F124 Grid D.

Small mammal humerus. This bone is comparable with a small rat, presumably the black rat. It is not possible to be certain of identification without skull or jaws. This rat (as opposed to the larger brown rat introduced in the 18th century, Yalden (1999)) became common throughout much of Britain, including Ireland, after the Norman Conquest (Armitage 1994). This is consistent with the RC date for this feature of AD 1420-1650. Small mammal remains were also recovered from grave cut F203 and can be identified as woodmouse.

6. Fish

As indicated above, no fish remains were recovered but all the bones were retrieved by hand excavation. While this can recover some elements of the larger fish species smaller ones such as those from eel and herring are simply too small. Substantial fish assemblages appear to be found only at coastal and urban sites but inland sites, particularly of Norman and later date and from features such as kitchen middens and cesspits, do usually offer some fish (Hamilton-Dyer forthcoming). In order to more fully understand the role of fish in the Irish faunal economy it is recommended that sieving for small faunal classes is given some priority in future work. Considering that the bones are all from hand excavation, the finding of any small fauna at all (small birds and rodents) is a testament to careful excavation.

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Table A1

SPECIES LIST AND ABBREVIATIONS USED IN TEXT, TABLES AND ARCHIVE

COW	domestic cattle
S/G	sheep and/or goat
PIG	domestic pig
LAR	large ungulate (probably mostly cattle but may also include some horse)
SAR	small artiodactyl (probably mostly S/G but may also include some pig)
MAM	unidentified bone, probably mostly SAR and/or LAR
DOG	domestic dog
CAT	domestic cat
LAGO	hare, *Lepus sp*., or rabbit, *Oryctolagus cuniculus*
MARTES	pine marten, *Martes martes*
RAT SPP	rat, probably black, *Rattus rattus*
APO SPP	woodmouse, *Apodemus* cf. *sylvaticus*
ARD CIN	heron, *Ardea cinerea*
GOO	domestic goose or greylag, *Anser anser*
ANA SPP	duck, cf. teal, *Anas crecca*
RAPTOR	raptor, cf. buzzard, *Buteo buteo*
FOW	domestic fowl
PER PER	partridge, *Perdix perdix*
CREX	corncrake, *Crex crex*
WADER	wader cf. woodcock, *Scolopax rusticola*, and snipe, *Gallinago gallinago,*
COL FAM	pigeon, cf. woodpigeon, *Columba palumbus*
RAVEN raven,	*Corvus corax*
CORVID	corvid cf. magpie, *Pica pica*, and rook, *Corvus frugilegus* or crow, *Corvus corone*
PASSER	small passerine, songbird of sparrow size

APPENDIX 8

ANIMAL PALAEOPATHOLOGY FROM JOHNSTOWN CO. MEATH

By Eileen M. Murphy

Animal palaeopathology from Johnstown I, Co. Meath

Eileen M. Murphy

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1. Introduction

A total of 15 animal bones with palaeopathological lesions were recovered from the excavation at Johnstown I, Co. Meath. The animals represented in the corpus included cattle, horse, pig and dog, and examples of developmental disease, joint disease, trauma and dental disease were apparent among their remains. The following discussion will provide a description of each pathological bone. It should be noted that in all cases the bones were fused unless stated otherwise.

2. Cattle

Developmental anomalies

<u>Feature 3, Grid A</u>

An enlarged foramen was apparent on the medial side of a fragment of right acetabulum. The foramen was situated at the junction between the iliac and the pubic parts of the acetabulum and measured 13.2 mm supero-inferiorly by 4.2 mm antero-posteriorly. The enlarged foramen is probably a minor developmental anomaly that would have been of no consequence to the animal.

Joint disease

<u>Feature 4, Grid A</u>

A male left acetabulum displayed an oval-shaped area of eburnation and porosity on the anterior region of its pubic aspect, which measured 21.3 mm medio-laterally by 10.2 mm antero-posteriorly. In addition, marginal osteophytes surrounded both the exterior and interior margins of this region, and marginal osteophytes were also apparent on the interior margins of the ischial region of the acetabulum.

Exostoses were evident which surrounded the proximal end of a left metatarsal. The lesions could be classed as being of Stage 2 severity (cf. Bartosiewicz *et al* 1997, 36). These lesions are considered to arise as a consequence of the ossification of the ligaments that surround the affected joint (Baker and Brothwell 1980, 225). The distal breadth of the metatarsal measured 60.9 mm, which suggests that the affected animal was male (cf. Murphy 1998).

The second and third tarsal bones were fused to the corresponding articular facet in a left proximal metatarsal (Plates 1 & 2). The fusion had occurred as a consequence of the development of exostoses around the margins of both bones. The proximal articular surfaces of the second and third tarsal bones had an uneven appearance which may have been due to the onset of degenerative joint disease as a secondary condition to the ankylosis. The exostoses in this case can be classified as Stage 4 severity since one or more of the tarsal were fused to the metatarsal (cf. Bartosiewicz *et al* 1997, 43). This condition, which involves fusion of the tarsals and metatarsals, is generally referred to as spavin. A variety of aetiologies have been proposed for spavin including inflammation, severe concussion and developmental factors that affect the morphology of the leg. It generally only results in a mild degree of lameness and, if the condition is not too extensive and the animal is allowed to rest, the joint will fuse and the animal can remain useful for slow work (Baker and Brothwell 1980, 118-119). The metatarsal had a distal breadth of 51.9 mm, which may indicate that it had originated from a female (cf. Murphy 1998).

<u>Feature 29, Grid A</u>
A left acetabulum from a male displayed marginal osteophytes which had resulted in the hypertrophy of its pubic aspect. In addition, exostoses were apparent that surrounded the entire circumference of the acetabulum.

<u>Feature 36, Grid B</u>
A right acetabulum from a female displayed a very pronounced oval-shaped area of eburnation and porosity on the anterior region of its pubic aspect (Plate 3). The affected area measured 27.9 mm supero-inferiorly by 16.8 mm antero-posteriorly. In addition, marginal osteophytes surrounded both the exterior and interior margins of this region, and they were also apparent on the interior margins of the remainder of the acetabulum.

<u>Feature 124, Grid A</u>
A left female acetabulum displayed an oval-shaped region of eburnation on the anterior aspect of its pubic area. The affected area measured 18.2 mm supero-inferiorly by 8.5 mm antero-posteriorly. Marginal osteophytes were also apparent that surrounded both the exterior and interior margins of this region and the interior margins of the ischial part of the acetabulum.

3. Horse

Joint disease

<u>Feature 556, Grid F</u>
The central tarsal and the first, second, third and fourth tarsals were all fused together and were further ankylosed to the proximal end of a left third metatarsal. In addition, the second metatarsal was also fused to the third metatarsal (Plates 4 & 5). Prominent bony exostoses were evident on the anterior surface of the proximal third of the third metatarsal. The exostoses in this case can be classified as Stage 4 severity since one or more of the tarsal were fused to the metatarsal (cf. Bartosiewicz *et al* 1997, 43). It is probable that the horse had been suffering from spavin (see above).

Trauma

Feature 124, Grid C

An enthesopathy was apparent at the proximal third of the anterior surface of a first phalanx. It is probable that the enthesopathy was due to stress and strain of the ligaments associated with the metatarsophalangeal/metacarpophalangeal joint.

4. Pig

Trauma

Feature 124, Grid B

A right calcaneus displayed an area of eburnation and pitting, which measured 6.6 mm supero-inferiorly by 9.1mm medio-laterally, on the inferior aspect of its sustentaculum (Plate 6). The adjacent areas of bone had an irregular appearance and displayed exostoses, which would tend to suggest that stress and strain had been put on the ligaments which maintained the integrity of the talal-calcaneal joints. It is probable that the animal had suffered from an injury to its hock region, which had damaged the structure of the joint and resulted in degenerative joint disease and stress and strain of the associated ligaments and tendons. The proximal end of the calcaneus was unfused, which indicates that the bone had originated from a pig with an age-at-death less than 2-2.5 years (cf. Silver 1969, 286).

Dental disease

Feature 225, Grid A

A mandibular incisor displayed medio-lateral curvature of the tip of its root. It is probable that this abnormality had arisen as a consequence of trauma when the tooth was developing.

5. Dog

Trauma

Feature 124, Grid C

A lumbar vertebra displayed a fractured spinous process (Plate 7). A transverse fracture line, which ran for the entire length of the spinous process, was clearly visible on its left side. A corresponding fracture line was not apparent on the right side of the spinous process. The superior aspect of the spinous process was abnormally curved towards the right, and it would appear that this had been due to the restriction of the fracture to the left side of the process. No malalignment of fracture parts was apparent and the two halves of the fracture were in the early stages of knitting together. It is probable that the injury had occurred as a consequence of the animal having fallen or being struck with a blunt implement on the left side of its back.

Feature 124, Grid D

A fused right distal tibia displayed a raised area of bone with an irregular appearance on its medial surface, immediately superior to the medial malleolus (Plate 8). The lesion measured 18.5 mm supero-inferiorly by 8 mm medio-laterally and had an antero-posterior thickness of approximately 3 mm. It is considered probable that it was an ossified haematoma which was in the process of developing. These lesions generally arise as a consequence of an impact from a blunt object which results in subperiosteal bleeding. The lesion develops when the swollen area gradually becomes replaced by a smooth fracture callus (Baker and Brothwell 1980, 83).

Feature 1131, Grid G

A bony nodule was apparent on the posterior surface of a fused left fourth metatarsal. The nodule was restricted to the medial aspect of the posterior surface and measured 11.7 mm supero-inferiorly by 3.5 mm medio-laterally. It is probable that the lesion was an ossified haematoma (see above).

Dental disease

Feature 124, Grid A

A fragment of a right mandible displayed ante-mortem loss of the second and fourth premolars. The sockets for the teeth had been completely remodeled, which is an indication that the tooth loss had been long standing.

6. Conclusions

A total of 15 animal bones displayed palaeopathological lesions, and the animals affected were cattle (n=7), horse (n=2), pig (n=2) and dog (n=4). A cattle acetabulum displayed an enlarged foramen, which was probably due to a developmental anomaly, and would have been of no consequence to the animal. The six other affected cattle bones all displayed lesions that can be classified as joint disease. Four of the cases involved the development of degenerative joint disease of the hip: two of the affected animals were male while two were female. A recent survey of animal palaeopathological lesions in Medieval Ireland has indicated that the hip was most susceptible to the development of degenerative joint disease in cattle (Murphy 2004 forthcoming). This finding would tend to suggest that the activities that cattle were being used for, presumably including traction, had placed particular strain on their hip joints. The occurrence of degenerative joint disease among the cattle bones from Johnstown may be an indication that older animals at the end of their working lives were being deliberately slaughtered.

The two other affected cattle bones were proximal metatarsals and involved the development of exostoses. In one case the exostoses were minor, but in the other example the exostoses had resulted in the ankylosis of the second and third tarsal bones to the proximal metatarsal. In this latter case the condition is referred to as spavin; the aetiologies that have been proposed for it include inflammation, severe concussion and developmental factors that affect the morphology of the leg (Baker and Brothwell 1980, 118-119). One of the affected animals was male while the other was female. These lesions have been observed in modern draught cattle (Bartosiewicz *et al* 1997, 32), and their occurrence among the Johnstown cattle may be an indication that these animals had been used for a similar purpose. It is interesting to note that both male (n=3) and female (n=3) cattle bones displayed lesions that may be related to traction.

Two horse bones displayed palaeopathological lesions; one of these was a case of spavin that had resulted in the ankylosis of all the tarsal bones and the second metatarsal with a third metatarsal. As was the case for cattle described above, it is probable that this lesion had arisen as a consequence of the horse having been used for traction purposes. The second affected horse bone was a first phalanx which displayed an enthesopathy and was indicative of stress and strain to the ligaments associated with the metatarsophalangeal/metacarpophalangeal joint. It is probable that this lesion had arisen as a consequence of minor trauma to the region of the joint.

A pig mandibular incisor displayed an abnormally curved root that may have been due to trauma when the tooth was developing. A pig calcaneus displayed evidence that stress and strain had disrupted the integrity of the talal-calcaneal joint and resulted in secondary degenerative joint disease of the sustentaculum. It is considered probable that the initial injury to the hock region may have been due to a kick from another animal or a knock against a blunt object. The proximal end of the calcaneus was unfused, and is a further indication that the degenerative joint disease was secondary to an injury rather than a primary lesion related to advancing age.

Four dog bones displayed palaeopathological lesions. A fragment of mandible displayed evidence for long standing ante-mortem tooth loss. A recent survey of animal palaeopathological lesions in Medieval Ireland found that 50% of dog palaeopathological lesions were dental in nature. This was considered to be an indication that dogs were particularly susceptible to dental disease (Murphy 2004 forthcoming). The survey also found that traumatic lesions occurred among dogs with next greatest frequency (31.4%), and it is interesting that the three remaining dog bones from Johnstown displayed traumatic lesions.

A lumbar vertebra displayed a fractured spinous process. A semi-complete dog skeleton from Medieval Kilkenny displayed fractures to the spinous processes of its lower thoracic vertebrae, and two right and two left fragments of rib midshafts. It was considered probable that the lesions had all been attained during a single incident of trauma in which the animal may have suffered from a fall or was subjected to a series of heavy blows (Murphy 2004 forthcoming). The fractured lumbar vertebra from Johnstown was not associated with any other bones so it is difficult to reconstruct the aetiology for the injury. It is feasible, however, that the animal had suffered a similar injury to the Kilkenny dog and that it had fallen or been subject to one or more blows from a blunt implement.

A right distal tibia and a left fourth metatarsal both displayed possible ossified haematomas. These lesions generally arise as a consequence of an impact with a blunt object. The occurrence of both haematomas on lower leg bones may be an indication that this region of the dog skeleton was particularly susceptible to such injuries.

The animal palaeopathological lesions recovered during the excavations at Johnstown represent an interesting corpus of material. The nature of the different lesions for each species appears to conform to a general pattern which became apparent in a wider survey of animal palaeopathology in Medieval Ireland (Murphy 2004 forthcoming). The results from Johnstown will further help us to elucidate the nature of animal health and husbandry practices in Medieval Ireland.

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Plate 1 – Johnstown, Feature 4 Grid A: Spavin which involved the fusion of the second and third tarsal bones to the corresponding articular facets in a cattle left proximal metatarsal (view of anterior surface).

Plate 2 – Johnstown, Feature 4 Grid A: Spavin which involved the fusion of the second and third tarsal bones to the corresponding articular facets in a cattle left proximal metatarsal (view of posterior surface).

Plate 3 – Johnstown, Feature 36 Grid B: Right acetabulum from a cow with degenerative joint disease. A very pronounced oval-shaped area of eburnation and porosity is apparent on the anterior region of its pubic aspect.

Plate 4 – Johnstown, Feature 556 Grid F: Spavin which involved the fusion of the central tarsal and the first, second, third and fourth tarsals to the proximal end of a horse left third metatarsal (view of anterior surface).

Plate 5 – Johnstown, Feature 556 Grid F: Spavin which involved the fusion of the central tarsal and the first, second, third and fourth tarsals to the proximal end of a horse left third metatarsal (view of posterior surface).

Plate 6 – Johnstown, Feature 124 Grid B: A right pig calcaneus with evidence of degenerative joint disease, in the form of eburnation and pitting (see arrow), and exostoses, which would tend to suggest that stress and strain had been put on the ligaments which maintained the integrity of the talal-calcaneal joints.

Plate 7 – Johnstown, Feature 124 Grid C: A dog lumbar vertebra with a fractured spinous process. A transverse fracture line, which ran for the entire length of the spinous process, was clearly visible on its left side.

Plate 8 – Johnstown, Feature 124 Grid D: A dog right distal tibia which displayed a raised area of bone with an irregular appearance on its medial surface, immediately superior to the medial malleolus. It is probable that the lesion was an ossified haematoma.

APPENDIX 7

ANALYSIS OF MAMMAL BONES

By Catherine Boner

Analysis of Mammal Bones
Johnstown 1, Enfield, Co. Meath
Licence No. 02EO462

By Catherine Boner, Queen's University Belfast,
For Archaeological Consultancy Services Ltd.,
2003

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1. Introduction

A large quantity of well-preserved animal bone was presented for analysis. The greater part of this material clearly comprises discarded food refuse but artefacts and waste material from activities such as bone-working and animal skinning are also represented (see Plates). Bird bones were recovered from a number of contexts, indicating that standards of preservation and retrieval were extremely good. These bones were examined by Dr. Sheila Hamilton-Dyer, and are discussed in detail in a separate report. Animal bone pathologies, which were analysed by Dr. Eileen Murphy, are also discussed in a separate report. A relatively small number of human bones were identified among the faunal samples. These were presented to Linda Fibiger and are discussed in the report on human remains.

2. Provenance and dating of the animal bone

The animal bones from Johnstown 1 are derived largely from the three main enclosures which represent successive phases of activity at the site. The first two phases, **F3** (Phase 1) and **F4**, (Phase 2) returned radiocarbon dates of cal AD 430-660 (02E462F3, 2 sigma calibration) and cal AD 440-670 (02E462F4, 2 sigma calibration) respectively. These phases represent the period in which the site was used exclusively as a settlement (ACS preliminary stratigraphical report).

F124, which represents Phase 3, is much later in date (cal AD 1420-1650; 02E462F124; 2 sigma calibration), and excavation of this enclosure and its associated features has revealed that by this time the primary function of the site had changed from an extensive settlement to a burial ground. Two human skeletons were recovered from the base of **F124**, and four hundred and twenty four burials were contained within its interior. This evidence suggests that the enclosure ditch was open and in use contemporaneously with the burial ground (*Ibid*.).

A smaller sample of animal bone was retrieved from **F556** (cal AD 1420-1640; 02E462F556; 2 sigma calibration), which was a linear ditch located outside the three main enclosures. This feature is thought to represent the remains of a boundary (*Ibid*.).

Small samples of animal bone were retrieved from a number of grave cuts/fills (N=61) located within and outside the Phase 3 enclosure, as well as from a range of other features. A summary of the species distributions for all of these features is given in the Appendix (Table 25 & 26), and more detailed archive material is kept on digital media. However, these samples are not examined in the main analysis.

3. Condition of the animal bone

As mentioned above, the animal bones from Johnstown 1 were found to be extremely well-preserved, although some variation in the condition of samples was observed. Predictably, the best-preserved samples came from the ditch fills and of these **F124** and **F556** survived in the best condition. In all samples from the ditch fills fragile bones such as skulls, immature specimens and bird bones were recorded, but in these two samples less erosion and fragmentation was observed overall. This is probably due primarily to their contexts' later date. The samples from within the main enclosures were generally small, fragmented, and in poor condition.

4. Methodology

Identification was undertaken using the Queen's University of Belfast comparative skeletal collection. Ribs and vertebrae were not recorded at species level (unless specified), but were classified according to their size: those of large mammals (cattle, horse, or red deer), of medium-sized mammals (sheep, goat, or pig), and of small mammals (cat, dog, fox, hare, or rabbit). Differentiation between sheep and goat was attempted for a restricted range of bone elements (horncore, proximal radius, distal metacarpal, proximal femur, distal tibia, distal metatarsal), using the criteria outlined by Boessneck (1969), and by Kratochvil (1969). Undifferentiated ovicaprid elements are categorised as sheep/goat.

The minimum number of individuals (MNI) was calculated on the basis of the most frequent skeletal element, taking left and right sides into consideration (after Chaplin 1971). No attempt was made to modify the MNI calculations on the basis of bone size or state of epiphyseal fusion and tooth eruption.

Measurements of complete bones were taken (in mm), following the recommendations of von den Driesch (1976). Further measurements for the future comparison with other sites were also taken (after Payne & Bull 1988). Estimated shoulder heights (ESH) were calculated using the multiplication factors of Fock and Matolcsi for cattle (von den Driesch and Boessneck 1974), Teichert for pig and sheep (*Ibid*.), Kiesewalter for horse (*Ibid*.), and Harcourt for dog (1974). The fusion data is based on Silver (1969) and Habermehl (1961). The stages of tooth eruption are those of Higham (1967).

A small number of mammal bones were identified by Dr. Sheila Hamilton Dyer (see report), and these have been included in the present analysis.

5 Analysis

Phase 1 (**F3**) and Phase 2 (**F4**) produced 8,742 mammal bone fragments in total, of which 2,959 (34%) could be identified at species level (excluding ribs and vertebrae). The species distribution of the MNI and fragments data for these samples is presented in Tables 12 and 13, and it can be seen from these that a limited range of species was recorded. The majority of bones were from the three main domesticates (cattle, pig, sheep/goat), and the remaining species (horse, dog, cat, red deer and lagomorph) are infrequently represented.

Table 1 provides a comparison of the MNI percentage values for the three main domesticates for Phases 1 and 2. The MNI percentage values for cattle, pig, and sheep/goat which were obtained from other Early Christian period sites in Co. Meath and in Co. Louth are also presented, in order to examine how the distribution at Johnstown 1 compares with these.

Site	MNI Total	**Cattle**	**Pig**	**Sheep/Goat**
		%	%	%
Johnstown 1 Phase 1 (**F3**), Co. Meath (cal AD 430-660)	28	46	36	18
Johnstown 1 Phase 2 (**F4**), Co.Meath (cal AD 440-670)	47	55	34	11
Knowth Phase 1, Co. Meath	60	52	33	15
Knowth Phase 2, Co. Meath (10th-12th century)	84	33	32	35
Lagore Phase 1A, Co. Meath (skulls)	88	61	13	26
Lagore Phase 1B, Co. Meath (skulls)	146	71	14	15
Lagore Phase 2, Co. Meath (skulls) (7th–10th century)	112	46	34	20
Moynagh Sample D, Co. Meath	262	40	37	22
Moynagh Sample A1, Co. Meath (c. 800 AD)	59	19	27	51
Marshes Upper 3, Co. Louth (11th-12th century)	40	45	35	20

Table 1. MNI distributions for cattle, pig and sheep/goat from Phases 1 and 2 at Johnstown 1, and from other Early Christian period sites in Co. Meath and in Co. Louth (after McCormick & Murray 2001).

It can be seen from Table 1 that Phases 1 and 2 are dominated by cattle, followed by pig and sheep/goat respectively, and that this pattern is matched at several Early Christian period sites in Co.Meath and in Co. Louth. This distribution has been noted at a number of other broadly contemporary sites throughout Ireland (McCormick & Murray 2001), and was demonstrated to be consistent with the idealised distribution of animals that should belong to a *mbrughifer* or 'prosperous farmer' as described in the *Crith Gabhlach* (*Ibid*.).

Phase 3 (**F124**) produced 10,289 fragments of mammal bone, and of these fragments 3,117 (30%) could be identified to species (Table 14). All species that are represented in the previous phases were recorded, as well as a range of other wild animals (fox, pine marten and rat). Figure 1 shows that like Phases 1 and 2 Phase 3 is dominated by cattle, followed by pig, and then sheep/goat. There is, however, a marked increase in the proportion of sheep/goat represented, compared to that of the previous phase. Although the sample from **F556** is small (Table 15) and should be interpreted with caution, its MNI distributions suggest that sheep/goat was more abundant than pig. Possible reasons for an increase in the importance of sheep/goat during this period are discussed below (p. 9).

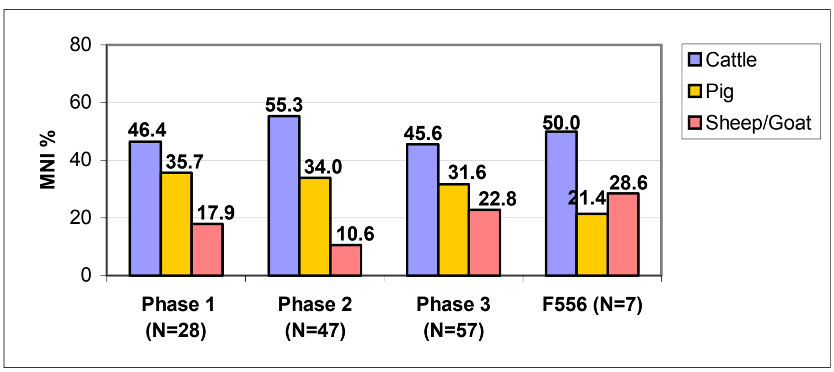

Fig. 1. Johnstown 1. MNI distributions of the principal livestock.

5.1.1 Cattle

As mentioned above, cattle were found to be the dominant species, both in terms of fragments and MNI distributions, indicating that cattle-rearing was the principal animal husbandry, and that beef was by far the most abundant meat consumed during all three phases.

Age Reconstructions

Based on the state of tooth eruption and wear (Higham 1967, 104) it was found that all but one of the cattle represented in Phases 1 and 2 (N=12) were between the ages of six months and two and a half years approximately at time of death (Table 16). The remaining specimen which came from Phase 4 had its third molar erupted and worn and represents an individual of approximately forty months. This suggested slaughter pattern where there is a peak in the killing of sub-adult individuals, lower incidences of slaughtered mature animals, and an extremely low frequency of young calves has been recorded at Early Christian period sites (Moynagh Crannóg, Lagore Crannóg, Knowth, Marshes Upper) which produced larger and therefore more reliable samples (McCormick 1987). It is considered to be indicative of specialised dairying (McCormick 1992). Despite being the largest and best-preserved sample, very few cattle mandibles from Phase 3 could be aged (N=4) due to their fragmented state (Table 16). In contrast to Phases 1 and 2, all of these specimens represent individuals of over thirty months of age, which suggests that predominantly mature cattle were slaughtered at the site during this time. None of the cattle mandibles from **F556** could be aged.

The fusion data for cattle were more abundant than that of tooth eruption (Silver 1969, 285-286), and suggest that for the three main phases the majority of animals were old at time of death. In contrast to this, the data from **F556** (which was the best-preserved sample) suggest a peak in the slaughter of cattle between the ages of one and three years of age (Table 2). Due to the inherent biases towards older animals associated with this method of ageing, however, it is difficult to know the accuracy of these data.

Bone	Approx. age at fusion (months)	Phase 1 (F3)		Phase 2 (F4)		Phase 3 (F124)		F556	
		Fused	Unfused	Fused	Unfused	Fused	Unfused	Fused	Unfused
Pelvis	7-10	11	2	22	1	48	0	10	0
Humerus d., Radius p.	10-18	27	2	56	1	72	3	12	0
Metacarpal d., Tibia d., Metatarsal d.	24-36	22	6	39	14	37	16	4	1
Femur p., Calcaneus	36-42	7	3	8	7	19	11	2	6
Humerus p., Radius d., Ulna p., Femur d., Tibia p.	42-48	15	3	23	10	57	13	2	6

Key: p=proximal, d=distal.

Table 2. Johnstown 1. Cattle epiphyseal fusion data after Silver (1969, 285-286).

Sex distributions

The restricted number of complete cattle metacarpals from Johnstown 1 precluded the determination of sex distributions based on multivariate analysis. Examination of large samples from other sites in Ireland (e.g. Moynagh Crannóg, Lagore Crannóg), however, indicated that metacarpals with distal widths (BFd) of less than 55.5 mm were definitely female, and those above 57.5 mm were definitely male (McCormick 1992, 205). These data were used as a criterion for the sexing of cattle based on metacarpal distal widths from Johnstown 1.

It can be seen from Table 3 that samples from Johnstown 1 are small. The largest sample comes from Phase 3 (N=9), and suggests that the vast majority of cattle over the age of twenty four to thirty two months (the age of fusion of the distal metacarpal) during this period were cows (78%). Samples from Phases 1 and 2 are extremely small, but suggest a more even distribution of the sexes.

The shape of the acetabular border of the pelvis in cattle (which fuses between seven and ten months) displays sexual dimorphism (Grigson 1982, 8), and was also used to determine sex distributions. Although samples are small, cows are predominant in all of the three main phases (Table 3). In Phase 3, however (N=7), the proportion of the suggested female population (57%) is smaller than that indicated by the previous method of sex determination. It could be inferred, therefore, that the proportion of slaughtered young males was larger than that of less than two and a half years of age.

Phase/Feature	BFd (in mm)	Sex	Pelvis	
1 (**F3**)	54.9	F	2F	1M
	57.7	M		
2 (**F4**)	52.3	F	7F	4M
	55.1	F		
	56.2	?		
	62.4	M		
3 (**F124**)	47.7	F	4F	3M
	51.3	F		
	51.5	F		
	53.0	F		
	53.8	F		
	54.0	F		
	55.8	F		
	56.2	?		
	64.9	M		
F556	49.6	F	2F	-

Key: F = female; M = male; BFd = distal width.

Table 3. Johnstown 1. Sex determination of cattle based on metacarpal distal widths (after McCormick 1992), and the shape of the acetabular border of the pelvis (Grigson 1982).

Metrical Analysis

A relatively large amount of metrical data was collected for cattle (Table 17), and the lengths of the longbones were used to estimate shoulder heights (Table 4). Although the site spans approximately one thousand years (see above, p. 1), no significant changes in the size of cattle could be detected between phases. Using the values obtained from metatarsal greatest lengths for example, estimated shoulder heights for Phases 1 and 2 produced a mean value of 112.8cm (N=17), compared to a value of 112.2cm (N=6) in Phase 3. This evidence is consistent with broadly contemporary sites, which indicate that intensive cattle breeding did not take place in Ireland during this time. There was no evidence in Phase 1 or 2 for the presence of extremely large cattle, which has been identified at some other sites such as Moynagh Crannóg, and interpreted as an indication of high status (McCormick 1987).

Phase/Feature	Bone	GL (mm)	Mult. Factor	ESH (cm)
1 (**F3**)	Radius	256.4	4.30	110.3
	Metacarpal	174.6	6.25	109.1
	Metacarpal	179.0	6.0	107.4
	Tibia	308.4	3.45	106.4
	Metatarsal	202.4	5.45	110.3
2 (**F4**)	Humerus	235.9 (GLC)	4.77	112.5
	Humerus	242.8 (GLC)	4.77	115.8
	Radius	254.5	4.30	109.4
	Radius	278.0	4.30	119.5
	Metacarpal	176.5	6.0	105.9
	Metacarpal	184.2	6.12	112.7
	Metacarpal	188.0	6.12	115.1
	Metacarpal	189.0	6.0	113.4
	Tibia	318.5	3.45	109.9
	Metatarsal	196.9	5.45	107.3
	Metatarsal	197.1	5.45	107.4
	Metatarsal	200.9	5.45	109.5
	Metatarsal	201.0	5.45	109.5
	Metatarsal	202.0	5.45	110.1
	Metatarsal	203.8	5.45	111.1
	Metatarsal	206.4	5.45	112.5
	Metatarsal	209.3	5.45	114.1
	Metatarsal	209.6	5.45	114.2
	Metatarsal	209.8	5.45	114.3
	Metatarsal	211.5	5.45	115.3
	Metatarsal	212.1	5.45	115.6
	Metatarsal	213.1	5.45	116.1
	Metatarsal	213.2	5.45	116.2
	Metatarsal	214.0	5.45	116.6
	Metatarsal	214.1	5.45	116.7
3 (**F124**)	Radius	264.6	4.30	113.8
	Metacarpal	174.6	6.12	106.9
	Metacarpal	179.5	6.0	107.7
	Metacarpal	180.8	6.0	108.5
	Metacarpal	183.0	6.0	109.8
	Metacarpal	194.8	6.12	119.2
	Tibia	312.5	3.45	107.8
	Tibia	336.0	3.45	115.9
	Metatarsal	198.8	5.45	108.3
	Metatarsal	199.0	5.45	108.5
	Metatarsal	205.0	5.45	111.7
	Metatarsal	206.3	5.45	112.4
	Metatarsal	209.9	5.45	114.4
	Metatarsal	216.2	5.45	117.8
F556	Metacarpal	185.6	6.0	111.4

Table 4. Johnstown 1. Estimated shoulder heights (ESH) for cattle after Fock and Malolsci (von den Driesch & Boessneck 1974, 336). Where possible, metacarpals were sexually determined (after McCormick 1992) and a multiplication factor of 6.0 was used for females and 6.25 for males. The multiplication factor for unsexed metacarpals is the averages of the male and female values (6.12).

Using the system devised by Armitage (1982,43), the horn-cores from Phases 1 and 2 at Johnstown 1 originated from cattle of a short-horned variety. Cut marks that were identified on a specimen from Phase 2 (Plate 11) indicate that they were used as a raw material.

5.1.2 Pig

Although wild pig (*Sus scrofa*) is thought to have survived in Ireland until the seventeenth century (McCormick 1998, 361) the species is curiously absent from many Early Christian period rural sites (McCormick 1987, 158). In Phase 2 at Johnstown 1, however, two large male tusks, possibly belonging to wild pig, were identified along with seventeen smaller specimens of male domesticates (Plate 20). Furthermore, a number of the measurements for pig are greater than the maximum values obtained from broadly contemporary rural sites (these are asterixed in Table 19). These skeletal elements probably represent larger domesticates, but because of the fact that they are big, it could be suggested that small proportions of wild pig were hunted.

Ageing & Sexing

Due to their fecundity and rapid growth rate, the keeping of domesticated pigs ensured a very reliable supply of meat in antiquity. Because the species had no other real economic value their age distributions are generally straightforward, with peaks in slaughter between approximately one and two years when the animals give maximum meat yield.

Thirty one pig mandibles from Phases 1 and 2 could be aged. All of these specimens come from domesticated pigs. The data obtained from these indicate that the majority of the animals were slaughtered between one and two years, and within this age bracket a large proportion were between seventeen and nineteen months (Table 5). If it is assumed that, like wild pigs, these animals farrowed once a year and the first of April is used as the mean farrowing date, these data indicate that most of the animals were slaughtered between August and October. An autumn/early winter kill-off of pigs after a period of fattening on woodland mast is a common subsistence strategy to reduce the number of animals that need to be over-wintered (McCormick 1987, 103). This slaughter pattern is consistent with that suggested by the fusion data for the same phases (Table 18).

Higham Stage	Approx. age (months)	Phase 1 (F3) N=9	Phase 2 (F4) N=22	Phase 3 (F124) N=11	F556
7	5-6	-	-	1	-
11	9-10	1	-	4 (1F)	-
12	10-11	1	1	-	-
18	17-19	3	11 (2M)	-	1
19	19-21	-	4 (1M)	1	-
20	21-23	2	2	1	-
21	23-25	1 (M)	-	-	-
22	25-27	2	3	3	-
23	27-29	-	1(F)	-	-
24+	30+	-	-	1 (F)	-

Key: M=male, F=female.

Table 5. Johnstown 1. Pig age distribution based on tooth eruption and wear after Higham (1967).

Five of the ageable mandibles from Phases 1 and 2 retained their canine teeth (which display sexual dimorphism) and four of these came from males between the ages of seventeen and twenty five months. The final specimen came from a female between twenty-seven and twenty-nine months. This sow was probably kept for breeding purposes beyond the optimum age of slaughter. Only one neo-natal pig bone (right ulna) was recorded in these phases, so there is little evidence to indicate that pigs were reared at the site. The paucity of immature bones may, however, be the result of post-depositional factors, as neo-natal bones, particularly those of pigs, are very prone to taphonomic destruction.

The data collected from Phase 3 for pig is difficult to interpret. Five of the eleven mandibles that could be aged came from pigs under the age of ten months (Table 5) and though the sample is small this high proportion of immature pigs (45%) suggests a slaughter pattern that is inconsistent with maximising meat production and maintaining herd sizes. It could be indicative of a shortage in food or that animals from a number of herds were brought to the site to be slaughtered. In contrast to this, the fusion data from Phase 3 which was obtained from a much larger sample (N=80) suggests that the majority of pigs were killed between twelve and thirty months (Table 18). A small number of neo-natal pig bones were recorded (N=8) which suggests that the animals were breeding on or close to the site and thus their piglets, dying of natural causes, were preserved in the sample.
Little interpretation can be made of the fusion data for pig from **F556**, but they suggest that the animals were under the age of thirty months when killed (Table 18).

Metrical Analysis
The metrical data for pig is presented in Table 19. Complete, fused longbones were absent from the samples and therefore estimation of shoulder heights was performed on measurements obtained from the less reliable calcaneus and astragalus greatest length measurements (Table 6). Although it is suggested that the animals in Phase 2 were larger than in Phase 1, all values fall within the range of those obtained from Early Christian period sites in Ireland and Britain (McCormick 1987, 161). These animals were more slender than modern breeds (*Ibid*.). There is no indication for an increase in the size of pigs during Phase 3.

Phase	Bone	GL1 (mm)	Mult. Factor	ESH (cm)
1 (**F3**)	Calcaneus	69.7 (GL)	9.34	65.1
2 (**F4**)	Astragalus	41.0	17.9	73.4
		41.6	17.9	74.5
3 (**F124**)	Astragalus	39.3	17.9	70.4
		39.8	17.9	71.2
		42.9	17.9	76.8

Table 6. Johnstown 1. Estimated shoulder heights (ESH) for pig after Teichert (von den Driesch & Boessneck 1974, 341).

5.1.3 Sheep/Goat

Extremely low incidences of goat have been recorded at the vast majority of Early Christian period rural sites (e.g. Moynagh Crannóg), and in some cases (Lagore Crannóg) the species appears to have been completely absent (McCormick 1991). Due to the fact that the majority of sites excavated from this period are of considerably high status, and that the species is omitted from the *Crith Gabhlach* McCormick concludes that goat was probably regarded generally as an inferior animal, and thus was kept only by the lower orders (*Ibid*.).

At Johnstown 1, as mentioned above, differentiation between sheep and goat was attempted for a small range of the ovicaprid bone elements (p. 2). It can be seen from Tables 12 and 13 that none of the bones which could be positively identified from Phase 1 (N=7) came from goat, and in Phase 2 all but one of these bone elements (N=9) were of sheep. The only bone that came from goat from this phase was an unworked horn sheath.

In contrast to Phases 1 and 2, the remains of goat were common (N=13) among the ovicaprid skeletal elements that could be distinguished (N=30) in Phase 3. While a large proportion (69%) of these goat remains comprise horn (which has a better survival rate than that of sheep), post-cranial elements were also recorded in this phase, and in **F556** (Tables 14 & 15). The keeping of goats greatly increased with the establishment of Viking and Anglo-Norman towns in Ireland (McCormick 1991). Their increased proportion at this rural site therefore matches this pattern.

All of the fragments of goat horn from Phase 3 were of the female variety, which may suggest that the species was exploited for milk. Although cut marks were not apparent on the goat horns from this phase it is probable that because of their straightness and durability horns were used in this period as a raw material. (Cut marks were identified on a fragment of goat horn from **F779**, a cobbled surface which was located above **F4**).

The inferior role of sheep compared to that of cattle and pig in Phases 1 and 2 is not exceptional for the Early Christian period. Documentary sources indicate that, unlike in contemporary Britain, in Ireland the species was not exploited primarily for milk, and mutton was regarded as inferior to beef and to pork. The primary purpose for the keeping of sheep was therefore to provide wool (*Ibid*.).

As already mentioned, there is an increase in the proportion of ovicaprids represented in Phase 3 from that of the previous phase, and in **F556** the species is suggested to be more abundant than pig. With the development by the Cistercians of the woollen export industry from the 12th century, sheep rearing became an important focus of agricultural activity, not only at the monastic granges but also, on secular farms which sold their wool to the nearest towns (O' Neill 1987, 58). The increased demand for wool is probably reflected in the increased proportions of ovicaprids represented in the later samples. It should be noted, however, that the extent of wool production during Phase 3 is complicated, due to the presence of goat remains in the sample. It is also possible that the increase in ovicaprid remains reflects a greater demand for sheep and goat skins. However, the paucity of ageing data makes this very difficult to determine.

Age Reconstructions

Sheep will not yield their first fleece until after the age of approximately 18 months (Maltby 1979, 45), and the optimal economic meat yield is gained if they are slaughtered between 18 and 30 months (Payne 1973, 281-282). Although the fusion data obtained from Phases 1 and 2 are limited, they suggest that few young sheep were slaughtered, and that the majority of the animals were over the age of eighteen months at time of death (Table 7). The data based on tooth eruption from these phases (which are less abundant) suggest the presence of similarly low proportions of young sheep (Table 20). Because the fusion data from Phase 3 and **F556** (Table 7) includes goat, analysis could be misleading. It should be noted however, that animals under the age of ten months were absent from these samples.

Metrical Analysis

Metrical data and estimated shoulder heights for sheep/goat are presented in Table 21. Although no complete longbone measurements were obtained from Phases 1 and 2, all measurements are within the range of those obtained from Early Christian period sites (McCormick 1987). Two estimated shoulder heights of sheep were obtained from Phase 3 and these are comparable to broadly contemporary Irish sites, but because of the presence of goat in Phase 3, it was not possible to compare measurements with those of the earlier phases.

Bone	**Approx. age at fusion (months)**	**Phase 1 (F3)**		**Phase 2 (F4)**		**Phase 3 (F124)**		**F556**	
		Fused	Unfused	Fused	Unfused	Fused	Unfused	Fused	Unfused
Pelvis, Humerus d., Radius p.	0-10	14	-	9	1	28	-	9	-
Tibia d.	18-24	6	1	6	1	15	3	5	-
Radius d., Femur p., Calcaneus	30-36	-	-	-	2	5	8	1	-
Humerus p., Femur d., Tibia p.	36-42	-	1	2	-	1	3	-	1

Key: p=proximal, d=distal.

Table 7. Johnstown 1. Sheep (**F3**, **F4**) and sheep/goat (**F124, F556**) epiphyseal fusion data after Silver (1969, 285-286).

5.1.4 Horse

Horse is represented in small proportions in the three main phases at Johnstown 1. It can be seen from Table 8 that juveniles as well as adults were recorded in Phases 2 and 3. This may indicate that horseflesh was consumed during these periods, but there was no evidence in the form of butchery marks to validate this assumption. It should be noted, however, that direct evidence for the consumption of horseflesh was recorded from **F1131,** where cut marks were identified on a horse ulna (Plate 9).

In Phase 2 all of the juvenile horse bones were recovered from the same area (Grid C), and are likely to come from a single individual. This animal of less than three years of age may have been dumped in the ditch after its death. The unfused epiphyses of the animal's left humerus and both femora are present, as well other leg bones, which suggests that the limbs were discarded in an articulated state.

Unlike the three main phases at Johnstown 1, a high proportion of horse was recorded in **F556**. The remains of at least three individuals were recovered, which constitute 16% of the sample's overall MNI total (Table 15). All of the ageable bone fragments from this feature are of mature horses (Table 8).

The metrical data for horse is presented in Table 22 and seven bones from the three main phases enabled the estimation of shoulder heights (Table 9). These shoulder height values indicate that the animals were of a small pony-sized variety, and no significant difference in sizes is apparent between phases. Shoulder heights ranged from 129.9cm to 137.4cm (12.8-13.5 hands), and are similar to those obtained from contemporary sites.

A shoulder height value for horse of 155.3cm (15.3 hands) was obtained from **F556** (Table 9). It is larger than those obtained from the three main phases, and than the average height of a Connemara pony, which ranges from 13 to 14 hands (Miller 1935, 485). However, when compared to values obtained from Irish Medieval sites such as Waterford, it is found to be unexceptional (McCormick 1997).

Bone	**Approx. age of fusion (in months)**	**Phase 1 (F3)**		**Phase 2 (F4)**		**Phase 3 (F124)**		**F556**	
		Fused	**Unfused**	**Fused**	**Unfused**	**Fused**	**Unfused**	**Fused**	**Unfused**
2nd phalanx p.	9-12	-	-	-	-	4	-	-	-
1st phalanx p.	13-15	-	-	2	-	4	1	1	-
Humerus d., Radius p., Metacarpal d.	15-18	1	-	1	1	5	-	6	-
Metatarsal d.	16-20	-	-	1	-	2	-	1	-

Tibia d.	20-24	-	-	1	-	3	-	1	-
Calcaneus	36	-	-	-	1	2	-	-	-
Humerus p., Radius d., Femur p., Femur d., Tibia p.	36-42	1	-	-	4	7	-	3	-

Table 8. Johnstown 1. Fusion data for horse (after Silver 1969,285-286).

Phase	Bone	L1 (mm)	Mult. Factor	ESH (cm)
1 (**F3**)	Metacarpal	207.9	6.41	133.3
	Metacarpal	213.9	6.41	137.1
2 (**F4**)	Metatarsal	243.8	5.33	129.9
3 (**F124**)	Tibia	302.5	4.36	131.9
	Tibia	312.7	4.36	136.3
	Metatarsal	251.4	5.33	134.0
	Metatarsal	257.8	5.33	137.4
F556	Radius	301.5	4.34	130.9
	Metacarpal	242.3	6.41	155.3

Table 9. Johnstown 1. Estimated shoulder heights for horse, after Kiesewalter (quoted in von den Driesch and Boessneck 1974, 333).

5.1.4 Dog

Dog bones were commonly recorded in all samples. In Phase 2 and 3 their fragments and MNI percentage values indicate that they were more abundant than horse. In Phase 3 their proportion dramatically increases from that of the previous phase.

Table 10 shows that juvenile dog bones are absent in the first two phases at Johnstown 1. Conversely, in Phase 3 they constitute 7% of the bones that could be aged (N=42). These juvenile bones may indicate the deliberate killing of immature dogs.

Bone	Approx. age of fusion (months)	Phase 1 (F3)		Phase 2 (F4)		Phase 3 (F124)		F556	
		Fused	Unfused	Fused	Unfused	Fused	Unfused	Fused	Unfused
1st Phalanx p., 2nd Phalanx p.	7	-	-	-	-	6	1	-	-
Humerus d.	8-9	-	-	2	-	6	-	1	-
Radius p., Radius d., Ulna d.	11-12	-	-	1	-	7	-	-	-
Tibia d., Calcaneus	13-16	2	-	-	-	6	2	-	-
Humerus p.	15	-	-	-	-	4	-	-	-
Femur p., Femur d., Tibia p.	18	2	-	2	-	10	-	-	-

Table 10. Johnstown 1. Fusion data for dog (after Silver 1969, 285-286).

A right scapula of dog was recovered from Phase 3 which had been cut transersally along the blade (Plate 7). This is related to dismemberment and butchering of the shoulder, and therefore provides direct evidence for the consumption of dogflesh.

The consumption of dog in the Medieval period is usually related to times of extreme hardship, generated by famine or warfare. Alternatively, it could indicate the economic exploitation of the animals for their meat. Although dog pelts were exported from Youghal during the sixteenth century (McCormick 1991), no direct evidence for the skinning of dogs was available from this site.

The measurements and estimated shoulder heights for dog are shown in Table 23 (Harcourt, 1974, 154). Unfortunately, all of the complete longbones came from Phase 3, and therefore it was not possible to establish whether there was chronological variability in dog sizes.

Seven shoulder height values were obtained in total, the majority of which (N=6) were roughly equivalent to the average height of a retriever or a labrador. One humerus, however, produced an exceptionally small shoulder height value of 25.4 cm, roughly equivalent to the average height of toy fox terrier. Bones (N=38) of an even smaller lap-dog were recovered from **F695** (see Table 25), with an estimated shoulder height value of just 23.7cm (radius). This context could not be precisely dated, but is known to be somewhat later than Phase 3 (L. Clarke, pers. comm.). These two shoulder height values lie at the lower limit of the size range for lap-dogs which have been recorded at Early Christian and Medieval period sites in Ireland (F. McCormick, pers.comm.).

5.1.5 Cat

Cat remains were infrequently recorded, but were present throughout all phases (but not in **F556**). Generally, they appear to have been less abundant than dogs, except in Phase 2 where they make up 5.5% of the MNI total. Both mature and immature cats were recorded in the earlier phases, but in the final phase only bones of mature individuals were found (Table 11).

In Plate 4 cut marks which were identified on a feline tibia from Phase 2 are shown. Both proximal and distal epiphyses of this bone are fused, indicating that this animal was over eleven and a half months at time of death (Habermehl 1961, 151). Skinning can be accomplished without leaving cut marks on the tibia, but marks on the caudal face of the shaft are clearly visible, and are most likely to have been caused by skinning. This evidence and the presence of juvenile bones indicate that cats were killed and exploited for their pelts.

The killing of cats for their pelts in the Early Christian period was apparently extremely uncommon. Both zooarchaeological and literary evidence indicate that they were generally kept as prized domestic pets, and lived relatively comfortable, long lives (McCormick 1991). Their bones tend to be larger than those found in Medieval contexts, when animal skins became one of Ireland's most important exports (McCormick 1988, 226).

Unlike broadly contemporary sites evidence for the exploitation of cats for their pelts was unavailable from Phase 3. The presence of rat in this phase, however (see below), could indicate that they were kept primarily to control vermin.

Only a small amount of metrical data for cat is available from Johnstown 1 (Table 24). The vast majority of longbone measurements come from the earlier phases and all of these fall within the range of data obtained from both urban and rural Early Christian period sites (McCormick 1987, 360).

Bone	Approx. age of fusion (in months)	Phase 1 (F3)		Phase 2 (F4)		Phase 3 (F124)	
		Fused	Unfused	Fused	Unfused	Fused	Unfused
Humerus d., Radius p., Femur p., Femur d.	8.5	0	2	10	1	2	-
Ulna	10	-	-	-	3	1	-
Humerus p., Radius d., Tibia p., Tibia d.	11.5	-	-	7	4	1	-

Table 11. Johnstown 1. Cat fusion data (after Habermehl 1961,151).

5.1.6 Wild Animals

In Phase 1 red deer is the only wild animal that was identified, and post-cranial bones were exclusively recorded for the species. The absence of antler suggests that during this time the animal was primarily exploited for venison. This contrasts with the available archaeozoological data from contemporary sites where the majority of red deer remains comprise antler. It should be noted, however, that in this phase only three red deer fragments were recovered (0.3% of the fragments total), indicating that venison made little contribution to the diet overall. In Phase 2 the majority of red deer bones comprise antler (73%), and a relatively large proportion of these showed direct evidence for having been worked or cut (36%). Therefore, red deer became more valued for its hard durable antler than for its meat. Two burrs present in the sample indicate that shed antler was collected. The presence of small numbers of post-cranial elements, however, suggests that venison continued to be consumed, and that animals were also butchered on site.

Two juvenile lagomorph (hare/rabbit) bones were identified from Phase 2 by Sheila Hamilton Dyer (see report). She concluded that given their date they are likely to be leveret rather than young rabbit.

Of the wild species that occur in Phase 3 red deer and rabbit fragments are the most numerous. Similar to the previous phase, the remains of red deer comprise antler fragments primarily (67%), and seventy five per cent of these bear cut marks. Rabbits were introduced into Ireland by the Anglo-Normans (McCormick 1999, 366) and therefore it is not surprising that definite identification of the species occurs only in the final phase. Because rabbits are burrowers, however, it is possible that their proportions in Phase 3 are an inaccurate representation. Both fused and unfused bone elements were recorded for the species.

Extremely small numbers of fox (N=5) and hare bones (N=1) were identified in Phase 3. Bones from both of these species were fused, representing mature individuals. Evidence for butchery or skinning was unavailable. Two additional species were identified from Phase 3 by Sheila Hamilton Dyer (see report). These are pine marten and rat (black rat). The remains of pine marten have been recorded at Early Christian period and Medieval sites in Ireland and documentary sources from the twelfth and thirteenth century indicate that they were common in woodlands, and exploited by humans for their skins (McCormick 1998, 363). The black rat, which is today one of Ireland's rarest land mammals (Hayden & Harrington 2000, 140), is found on many archaeological sites from the thirteenth century onwards (McCormick 1998, 366).

A single tibia of a young lagomorph (probably rabbit) was identified in **F556** (by Sheila Hamilton Dyer).

6. Summary

Interpretation of the zooarchaeological data from Johnstown 1 was problematical, due to the fact that, as mentioned above, the function of the site changed from a settlement in the Early Christian period to a burial ground in medieval times. Therefore, changes in species and age distributions that have been identified between phases may be a reflection of this change in function, rather than of direct changes in patterns of animal husbandry. Further archaeological and zooarchaeological research could answer this question.

Early Christian Period

From the analysis it can be seen that the data from Phases 1 and 2 at Johnstown 1 are generally similar to those obtained from the majority of Early Christian period rural sites in Ireland. A limited range of mammalian species was recorded, and cattle were found to be the principal domesticate. As mentioned above, age and sex distributions for cattle suggest that they were exploited primarily for dairying. Palaeopathological examination revealed that the species (perhaps both bulls and cows) was exploited for traction also. Beef was the most abundant meat in supply, and it can be seen from the plates that cattle bone was used extensively as a raw material.

Pigs were the second most important domesticate and were exploited exclusively for their meat. A rigid slaughter strategy was in place, where a large proportion of the population was killed, immediately after having been fattened on woodland mast in early autumn. Sheep are indicated to have been considerably less abundant than pigs. The very low proportions of animals under the age of eighteen months may indicate that sheep were not exploited for their milk, but rather for their meat and wool. An extremely low number of goat bones were recorded.

In contrast to other Early Christian period sites, however, and to documentary sources of the seventh and eight centuries which state that cats were valued because of their attractiveness as pets (O' Kelly 2000, 121), Phases 1 and 2 at Johnstown 1 produced direct evidence for the skinning of cats for their pelts. This may reflect the earlier date of these phases, and could be an indication that during the fifth/sixth centuries, cats had not yet reached the pet status which they were later to achieve.

Medieval Period

The greater part of the faunal material from Phase 3 at Johnstown 1 was disarticulated, and it can be seen from the plates that butchery marks were recorded on some of the bones. This evidence indicates that the material mainly represents discarded food waste.

Similar to Phases 1 and 2 cattle appear to have made the greatest contribution in terms of numbers of animals and of meat supplied to the site during this time. The majority of cattle represented in Phase 3 would appear to be female, and killed at over the age of thirty months. This is older than the average age of slaughtered cattle in the previous phases.

As mentioned above, the ageing data based on tooth eruption for pigs suggest that a large proportion of immature animals were killed before reaching maturity. This may be indicative of a period of severe food shortages for the people associated with the site, because in winter pigs are in direct competition with humans for food. The fact that direct evidence for the consumption of dogflesh was recorded from this phase supports this theory.

7. Conclusion

Due to the survival and careful retrieval of large, well-preserved faunal samples from Johnstown 1 the collection of a large corpus of zooarchaeological data has been facilitated. This data has made a significant contribution to our understanding of past animal husbandry, and will be used in conjunction with those of other sites for further analysis.

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	Cattle	Horse	Pig	Sheep/Goat	Dog	Cat	Red Deer
Horn/Antler	17	-	-	1 (S)	-	-	-
Skull	98	-	45	4 (1S)	-	-	-
Mandible	53	1	27	9	-	-	-
Teeth	125	-	46	14	-	-	-
Atlas	3	-	-	-		-	-
Axis	7	-	-	1	-	-	-
Cervical vertebra	13	-	-	-	-	-	-
Thoracic vertebra	2	-	-	-	-	-	-
Lumbar vertebra	5	-	-	-	-	-	-
Sacrum	5	-	-	-	-	-	-
Scapula	16	-	16	4	-	-	1
Humerus	27	-	19	6 (2S)	-	-	2
Radius	32	-	9	5 (1S)	-	-	-
Ulna	14	-	13	-	-	-	-
Metacarpal	19	2	2	3	1	-	-
Pelvis	32	-	17	7	-	-	-
Femur	19	1	5	3	1	1	-
Tibia	21	-	22	12 (2S)	1	-	-
Fibula	-	-	2	-	-	-	-
Astragalus	6	1	-	-	-	-	-
Calcaneus	10	-	1	-	1	-	-
Metatarsal	24	-	5	2	-	-	-
Carpals/Tarsals	4	-	-	-	-	-	-
Metapodials	16	1	-	2	-	-	-
Phalanx 1	7	-	1	-	-	-	-
Phalanx 2	-	-	-	-	-	-	-
Phalanx 3	4	-	-	-	-	-	-
Fragments total	579	6	230	73	4	1	3
Fragments %	64.6	0.7	25.7	8.1	0.4	0.1	0.3
MNI	13	1	10	5	1	1	2
MNI %	39.4	3.0	30.3	15.2	3.0	3.0	6.1
	LM	**MM**	**SM**				
Ribs	146	84	10				
Vertebrae	47	26	1				
Unidentified	1230						

Key: S=sheep; G=goat; MNI=minimum number of individuals; LM=large mammal; MM=medium mammal; SM=small mammal.

Table 12. Johnstown 1 Phase 1 (**F3**). Fragments total and minimum number of individuals distribution.

	Cattle	Horse	Pig	Sheep /Goat	Dog	Cat	Red deer	Rabbit/ Hare
Horn/Ant.	42	-	-	2(1G)	-	-	11	-
Skull	119	-	63	3	1	5	-	-
Mandible	182	2	61	10	6	-	-	-
Teeth	318	4	128	31	10	-	-	-
Atlas	7	-	1	-	-	1	-	-
Axis	8	-	-	-	-	-	-	-
Hyoid	2	-	-	-	-	-	-	-
Cerv.	4	-	-	-	-	-	-	-
Thor.	3	-	-	-	-	-	-	-
Sacrum	4	-	-	-	-	-	-	-
Scapula	88	-	29	18	-	2	-	-
Humerus	86	1	28	9(1S)	2	5	-	-
Radius	68	1	27	12(3S)	1	1	1	-
Ulna	38	-	18	-	-	2	-	-
Metacarpal	55	3	13	9	-	3	-	-
Pelvis	55	2	36	3	2	2	-	-
Femur	41	2	15	8	2	3	1	1
Patella	4	-	-	-	-	-	-	-
Tibia	54	1	25	17(4S)	2	4	1	-
Fibula	-	-	3	-	-	1	-	-
Astragalus	25	1	2	-	-	-	1	-
Calcaneus	19	-	6	-	-	-	-	-
Metatarsal	81	2	6	7	-	1	-	1
Car/Tar	10	-	-	-	-	-	-	-
Metap.	24	-	-	-	-	3	-	-
Phalanx 1	24	2	-	1	-	-	-	-
Phalanx 2	3	-	-	1	-	-	-	-
Phalanx 3	8	1	-	-	-	-	-	-
Frag. Total	1372	22	461	131	26	33	15	2
Frag. %	66.5	1.1	22.4	6.4	1.3	1.6	0.7	0.1
MNI	26	1	16	5	2	3	1	1
MNI %	47.3	1.8	29.1	9.1	3.6	5.5	1.8	1.8
	LM	**MM**	**SM**					
Ribs	453	191	44					
Vert.	111	42	4					
Unid.	3559							

Key: S=sheep; G=goat; MNI=minimum number of individuals; LM=large mammal; MM=medium mammal; SM=small mammal.

Table 13. Johnstown 1 Phase 2 (**F4**). Fragments total and minimum number of individuals distribution.

	Cattle	**Horse**	**Pig**	**Sheep/ Goat**	**Dog**	**Cat**	**Red deer**	**Fox**	**Hare**	**Rabbit**	**Pine marten**	**Rat**
Horn/Ant.	49	-	-	16 (3S, 9G)	-	-	5	-	-	-	-	-
Skull	108	1	79	31	26	-	-	-	-	-	-	-
Mandible	125	9	55	38	20	-	-	-	-	2	-	-
Teeth	559	68	186	152	43	-	-	-	-	1	-	-
Atlas	4	-	1	1	6	-	-	-	-	-	-	-
Axis	2	-	-	3	2	1	-	-	-	-	-	-
Hyoid	-	-	-	1	-	-	-	-	-	-	-	-
Cerv.	3	-	-	-	3	-	-	-	-	-	-	-
Thor.	1	-	-	-	4	-	-	-	-	-	-	-
Sacrum	7	-	-	-	-	-	-	-	-	-	-	-
Scapula	87	4	42	39	5	-	-	-	1	-	-	-
Humerus	88	4	28	27 (1S, 1G)	8	2	-	-	-	-	-	1
Radius	104	-	21	32 (3S, 1G)	6	-	1	-	-	-	1	-
Ulna	32	1	1	5	6	1	-	2	-	1	-	-
Metacarpal	71	5	36	29	16	-	-	-	-	-	-	-
Pelvis	98	10	35	25	7	-	-	-	-	-	-	-
Femur	55	4	9	22(1S)	6	-	-	-	-	-	-	-
Patella	3	1	-	-	-	-	-	-	-	-	-	-
Tibia	70	9	27	56 (7S, 2G)	9	1	-	-	-	3	-	-
Fibula	-	-	1	-	2	-	-	-	-	-	-	-
Astragalus	30	3	3	4	2	-	1	-	-	-	-	-
Calcaneus	37	2	8	6	4	-	-	2	-	-	-	-
Metatarsal	61	2	9	26(2S)	11	-	-	-	-	-	-	-
Car/Tar	16	-	3	1	-	-	-	-	-	-	-	-
Metap.	34	-	1	5	4	-	-	1	-	-	-	-
Phalanx 1	28	5	5	9	8	-	-	-	-	-	-	-
Phalanx 2	15	5	-	1	2	-	-	-	-	-	-	-
Phalanx 3	5	1	-	3	-	-	-	-	-	-	-	-
Frag. Total	1692	134	532	532	200	5	7	5	1	7	1	1
Frag. %	54.3	4.3	17.1	17.1	6.4	0.2	0.2	0.2	0.0	0.2	0.0	0.0
MNI	26	3	18	13	5	2	1	1	1	2	1	1
MNI %	35.1	4.1	24.3	17.6	6.8	2.7	1.4	1.4	1.47	2.7	1.4	1.4
	LM	**MM**	**SM**									
Ribs	141	128	127									
Vert.	118	56	34									
Unid.	6568											

Key: S=sheep; G=goat; MNI=minimum number of individuals; LM=large mammal; MM=medium mammal; SM=small mammal.

Table 14. Johnstown 1 Phase 3 (**F124**). Fragments total and minimum number of individuals distribution.

	Cattle	Horse	Pig	Sheep/Goat	Dog	Rabbit/Hare
Horn/Antler	1	-	-	-	-	-
Skull	13	2	4	3	-	-
Mandible	23	3	6	7	-	-
Teeth	80	32	17	32	5	-
Atlas	2	1	2	-	-	-
Axis	1	1	-	-	-	-
Scapula	16	7	4	4	-	-
Humerus	10	6	-	7 (2S, 3G)	1	-
Radius	17	3	2	5	-	-
Ulna	4	1	1	1	-	-
Metacarpal	7	3	1	4	-	-
Pelvis	31	8	1	3	-	-
Femur	12	1	5	5	1	-
Patella	1	-	-	-	-	-
Tibia	5	3	4	11 (3S)	-	1
Fibula	-	-	2	-	-	-
Astragalus	2	4	-	-	-	-
Calcaneus	6	1	1	-	1	-
Metatarsal	12	3	1	3	-	-
Carpals/Tarsals	-	-	-	1	-	-
Metapodials	2	-	1	-	-	-
Phalanx 1	2	1	-	5	-	-
Phalanx 2	1	-	-	-	-	-
Phalanx 3	-	1	-	-	-	-
Sacrum	-	-	-	1	-	-
Total fragments	248	81	52	92	8	1
Fragments %	51.5	16.8	10.8	19.1	1.7	0.2
MNI	7	3	3	4	1	1
MNI %	36.8	15.8	15.8	21.1	5.3	5.3
	LM	**MM**	**SM**			
Ribs	30	23	5			
Vertebrae	29	10	2			
Unidentified	1144					

Key: S=sheep; G=goat; MNI=minimum number of individuals; LM=large mammal; MM=medium mammal; SM=small mammal.

Table 15. Johnstown 1 **F556**. Fragments total and minimum number of individuals distribution.

Higham stage	Approx. age (months)	Phase 1 (F3)	Phase 2 (F4)	Phase 3 (F124)
5	6-7	-	2	-
6	7-9	-	1	-
8	15-16	1	-	-
9	16-17	1	2	-
11	18-24	-	1	-
12	24	-	2	-
14	24-30	1	-	-
15	30-31	-	-	1
18	36	-	-	1
20	40	-	1	1
22	50	-	-	1

Table 16. Johnstown 1. Cattle age distribution for three main phases based on tooth eruption and wear after Higham (1967).

Bone	Phase	Measurement	N.	Min.	Max.	Mean	sd.
Cranium	1 (**F3**)	Least frontal breadth (32)	1	186.0	-	-	-
Horncore	1 (**F3**)	Least diameter of base (46)	3	47.1	65.5	57.7	9.5
		Length of outer curvature (47)	3	120.0	130.0	126.7	5.8
	2 (**F4**)	Least diameter of base (46)	7	47.5	72.4	58.1	10.4
		Length of outer curvature (47)	4	120.0	180.0	148.5	30.9
	3 (**F124**)	Least diameter of base (46)	1	56.2	-	-	-
		Length of outer curvature (47)	1	136.0	-	-	-

Key: N = number; Min = minimum value; Max = maximum value; sd = standard deviation.

Table 17. Johnstown 1. Cattle metrical information (mm) after von den Driesch (1976).

Bone	Phase/F	Meas.	N.	Min.	Max.	Mean	sd.
Scapula	1 (**F3**)	SLC	5	44.3	52.2	48.6	3.1
		GLP	4	58.8	61.6	60.2	1.5
		LG	6	49.1	55.5	52.3	2.9
	2 (**F4**)	SLC	12	43.4	60.1	49.5	5.7
		GLP	10	60.0	75.0	64.7	4.8
		LG	11	50.3	61.4	54.1	3.6
	3 (**F124**)	SLC	3	45.4	50.0	47.8	2.3
		GLP	7	59.0	66.4	62.6	2.6
		LG	6	48.8	56.0	51.8	3.1
	F556	SLC	4	46.0	61.2	50.3	7.3
		GLP	4	58.0	74.6	66.1	7.1
		LG	5	49.9	62.5	55.0	5.2

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 17 (contd.). Johnstown 1. Cattle metrical information (mm) after von den Driesch (1976).

Bone	Phase/F	Meas.	N.	Min.	Max.	Mean	sd.
Humerus	1 (**F3**)	Bd	6	70.4	82.7	74.2	4.5
		BT	7	61.0	69.3	66.6	2.8
		HTC	9	27.2	33.4	29.8	1.9
	2 (**F4**)	GLC	2	235.9	242.8	239.4	4.9
		Bp	2	90.8	94.8	92.8	2.8
		Bd	15	62.5	82.9	71.4	5.4
		BT	15	62.4	79.4	69.5	4.4
		HTC	22	27.3	33.1	30.0	1.7
	3 (**F124**)	Bd	7	67.6	80.0	73.5	4.7
		BT	7	64.9	73.2	68.1	2.8
		HTC	12	27.8	31.3	29.6	1.1
	F556	Bd	1	68.7	-	-	-
		BT	1	65.5	-	-	-
		HTC	1	29.4	-	-	-
Radius	1 (**F3**)	GL	1	256.4	-	-	-
		Bp	10	62.9	77.2	72.2	4.8
		SD	1	36.4	-	-	-
		Bd	2	61.6	61.6	61.6	0.0
	2 (**F4**)	GL	2	254.5	278.0	266.3	16.6
		Bp	8	67.5	83.6	77.7	5.4
		SD	2	37.2	38.1	37.7	0.6
		Bd	10	59.3	79.0	67.7	6.4
	3 (**F124**)	GL	1	264.6	-	-	-
		Bp	9	65.6	77.7	73.0	3.8
		SD	1	38.1	-	-	-
		Bd	5	60.3	67.5	63.8	2.6
	F556	Bp	4	71.0	84.1	74.4	6.5
Ulna	1 (**F3**)	DPA	5	44.7	60.0	53.3	6.4
	2 (**F4**)	DPA	10	54.8	68.5	59.7	4.8
		SDO	1	48.6	-	-	-
	3 (**F124**)	DPA	6	49.2	70.7	57.3	7.6
		SDO	2	44.6	45.8	45.2	0.8
	F556	DPA	2	65.8	66.9	66.4	0.8

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 17 (contd.). Johnstown 1. Cattle metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Metacarpal	1 (**F3**)	GL	2	174.6	179.0	176.8	3.1
		Bp	3	45.4	56.0	51.9	5.7
		SD	2	30.3	31.5	30.9	0.8
		BFd	2	54.9	57.7	56.3	2.0
		BFdm	1	28.3	-	-	-
		Ddm	1	30.3	-	-	-
		BFdl	1	26.2	-	-	-
		Ddl	1	29.2	-	-	-
	2 (**F4**)	GL	4	176.5	189.0	184.4	5.7
		Bp	8	67.5	83.6	77.7	5.4
		SD	4	28.2	33.4	30.4	2.2
		BFd	4	52.3	62.4	56.6	4.3
		B at F	3	48.8	57.6	52.4	4.6
		BFdm	2	25.7	26.7	26.2	0.7
		Ddm	2	28.5	31.4	30.0	2.1
		BFdl	3	24.5	25.0	24.8	0.3
		Ddl	3	27.6	30.0	29.1	1.3
	3 (**F124**)	GL	5	174.6	194.8	182.5	7.5
		Bp	9	46.0	55.5	51.4	2.6
		SD	4	28.8	32.5	30.6	2.0
		BFd	9	47.7	64.9	54.2	4.8
		B at F	4	46.1	54.1	48.9	3.6
		BFdm	4	24.6	26.8	25.4	1.0
		Ddm	4	28.7	31.3	29.4	1.3
		BFdl	4	24.2	25.6	24.7	0.6
		Ddl	4	28.1	30.6	29.1	1.2
	F556	GL	1	185.6	-	-	-
		Bp	1	54.5	-	-	-
		SD	1	28.1	-	-	-
		BFd	1	49.6	-	-	-
		B at F	1	48.0	-	-	-

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 17 (contd.). Johnstown 1. Cattle metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Pelvis	1 (**F3**)	LA	1	53.0	-	-	-
		LAR	1	48.2	-	-	-
	2 (**F4**)	LA	4	63.6	67.7	65.8	1.7
		LAR	4	49.3	55.4	51.7	2.6
	3 (**F124**)	LA	3	57.4	74.9	66.6	8.8
		LAR	2	55.1	60.3	57.7	3.7
	F556	LA	1	66.5	-	-	-
		LAR	1	50.0	-	-	-
Tibia	1 (**F3**)	GL	1	308.4	-	-	-
		Bp	1	78.4	-	-	-
		SD	1	33.3	-	-	-
		Bd	10	53.9	62.2	56.7	2.5
	2 (**F4**)	GL	1	318.5	-	-	-
		SD	1	33.0	-	-	-
		Bd	11	51.3	61.3	55.1	2.7
	3 (**F124**)	GL	2	312.5	336.0	324.3	16.6
		SD	2	35.0	36.4	35.7	1.0
		Bd	10	51.8	62.1	55.7	2.9
Astragalus	1 (**F3**)	GLl	4	58.8	66.8	62.1	3.5
		GLm	4	52.9	60.6	56.4	3.3
		Dl	3	32.9	37.4	34.5	2.5
		Dm	4	32.4	35.2	34.0	1.4
		Bd	4	37.1	42.6	38.7	2.6
	2 (**F4**)	GLl	22	57.6	67.1	62.3	2.5
		GLm	21	51.4	60.5	56.4	2.2
		Dl	21	32.0	37.5	34.8	1.2
		Dm	19	32.7	38.0	34.9	1.3
		Bd	20	36.1	45.6	39.9	2.5
	3 (**F124**)	GLl	21	56.2	66.1	61.1	2.5
		GLm	22	52.1	61.0	55.8	2.4
		Dl	18	32.3	36.2	34.5	1.1
		Dm	19	30.2	36.9	33.7	1.7
		Bd	19	35.5	45.0	38.6	2.3
	F556	GLl	1	59.9	-	-	-
		GLm	1	55.1	-	-	-
		Dl	1	32.5	-	-	-
		Dm	1	30.6	-	-	-
		Bd	1	36.4	-	-	-

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 17 (contd.). Johnstown 1. Cattle metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Calcaneus	1 (**F3**)	GL	2	122.0	125.0	123.5	2.1
	2 (**F4**)	GL	3	122.3	137.6	130.1	7.7
	3 (**F124**)	GL	2	122.4	128.3	125.4	4.2
Metatarsal	1 (**F3**)	GL	1	202.4	-	-	-
		Bp	4	40.6	47.4	43.1	3.0
		SD	1	25.5	-	-	-
		BFd	2	48.3	58.2	53.3	7.0
		B at F	1	45.4	-	-	-
		BFdm	1	23.9	-	-	-
		Ddm	1	28.8	-	-	-
		BFdl	1	22.0	-	-	-
		Ddl	1	28.0	-	-	-
	2 (**F4**)	GL	16	196.9	214.1	207.2	6.1
		Bp	28	38.0	53.4	43.9	3.2
		SD	16	25.0	32.2	26.8	1.9
		BFd	18	47.4	62.2	51.2	4.2
		B at F	16	44.4	56.3	48.4	3.7
		BFdm	17	22.5	31.2	24.8	2.6
		Ddm	17	26.5	34.7	30.0	2.3
		BFdl	18	21.2	28.0	23.6	1.9
		Ddl	17	26.1	32.0	28.7	1.7
	3 (**F124**)	GL	6	198.8	216.2	205.9	6.6
		Bp	12	38.6	45.2	41.9	2.3
		SD	5	22.6	25.7	24.4	1.1
		BFd	5	46.9	49.7	48.3	1.2
		B at F	5	43.9	48.7	45.7	1.9
		BFdm	7	21.4	23.4	22.6	0.6
		Ddm	6	26.4	30.0	28.2	1.4
		BFdl	6	20.5	23.8	22.0	1.2
		Ddl	6	24.6	29.3	27.2	1.7
	F556	BFd	1	46.5	-	-	-

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 17 (contd.). Johnstown 1. Cattle metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Phalanx 1	1 (**F3**)	Glpe	6	52.3	59.4	54.3	2.6
		Bp	6	24.0	30.7	27.2	2.3
		SD	5	23.2	27.2	24.5	1.6
		Bd	5	24.9	27.5	26.2	1.0
	2 (**F4**)	Glpe	16	49.6	62.8	54.2	3.1
		Bp	17	25.3	33.3	28.0	2.5
		SD	15	20.5	29.8	23.3	2.4
		Bd	15	22.3	30.5	24.9	2.3
	3 (**F124**)	Glpe	19	50.6	59.2	53.7	2.1
		Bp	18	24.4	31.2	26.4	1.7
		SD	18	20.1	26.5	22.6	1.6
		Bd	18	21.2	29.4	24.5	2.1
	F556	Glpe	1	52.2	-	-	-
		Bp	1	26.7	-	-	-
		SD	1	22.3	-	-	-
		Bd	1	25.1	-	-	-
Phalanx 2	2 (**F4**)	GL	3	35.8	40.0	37.6	2.2
		Bp	3	26.4	32.5	28.6	3.4
		SD	3	20.6	25.4	22.8	2.4
		Bd	3	20.3	27.0	22.6	3.8
	3 (**F124**)	GL	10	32.8	38.2	35.2	1.6
		Bp	11	23.8	29.5	26.4	1.6
		SD	10	20.0	23.6	21.4	1.3
		Bd	10	18.7	29.0	21.0	3.0
Phalanx 3	1 (**F3**)	DLS	3	53.5	77.3	68.6	13.1
		Ld	3	42.0	59.2	52.9	9.5
		MBS	3	18.0	23.6	21.5	3.0
	2 (**F4**)	DLS	4	59.3	80.2	68.7	8.7
		Ld	4	47.3	58.0	50.7	4.9
		MBS	5	19.3	26.0	22.2	2.7
	3 (**F124**)	DLS	1	66.3	-	-	-
		Ld	1	53.5	-	-	-
		MBS	3	23.5	24.6	23.9	0.6

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation.

Table 17 (contd.). Johnstown 1. Cattle metrical information (mm), after von den Driesch.

Bone	Approx. age at fusion (months)	Phase 1 (F3)		Phase 2 (F4)		Phase 3 (F124)		F556	
		Fused	Unfused	Fused	Unfused	Fused	Unfused	Fused	Unfused
Pelvis	0-12	14	-	10	-	10	-	-	-
Humerus d., Radius p. Metacarpal d., Tibia d., Metatarsal d.	12-24	15	11	37	24	31	19	2	3
Calcaneus, Humerus p., Radius d., Femur p., Femur d., Ulna, Tibia p.	30-42	1	2	9	26	4	16	-	3

Table 18. Johnstown 1. Pig fusion data (based on Silver 1969, 285-286).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Scapula	1 (**F3**)	SLC	5	19.9	24.0	21.8	1.5
		GLP	3	32.8	34.5	33.4	0.9
	2 (**F4**)	SLC	8	20.4	*27.2	23.3	2.1
		GLP	6	32.3	35.4	33.5	1.5
	3 (**F124**)	SLC	4	21.4	23.8	22.4	1.0
		GLP	4	31.3	33.4	32.4	0.9
	F556	SLC	3	*25.2	29.5	27.2	2.2
		GLP	1	*36.9	-	-	-
Humerus	1 (**F3**)	Bd	4	37.0	42.7	39.3	2.5
		BT	4	31.2	36.7	33.3	2.5
		HTC	4	17.7	21.2	19.5	1.5
	2 (**F4**)	Bd	11	32.4	41.1	37.3	2.5
		BT	10	24.7	32.0	29.8	2.2
		HTC	11	14.3	20.0	17.7	1.4
	3 (**F124**)	Bd	7	35.4	42.7	38.4	2.5
		BT	8	28.8	35.6	31.0	2.3
		HTC	9	14.5	29.8	20.7	5.2
Radius	1 (**F3**)	Bp	5	23.8	27.9	25.7	1.5
	2 (**F4**)	Bp	14	23.6	28.8	26.5	1.7
	3 (**F124**)	Bp	5	23.9	31.4	28.0	2.7
	F556	Bp	1	*29.8	-	-	-

Key: *Large; Meas=measurement; N=number; Min=minimum value; Max=maximum value; sd = standard deviation.

Table 19. Johnstown 1. Pig metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Ulna	1 (**F3**)	DPA	5	29.7	39.8	34.4	4.5
		SDO	2	24.1	24.7	24.4	0.4
	2 (**F4**)	DPA	8	28.7	38.0	33.1	3.5
		SDO	5	22.9	27.6	25.3	1.8
	3 (**F124**)	DPA	3	31.0	35.2	33.2	2.1
		SDO	1	27.7	-	-	-
	F556	DPA	1	*45.3	-	-	-
Pelvis	1 (**F3**)	LA	4	31.4	34.0	33.0	1.1
		LAR	5	28.9	33.5	31.2	1.9
	2 (**F4**)	LA	6	30.5	35.3	32.4	2.0
	3 (**F124**)	LA	3	32.2	34.6	33.1	1.3
		LAR	3	28.0	32.1	29.8	2.1
Tibia	1 (**F3**)	Bd	5	26.5	*30.7	28.5	1.9
	2 (**F4**)	Bd	4	27.6	28.4	28.0	0.3
	3 (**F124**)	Bd	3	27.4	*30.5	28.9	1.6
	F556	Bd	1	26.5	-	-	-
Astragalus	2 (**F4**)	GL1	2	41.0	*41.6	41.3	0.4
		GLm	2	37.6	38.0	37.8	0.3
	3 (**F124**)	GL1	3	39.3	*42.9	40.7	2.0
		GLm	3	36.0	39.9	37.6	2.1
Calcaneus	1 (**F3**)	GL	1	69.7	-	-	-
MT IV	2 (**F4**)	GL	1	74.4	-	-	-
Phalanx 1	3 (**F124**)	GL	1	31.4	-	-	-
		Bp	1	15.0	-	-	-
		SD	1	12.0	-	-	-
		Bd	1	13.4	-	-	-

Key: *Large; Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation.

Table 19 (contd.). Johnstown 1. Pig metrical information (mm), after von den Driesch (1976).

Higham stage	Approx. age (months)	Phase 1 (F3)	Phase 2 (F4)	Phase 3 (F124)
9	9-10	-	-	1
12	12-21	1	-	-
13	21-24	-	2	-
14	25-26	-	1	-
16+	28+	-	1	1

Table 20. Johnstown 1. Sheep (**F3, F4**) and sheep/goat (**F124**) age distributions based on tooth eruption and wear after Higham (1967).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Horncore	1 (**F3**)	Basal circumference (40)	1	90.0	-	-	-
		Greatest diameter at base (41)	1	32.8	-	-	-

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation.

Table 21. Johnstown 1. Sheep/goat metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Scapula	2 (**F4**)	SLC	1	19.0	-	-	-
		GLP	1	30.6	-	-	-
Humerus	1 (**F3**)	Bd	3	23.7	25.5	24.5	0.9
		BT	3	22.9	24.0	23.5	0.6
	2 (**F4**)	GLC	1	122.5	-	-	-
		Bp	1	41.0	-	-	-
		Bd	2	27.0	28.0	27.5	0.7
		BT	3	26.9	29.2	27.8	1.3
	3 (**F124**)	Bd	1	24.1	-	-	-
		BT	2	23.4	27.5	25.5	2.9
	F556	Bd	5	26.5	37.5	30.8	4.9
		BT	3	26.4	36.4	32.0	5.1
Radius	1 (**F3**)	Bp	2	25.7	27.8	26.8	1.5
	2 (**F4**)	Bp	3	26.1	29.1	27.6	1.5
	3 (**F124**)	Bp	3	24.4	32.0	29.2	4.2
		Bd	1	24.6	-	-	-
Ulna	3 (**F124**)	DPA	4	23.0	30.0	25.5	3.1
		SDO	3	19.2	24.8	21.2	3.1
	F556	DPA	1	25.4	-	-	-
Metacarpal	2 (**F4**)	Bp	3	18.5	21.4	19.6	1.6
	3 (**F124**)	Bp	2	20.6	23.0	21.8	1.7
Pelvis	1 (**F3**)	LA	1	24.0	-	-	-
		LAR	1	21.4	-	-	-
	3 (**F124**)	LAR	1	23.9	-	-	-
	F556	LA	1	24.7	-	-	-
Femur	3 (**F124**)	GL	1	*178.3	-	-	-
		Bp	2	38.2	46.2	42.2	5.7
		SD	1	17.5	-	-	-
		Bd	1	38.4	-	-	-

Key: *Goat; Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 21 (contd.). Johnstown 1. Sheep/Goat metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.	ESH (cm)
Tibia	1 (**F3**)	Bd	4	20.4	26.0	23.6	2.3	-
	2 (**F4**)	Bd	4	21.4	23.5	22.4	0.9	-
	3 (**F124**)	GL	1	*205.9	-	-	-	-
		Bp	1	42.7	-	-	-	-
		SD	1	16.2	-	-	-	-
		Bd	7	21.8	29.0	25.0	2.6	-
	F556	Bd	3	21.8	24.4	23.2	1.3	-
Astragalus	3 (**F124**)	GLl	3	23.8	25.4	24.7	0.8	-
		Bd	3	15.5	16.2	15.9	0.4	-
Calcaneus	3 (**F124**)	GL	1	45.2	-	-	-	-
Metatarsal	1 (**F3**)	Bp	1	17.2	-	-	-	-
	3 (**F124**)	GL	2	121.4	127.0	124.2	4.0	55.1-57.7
		Bp	2	17.6	17.7	17.7	0.1	-
		SD	1	10.5	-	-	-	-
		Bd	1	21.9	-	-	-	-
Phalanx 1	3 (**F124**)	GLpe	7	26.1	39.7	33.9	5.5	-
		Bp	7	9.7	13.0	11.6	1.3	-
		SD	7	7.4	10.6	9.0	1.2	-
		Bd	7	8.5	12.6	10.4	1.5	-
	F556	GLpe	2	29.5	29.6	29.6	0.1	-
		Bp	3	10.7	11.4	11.0	0.4	-
		SD	2	8.7	10.0	9.4	0.9	-
		Bd	4	9.1	11.0	10.0	0.8	-
Phalanx 2	2 (**F4**)	GL	1	20.0	-	-	-	-
Phalanx 3	3 (**F124**)	DLS	2	24.7	30.6	27.7	4.2	-
		Ld	2	21.5	28.9	25.2	5.2	-
		MBS	2	10.5	12.3	11.4	1.3	-

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 21 (contd.). Johnstown 1. Sheep/Goat metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Scapula	3 (**F124**)	LG	1	52.3	-	-	-
	F556	SLC	4	52.5	80.2	61.0	13.0
		GLP	4	77.7	109.3	93.5	16.0
		LG	4	48.9	70.0	58.7	11.0
Humerus	3 (**F124**)	BT	2	69.1	69.3	69.2	0.1
		HTC	2	29.7	31.8	30.8	1.5
	F556	Bp	1	76.5	-	-	-
		Bd	2	70.7	88.8	79.8	12.8
		BT	2	71.5	88.0	79.8	11.7
Radius	**F556**	GL	1	315.0	-	-	-
		PL	1	307.8	-	-	-
		L1	1	301.5	-	-	-
		Bp	1	72.2	-	-	-
		BFp	1	67.4	-	-	-
		SD	1	36.4	-	-	-
		Bd	1	69.4	-	-	-
		BFd	1	55.4	-	-	-
Ulna	**F556**	DPA	1	56.8	-	-	-
		SDO	1	43.1	-	-	-
Metacarpal	1 (**F3**)	GL	2	217.9	221.6	219.8	2.6
		GLl	2	214.5	217.5	216.0	2.1
		Ll	2	207.9	213.9	210.9	4.2
		Bp	2	48.7	50.3	49.5	1.1
		Dp	1	32.2	-	-	-
		SD	2	31.6	34.7	33.2	2.2
		Bd	2	45.8	47.7	46.8	1.3
		Dd	2	35.5	36.0	35.8	0.4
	2 (**F4**)	Bp	1	40.5	-	-	-
		Dp	1	27.0	-	-	-
	3 (**F124**)	Bd	2	44.1	48.7	46.4	3.3
	F556	GL	1	252.6	-	-	-
		GLl	1	248.0	-	-	-
		Ll	1	242.3	-	-	-
		Bp	2	57.9	58.3	58.1	0.3
		SD	1	37.3	-	-	-
		Bd	1	55.5	-	-	-
Pelvis	3 (**F124**)	LA	1	64.2	-	-	-
		LAR	1	59.3	-	-	-
Femur	3 (**F124**)	Bd	2	85.7	90.4	88.1	3.3

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 22. Johnstown 1. Horse metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Tibia	3 (**F124**)	GL	2	326.1	335.6	330.9	6.7
		Ll	2	302.5	312.7	307.6	7.2
		Bp	1	85.1	-	-	-
		SD	2	36.1	40.2	38.2	2.9
		Bd	3	63.4	69.2	67.1	3.2
		Dd	3	38.2	42.9	40.5	2.4
	F556	Bd	1	62.4	-	-	-
		Dd	1	39.2	-	-	-
Astragalus	1 (**F3**)	GH	1	53.6	-	-	-
		GB	1	55.7	-	-	-
		BFd	1	48.6	-	-	-
		LmT	1	50.3	-	-	-
	2 (**F4**)	GH	1	48.2	-	-	-
		GB	1	49.8	-	-	-
		LmT	1	46.9	-	-	-
	3 (**F124**)	GH	1	52.6	-	-	-
		GB	1	60.7	-	-	-
		BFd	1	48.5	-	-	-
		LmT	1	55.4	-	-	-
	F556	GH	2	51.0	57.7	54.4	4.7
		GB	2	56.5	59.3	57.9	2.0
		LmT	2	50.5	57.2	53.9	4.7
Metatarsal	2 (**F4**)	GL	1	249.7	-	-	-
		GL1	1	245.6	-	-	-
		L1	1	243.8	-	-	-
		Bp	1	46.3	-	-	-
		Bd	1	44.1	-	-	-
	3 (**F124**)	GL	2	254.2	262.2	258.2	5.7
		GL1	2	253.3	259.6	256.5	4.5
		L1	2	251.4	257.8	254.6	4.5
		Bp	2	46.1	46.5	46.3	0.3
		SD	2	30.1	31.3	30.7	0.8
		Bd	2	45.8	47.2	46.5	1.0
	F556	Bp	1	44.3	-	-	-
		Bd	1	43.9	-	-	-

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 22 (contd.). Johnstown 1. Horse metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max	Mean	sd.
Phalanx 1	2 (**F4**)	GL	2	73.5	74.7	74.1	0.8
		Bp	1	53.3	-	-	-
		BFp	1	46.9	-	-	-
		Dp	1	36.3	-	-	-
		SD	1	33.1	-	-	-
		Bd	2	44.0	45.5	44.8	1.1
	3 (**F124**)	GL	2	83.8	85.4	84.6	1.1
		Bp	2	53.9	56.6	55.3	1.9
		BFp	2	50.0	50.3	50.2	0.2
		SD	2	33.8	34.9	34.4	0.8
		Bd	2	48.2	48.7	48.5	0.4
		BFd	2	43.7	44.7	44.2	0.7
	F556	GL	1	88.0	-	-	-
		Bp	1	53.9	-	-	-
		Dp	1	36.5	-	-	-
		BFp	1	49.1	-	-	-
		SD	1	35.4	-	-	-
		Bd	1	46.3	-	-	-
		BFd	1	44.3	-	-	-
Phalanx 2	3 (**F124**)	GL	3	42.6	46.9	44.3	2.3
		Bp	4	48.8	52.1	49.7	1.6
		BFp	4	42.4	45.4	43.3	1.4
		Dp	4	29.9	30.9	30.2	0.5
		SD	3	39.2	44.9	42.3	2.9
		Bd	3	43.6	50.1	45.8	3.7

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 22 (contd.). Johnstown 1. Horse metrical information (mm), after von den Driesch (1976).

Bone	Phase	Measurement	N.	Min.	Max.	Mean	sd.
Cranium	3 (**F124**)	Greatest mastoid breadth (23)	1	65.7	-	-	-
		Greatest breadth of occipital condyles (25)	1	37.1	-	-	-
Mandible	2 (**F4**)	Length of molar row (10)	1	34.2	-	-	-
		Length of premolar row P1-P4 (11)	1	38.4	-	-	-
		Length of premolar row P2-P4 (12)	1	33.9	-	-	-
		Length of carnassial alveolus (14)	1	18.7	-	-	-
		Height of vertical ramus (18)	1	43.8	-	-	-
		Height of mandible behind M1 (19)	1	19.9	-	-	-
		Height of mandible between P2 and P3 (20)	3	15.5	23.4	19.7	4.0
	3 (**F124**)	Total length (1)	1	134.3	-	-	-
		Length from indentation between condyle process and the angular process to Infradentale (3)	1	127.0	-	-	-
		Length from condyle process to aboral border of the canine alveolus (4)	1	117.1	-	-	-
		Length from indentation between condyle and angular process to aboral border of the canine alveolus (5)	1	110.0	-	-	-
		Length from the aboral border of the alveolus of M3 to aboral border of the canine alveolus (7)	1	78.3	-	-	-
		Length of cheektooth row, M3-P1 (8)	3	74.9	77.8	76.1	1.5
		Length of cheektooth row, M3-P2 (9)	32	63.1	74.1	69.5	5.7
		Length of molar row (10)	5	24.3	39.7	34.0	5.8
		Length of premolar row P1-P4 (11)	3	36.3	41.6	39.7	2.9
		Length of premolar row P2-P4 (12)	3	31.6	37.8	35.2	3.2
		Length of carnassial (13)	2	20.4	21.1	20.8	0.5
		Length of carnassial alveolus (14)	4	15.2	22.2	19.3	2.9
		Height of vertical ramus (18)	2	52.4	57.4	54.9	3.5
		Height of mandible behind M1 (19)	4	13.2	21.7	18.7	4.0
		Height of mandible between P2 and P3 (20)	5	16.2	23.1	20.6	3.1

Key: N = number; Min = minimum value; Max = maximum value; sd = standard deviation.

Table 23. Johnstown 1. Dog metrical information (mm), after von den Driesch (1976).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.	ESH (cm)
Scapula	3 (**F124**)	SLC	2	21.9	26.4	24.2	3.2	-
		GLP	2	28.2	30.3	29.3	1.5	-
Humerus	2 (**F4**)	Bd	1	35.8	-	-	-	-
		BT	1	25.0	-	-	-	-
	3 (**F124**)	GL	3	81.7	152.7	128.7	40.7	25.4-49.7
		Dp	4	19.1	35.2	30.3	7.6	-
		SD	2	11.1	11.1	11.1	0.0	-
		Bd	4	20.0	31.0	27.9	5.3	-
		BT	1	13.6	-	-	-	-
	F556	Bd	1	34.4	-	-	-	-
Radius	2 (**F4**)	Bp	1	20.7	-	-	-	-
	3 (**F124**)	GL	2	145.7	145.9	145.8	0.1	48.3
		Bp	3	15.7	18.4	16.6	1.5	-
		Bd	3	21.4	26.4	23.2	2.8	-
Ulna	3 (**F124**)	DPA	1	14.0	-	-	-	-
		SDO	1	11.5	-	-	-	-
MC II	3 (**F124**)	GL	1	52.9	-	-	-	-
MC III	3 (**F124**)	GL	1	71.6	-	-	-	-
MC IV	3 (**F124**)	GL	2	60.1	78.8	69.5	13.2	-
MC V	3 (**F124**)	GL	1	50.3	-	-	-	-
Pelvis	3 (**F124**)	LA	1	22.0	-	-	-	-
		LAR	1	18.4	-	-	-	-
Femur	2 (**F4**)	Bp	1	38.7	-	-	-	-
	3 (**F124**)	GL	2	165.0	165.0	165.0	0.0	50.5
		Bp	3	21.9	39.1	31.8	8.9	-
		SD	2	10.8	10.9	10.9	0.1	-
		Bd	3	26.9	30.6	28.2	2.1	-
Tibia	3 (**F124**)	Bp	3	30.2	35.5	33.6	3.0	-
		Bd	3	19.4	24.9	21.4	3.0	-
Astragalus	3 (**F124**)	GL	2	22.8	24.4	23.6	1.1	-
Calcaneus	3 (**F124**)	GL	4	39.4	53.9	45.9	7.3	-
MT II	3 (**F124**)	GL	1	55.8	-	-	-	-
MT IV	3 (**F124**)	GL	2	67.1	81.1	74.1	9.9	-
Phalanx 2	3 (**F124**)	GL	1	11.4	-	-	-	-

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation; ESH = estimated shoulder height.

Table 23 (contd.). Johnstown 1. Dog metrical information (mm) after von den Driesch (1976). Estimated shoulder heights were obtained using factors of Harcourt (1974, 154).

Bone	Phase	Meas.	N.	Min.	Max.	Mean	sd.
Scapula	2 (**F4**)	GLP	1	12.3	-	-	-
Humerus	2 (**F4**)	GL	2	93.4	93.4	93.4	0.0
		Dp	2	16.5	16.7	16.6	0.1
		SD	1	5.6	-	-	-
		Bd	3	17.1	19.2	17.8	1.2
Radius	2 (**F4**)	Bp	1	7.0	-	-	-
Ulna	2 (**F4**)	DPA	2	9.5	9.9	9.7	0.3
		SDO	2	8.0	8.2	8.1	0.1
	3 (**F124**)	DPA	1	11.3	-	-	-
		SDO	1	10.4	-	-	-
Femur	2 (**F4**)	GL	2	99.7	102.0	100.9	1.6
		Bp	2	18.9	18.9	18.9	0.0
		SD	2	7.2	8.0	7.6	0.6
		Bd	2	16.7	17.0	16.9	0.2
Tibia	2 (**F4**)	GL	1	109.4	-	-	-
		Bp	1	17.7	-	-	-
		SD	1	7.7	-	-	-
		Bd	2	12.7	13.4	13.1	0.5
	3 (**F124**)	Bd	1	10.6	-	-	-

Key: Meas = measurement; N = number; Min = minimum value; Max = maximum value; sd = standard deviation.

Table 24. Johnstown 1. Cat metrical information (mm), after Habermehl (1961).

Feature/ Grid	Details	Cattle	Horse	Pig	Sheep/Goat	Dog	Cat	Red Deer	Other
3/A	430-660 AD	286 (7)	5	100 (5)	36 (2)	4	-	2 (2)	610 unid.
3/B	430-660 AD	293 (7)	1	130 (4)	37 (4)	-	1	1	934 unid.
4/A	440-670 AD	357 (7)	5	135 (6)	51 (4)	13 (2)	10	2	1207 unid.
4/B	440-670 AD	3	-	-	1	-	8	-	17 unid.
4/C	440-670 AD	573 (11)	13	219 (7)	54 (3)	5	3 (2)	7	2 lagomorph, 2007 unid.
4/D	440-670 AD	439 (11)	4	107 (6)	25 (2)	8 (2)	13	6	1008 unid.
5/A		2	-	-	1	-	-	-	1 unid.
16/C		13	1	2	5	2	-	-	6 unid.
17/C		1	1	-	5	-	-	-	25 unid.
26/A		-	-	-	-	-	-	-	1 unid.
29/A		110 (3)	7	108 (4)	27	1	1	1	976 unid.
30/A		-	-	2	1	-	-	-	5 unid.
31/A		-	-	-	-	-	-	-	1 unid.
33/C		3	-	-	1	-	-	-	16 unid.
36/B		87 (3)	29	30	129 (5)	1	-	3	890 unid.
42/A		19	1	1	1	-	-	-	83 unid.
50/C		-	-	-	-	-	-	-	1 rabbit
51/C		2	-	-	-	-	-	-	2 unid.
52/C		7 (2)	-	2	1	-	-	-	61 unid.
54/C		2	-	-	-	-	-	-	24 unid.
58/C		-	-	-	1	-	-	-	1 unid.
60/C		1	-	2	1	-	-	-	4 unid.
64/C		-	-	-	-	-	-	-	1 unid.
66/D		-	-	-	-	-	-	-	6 unid.
67/C		54 (3)	4	15 (2)	12 (2)	2	-	-	174 unid.
75/C		4	-	1	-	-	-	-	19 unid.
96		-	-	-	-	-	-	-	6 unid.
109/C		-	-	-	1	-	-	-	4 unid.
123/A		30 (2)	3	21 (2)	61(3)	-	-	-	305 unid.
124/A	1420-1650 AD	269 (6)	21	83 (6)	39 (2)	16 (2)	-	4	873 unid.
124/B	1420-1650 AD	341 (7)	23 (2)	87 (4)	150 (5)	15	-	-	1218 unid.
124/C	1420-1650 AD	670 (13)	28 (2)	270 (13)	205 (9)	117 (3)	2	3	7 Rabbit, 1 pine marten, 1 rat. 3272 unid.
124/D	1420-1650 AD	412 (10)	62 (3)	92 (6)	138 (5)	52 (2)	3 (2)	-	5 Fox, 1Hare. 1809 unid.
174/A		-	-	-	-	-	-	-	2 unid
179/A		6	-	-	-	-	-	-	1 Unid.
205/C		3	-	1	-	-	-	-	94 unid.

Table 25. Johnstown 1. Summary table of the fragments and MNI distributions for all contexts excluding burials. (MNI's, when greater than one, are given in brackets).

Feature/ Grid	Details	Cattle	Horse	Pig	Sheep/Goat	Dog	Cat	Red deer	Other
221/B		10	-	-	1	-	-	-	27 unid.
223/B		6	1	1	1	-	-	-	5 unid
224/B		17	1	6	2	13	-	-	130 unid.
225/A		107 (6)	-	7	12	2	-	-	363 unid.
237/C		-	-	-	1	-	-	-	5 unid.
278/B		35 (2)	-	9 (2)	4	-	-	-	70 unid.
297/B		56 (3)	2	25 (2)	10 (2)	-	-	-	102 unid.
300/B		37 (2)	2	4	2	-	-	-	38 unid.
306/B		13	-	2	1	-	-	-	40 unid.
323/C		-	-	1	-	-	-	-	10 unid.
333/A		14	-	6	-	1	-	-	98 unid.
334/A		96 (4)	17	55 (2)	18 (2)	-	-	1	548 unid.
344/C		42 (2)	-	22	11	-	6	-	201 unid.
348/A		9	-	2	2	-	-	-	58 unid.
363/B		1	-	1	-	-	-	-	2 unid.
368/C		-	-	-	-	-	-	-	4 unid.
441/B		3	-	-	-	-	-	-	1 unid.
498/B		2	-	-	-	-	-	-	1 unid.
542/C		-	-	-	-	-	-	-	1 unid.
550/C		1	-	-	2	-	-	-	15 unid.
554/B		86 (5)	2	27 (2)	11	-	-	-	257 unid.
554/F		-	-	-	-	-	1	-	-
556/E	1420-1640 AD	42 (2)	12	6 (2)	7	1	-	-	191 unid.
556/F	1420-1640 AD	206 (4)	69 (3)	51 (3)	85 (4)	6	-	-	1 lago., 1052 unid.
557/B		7	-	-	-	-	-	-	17 unid.
603/D		3		3	1	-	-	-	13 unid.
610/D		9	2	4	6	1	-	-	28 unid.
615/D		-	-	-	-	-	-	-	1 unid.
634/F		1	-	-	-	-	-	-	22 unid.
660/D		18	-	7	1	-	-	-	193 unid.
695/D		-	-	-	-	38	-	-	-
768/D		186 (4)	2	46 (2)	34	1	1	-	563 unid.
778/D		7	-	-	-	-	-	-	35 unid.
779/D		58 (3)	3	17 (3)	6	-	-	1	240 unid.
796/D		4	-	2	2	-	-	-	23 unid.
797/D		-	-	-	-	-	-	-	1 unid.
798/D		-	-	1	-	-	-	-	1 unid.
799/D		-	-	-	-	-	-	-	1 unid.
808/D		2	1	2	2	-	-	-	44 unid.
820/E		-	-	-	3	-	-	-	5 unid.
848/D		1	-	-	-	-	-	-	1 unid.
859/D		-	-	-	-	-	-	-	13 unid.
871/D		1	-	1	-	-	-	-	3 unid.
876/E		1	-	3	2	-	-	-	32 unid.
878/D		4	-	2	1	-	-	-	10 unid.
912/D		-	-	1	-	-	-	-	5 unid.
914/D		2	-	-	-	-	-	-	3 unid.
928/D		11	-	-	-	2	-	-	92 unid.
939/D		4	-	-	2	-	-	-	13 unid.
1131/F	1000-1240 AD	19 (2)	7	10	2	-	-	-	86 unid.
1131/G	1000-1240 AD	63 (2)	2	34	12	1	-	2	346 unid.
1036/D		8	6	-	1	-	-	-	48 unid.
1039/F		3	-	-	-	-	-	-	-
1052/F		75 (3)	3	18	12 (2)	1	-	3	174 unid.
1154/B		6	-	-	-	-	-	-	5 unid.
1173/F		1	-	1	-	-	-	-	14 unid.
1176/D		14	-	2	3	-	-	-	8 unid.

Table 25 (contd.). Johnstown 1. Summary table of the fragments and MNI distributions for all contexts excluding burials. (MNI's, when greater than one, are given in brackets).

Burial	(Adult/Juv./ Infant)	Context/Grid	Cattle	Pig	S/G	Dog	Cat	Other
3	A	34	1	-	-	-	-	1 unid.
4	A (F)	9	1	-	-	-	-	-
29	A (M?)	128	1	-	-	-	-	1 unid.
42	A (M)	155	-	1	2	-	-	3 unid.
65	A (F)	200	-	-	-	-	-	1 burnt
66	DIS	1	8	2	1	-	-	44 unid.
67	J	203/A	-	-	-	-	-	19 woodmouse, 1 fish
68	J	60	-	1	1	-	-	1 unid.
75-78	As	238,240,242,244	-	-	-	5	-	5 unid.
76	A	240	1	-	1	-	-	4 unid.
82	A	252	-	-	2	-	-	-
96	J	276	-	-	1	-	-	-
97	I	279	1	1	2	-	-	4 unid.
98	A (F)	281	12	2	8	-	1	2 bird, 42 unid.
103	A (F)	290	-	-	-	-	-	1 unid.
104	A	290	-	-	-	-	-	2 unid.
114	A (F)	317	1	-	-	-	-	-
119	A (M)	1	1	-	-	-	-	-
121	A (M)	337	1	2	-	-	-	-
127	A (M)	353	1	1	1	-	-	8 unid.
128	A (M?)	355	-	-	-	-	-	1 unid.
145	A (M)	389	1	-	-	-	-	-
165			5	8	3	-	-	4 unid.
166	A (F)	429	1	-	-	-	-	-
188	A	468/D	6(2)	-	3	-	-	15 unid.
200	A (M)	383	-	1	-	-	-	-
210	J	507/D	3	-	-	-	-	-
218	A	518/D	1	-	-	-	-	-
252	J	598/D	3	-	-	-	-	21 unid.
259	DIS	Disturbed by B256	3	-	-	-	-	-
271	A (F)	609/C	2	1	-	-	-	12 unid.
273	A	233/A	2	-	-	-	-	17 unid.
274	J	644/D	-	2	1	-	-	-
280	A (M)	653	1	-	-	-	-	-
282	J	657/D	-	2	-	1	-	1 unid.
287	I	666	2	5	-	-	-	2 unid.
288	A	692/D	1	-	1	-	-	5 unid.
292	A	702	1	-	-	-	-	-
293	J	704	4	-	-	-	-	-
298	J	737	1	-	-	-	-	-
303	J	1	2	-	2	-	-	10 unid.
305	A	749/D	6	-	-	-	-	10 unid.
306	A	753/D	2	-	1	-	-	14 unid.
317	A	810/D	3	4	4	-	-	20 unid.
319	A	814/D	1	-	-	-	-	-
321	A	822/D	1	1	-	-	-	-
325	J	828	-	-	-	-	-	2 unid.
356			1	-	-	-	-	3 unid.
359	J	935/D	4	-	-	-	-	3 unid.
360			2	1	-	-	-	2 unid.
374	J	968/D	9	3	-	-	-	27 unid.
402	I	556	-	-	-	-	-	2 rat/mouse
410	I	556	-	-	-	-	-	4 bird
426	A (F)	1061	2(2)	-	-	-	-	1 unid.
430	A (F?)	1	-	-	-	-	-	1 unid.
464	I	556	1	-	1	-	-	5 unid.
482	A (F)	1150	1	-	2	-	-	3 unid.
483	A	1	-	1	-	-	-	-
485	A (F)	1155/D	-	93	4	-	-	10 unid.

Key: DIS=disarticulated.

Table 26. Johnstown 1. Summary table of the fragments and MNI distributions for animal bone recovered from burials. (MNI's, when greater than one, are given in brackets).

Plate 1. Johnstown 1 Feature 4 Grid C. Cattle astragalus showing fine cut marks at distal end (dorsal view).

Plate 2. Johnstown 1 Feature 4 Grid C. Cattle humerus with cut marks at distal end (lateral view).

Plate 3. Johnstown 1 Feature 4 Grid C. Cattle scapula showing evidence of burning.

Plate 4. Johnstown 1 Feature 4 Grid D. Cat tibia with cut marks at proximal end (lateral view).

Plate 5. Johnstown 1 Feature 124 Grid C. Cattle astragalus with fine cut marks at distal end (dorsal view).

Plate 6. Johnstown 1 Feature 124 Grid C. Pig radius with cut marks at proximal end (dorsal view).

Plate 7. Johnstown 1 Feature 124 Grid D. Dog scapula with cut marks (lateral view).

Plate 8. Johnstown 1 Feature 124 Grid D. Fragment of pig pelvis with cut marks.

Plate 9. Johnstown 1 Feature 1131 Grid F. Horse ulna with cut marks.

Plate 10. Johnstown 1 Feature 3 Grid A. Worked cattle metatarsal.

Plate 11. Johnstown 1 Feature 4 Grid C. Cattle horn with cut marks.

Plate 12. Johnstown 1 Feature 4 Grid C. Worked bones (longbones and antler).

Plate 13. Johnstown 1 Feature 4 Grid C. Detail of Plate 12.

Plate 14. Johnstown 1 Feature 4 Grid D. Worked antler.

Plate 15. Johnstown 1 Feature 29 Grid A. Sawn antler.

Plate 16. Johnstown 1 Feature 124 Grid A. Bone artefact (longbone of large mammal).

Plate 17. Johnstown 1 Feature 124 Grid A. Cut antler.

Plate 18. Johnstown 1 Feature 124 Grid C. Cut antler.

Plate 19. Johnstown 1 Feature 223 Grid B. Worked cattle metatarsal.

Plate 20. Johnstown 1 Feature 4 Grid C. Pig canines (wild/domesticated?).

APPENDIX 16

RADIOCARBON DATES

Beta Analytic Florida

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)

Beta - 181477 520 +/- 60 BP -25.6 o/oo 510 +/- 60 BP
SAMPLE : 02E462F17S1
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1310 to 1365 (Cal BP 640 to 585) AND Cal AD 1380 to 1470 (Cal BP 570 to 480)

Beta - 181478 1020 +/- 60 BP -25.5 o/oo 1010 +/- 60 BP
SAMPLE : 02E462F820S342
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 900 to 1170 (Cal BP 1050 to 780)

Beta - 181479 1540 +/- 60 BP -26.1 o/oo 1520 +/- 60 BP
SAMPLE : 02E462F912S352
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 410 to 650 (Cal BP 1540 to 1300)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 180650	1350 +/- 60 BP	-21.5 o/oo	1410 +/- 60 BP

N15/N14 = +11.6 o/oo

SAMPLE : 02E462B42F156
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 545 to 700 (Cal BP 1405 to 1250)

Beta - 180651	200 +/- 40 BP	-20.0 o/oo	280 +/- 40 BP

N15/N14 = +10.0 o/oo

SAMPLE : 02E462B68F61
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 1500 to 1665 (Cal BP 450 to 285)

Beta - 180652	600 +/- 60 BP	-20.1 o/oo	680 +/- 70 BP

N15/N14 = + 9.8 o/oo

SAMPLE : 02E462B196F482
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1225 to 1410 (Cal BP 725 to 540)

Beta - 180653	840 +/- 70 BP	-19.6 o/oo	930 +/- 70 BP

N15/N14 = +10.1 o/oo

SAMPLE : 02E462B269F631
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 990 to 1255 (Cal BP 960 to 695)

Sample Data	Measured	13C/12C
Conventional	Radiocarbon Age	Ratio
Radiocarbon Age(*)		

Beta - 177959 1450 +/- 60 BP -22.6 o/oo
1490 +/- 60 BP
SAMPLE : 02E462F3
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 430 to 660 (Cal BP 1520 to 1290)

Beta - 177960 1430 +/- 60 BP -22.2 o/oo
1470 +/- 60 BP
SAMPLE : 02E462F4
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 440 to 670 (Cal BP 1510 to 1280)

Beta - 177961 330 +/- 60 BP -22.0 o/oo
380 +/- 60 BP
SAMPLE : 02E462F124
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1420 to 1650 (Cal BP 530 to 300)

Beta - 177962 340 +/- 60 BP -21.8 o/oo
400 +/- 60 BP
SAMPLE : 02E462F556
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1420 to 1640 (Cal BP 530 to 310)

Beta - 177963 900 +/- 60 BP -22.9 o/oo
930 +/- 60 BP
SAMPLE : 02E462F1131
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1000 to 1240 (Cal BP 950 to 710)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)

Beta - 178194 1320 +/- 50 BP -20.5 o/oo
1390 +/- 50 BP
SAMPLE : 02E462B25F118
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 580 to 700 (Cal BP 1360 to 1250)

Beta - 178195 1500 +/- 70 BP -21.3 o/oo
1560 +/- 70 BP
SAMPLE : 02E462B110F311
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 370 to 640 (Cal BP 1580 to 1310)

Beta - 178196 710 +/- 50 BP -19.8 o/oo
790 +/- 50 BP
SAMPLE : 02E462B118F327
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1170 to 1290 (Cal BP 780 to 660)

Beta - 178197 1500 +/- 70 BP -21.3 o/oo
1560 +/- 70 BP
SAMPLE : 02E462B129F361
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 370 to 640 (Cal BP 1580 to 1310)

Beta - 178198 1400 +/- 50 BP -21.3 o/oo
1460 +/- 50 BP
SAMPLE : 02E462B219F521
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 530 to 660 (Cal BP 1420 to 1280)

Beta - 178199 730 +/- 50 BP -19.7 o/oo
820 +/- 50 BP
SAMPLE : 02E462B280F654
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1060 to 1080 (Cal BP 890 to 860) AND Cal AD 1150 to 1280 (Cal BP 800 to 670)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 178200	60 +/- 70 BP	-20.6 o/oo	130 +/- 70 BP

SAMPLE : 02E462B400F1024
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1650 to beyond 1960 (Cal BP 300 to 0)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 178201	700 +/- 60 BP	-19.5 o/oo	780 +/- 60 BP

SAMPLE : 02E462B485F1156
ANALYSIS : Radiometric-Standard delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1160 to 1300 (Cal BP 790 to 650)

Sample Data Measured 13C/12C
Conventional

Radiocarbon Age Ratio

Radiocarbon Age(*)

Beta - 184610 1400 +/- 70 BP -21.0 o/oo
1460 +/- 70 BP
N15/N14 = +11.7 o/oo
SAMPLE : 02E462B33
ANALYSIS : Radiometric-Advance delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 430 to 680 (Cal BP 1520 to 1270)

Beta - 184611 650 +/- 40 BP -19.3 o/oo
740 +/- 40 BP
N15/N14 = +11.2 o/oo
SAMPLE : 02E462B145
ANALYSIS : AMS-Advance delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 1230 to 1300 (Cal BP 720 to 650)

Beta - 184612 550 +/- 40 BP -19.9 o/oo
630 +/- 40 BP
N15/N14 = +10.5 o/oo
SAMPLE : 02E462B222
ANALYSIS : AMS-Advance delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 1290 to 1410 (Cal BP 660 to 540)

Beta - 184613 1140 +/- 60 BP -21.0 o/oo
1200 +/- 60 BP
N15/N14 = +11.3 o/oo
SAMPLE : 02E462B249
ANALYSIS : Radiometric-Advance delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 680 to 980 (Cal BP 1270 to 970)

Beta - 184614 490 +/- 60 BP -19.7 o/oo
570 +/- 60 BP
N15/N14 = +10.9 o/oo
SAMPLE : 02E462B295
ANALYSIS : Radiometric-Advance delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 1290 to 1440 (Cal BP 660 to 510)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 184615	650 +/- 40 BP	-19.7 o/oo	740 +/- 40 BP
		N15/N14 = +11.3 o/oo	

SAMPLE : 02E462B370
ANALYSIS : AMS-Advance delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 1230 to 1300 (Cal BP 720 to 650)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 184704	1170 +/- 40 BP	-20.7 o/oo	1240 +/- 40 BP
		15N/14N = +11.5 o/oo	

SAMPLE : 02E462B128
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 680 to 890 (Cal BP 1270 to 1060)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 184706	1200 +/- 70 BP	-20.8 o/oo	1270 +/- 70 BP
		15N/14N = +11.1 o/oo	

SAMPLE : 02E462B166
ANALYSIS : Radiometric-Advance delivery (collagen analysis)
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction with alkali
2 SIGMA CALIBRATION : Cal AD 650 to 900 (Cal BP 1300 to 1050)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 184700	1230 +/- 60 BP	-26.9 o/oo	1200 +/- 60 BP

SAMPLE : 02E462F558S323
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 680 to 980 (Cal BP 1270 to 970)

Beta - 184701	1670 +/- 60 BP	-25.4 o/oo	1660 +/- 60 BP

SAMPLE : 02E462F1105S447
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 240 to 540 (Cal BP 1710 to 1410)

Beta - 184702	1030 +/- 40 BP	-21.0 o/oo	1100 +/- 40 BP

SAMPLE : 02E462B26
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 880 to 1010 (Cal BP 1070 to 940)

Beta - 184703	1170 +/- 40 BP	-20.8 o/oo	1240 +/- 40 BP

SAMPLE : 02E462B34
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 680 to 890 (Cal BP 1270 to 1060)

Beta - 184705	690 +/- 40 BP	-19.8 o/oo	780 +/- 40 BP

SAMPLE : 02E462B142
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 1190 to 1290 (Cal BP 760 to 660)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 176806	2250 +/- 70 BP	-27.1 o/oo	2220 +/- 70 BP

SAMPLE : 02E462F1149S511
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 400 to 80 (Cal BP 2350 to 2030)

Beta - 176807	810 +/- 60 BP	-23.0 o/oo	840 +/- 60 BP

SAMPLE : 02E462F553S227
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1030 to 1280 (Cal BP 920 to 670)

Beta - 176808	1250 +/- 60 BP	-26.4 o/oo	1230 +/- 60 BP

SAMPLE : 02E462F554S535
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 670 to 960 (Cal BP 1280 to 990)

Beta - 176809	1280 +/- 60 BP	-25.1 o/oo	1280 +/- 60 BP

SAMPLE : 02E462F768S369
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 650 to 890 (Cal BP 1300 to 1060)

Beta - 176810	1390 +/- 60 BP	-25.5 o/oo	1380 +/- 60 BP

SAMPLE : 02E462F996S378
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 570 to 770 (Cal BP 1380 to 1180)
