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O'Connor, Terry (2010) Livestock and deadstock in early medieval Europe from the North Sea to the Baltic. Environmental Archaeology. pp. 1-15. ISSN 1461-4103

https://doi.org/10.1179/146141010X12640787648612

Livestock and deadstock in early medieval Europe from the North Sea to the Baltic

Terry O'Connor

The relative abundance and mortality profiles of cattle, sheep and pigs from a series of 8th- to 11th-century sites across northern Europe are reviewed with the aim of identifying broad regional trends in livestock husbandry and redistribution. Although based on published NISP data derived from hand-collected material, the broad scale and coarse precision of the survey mitigates the worst effects of differential recovery. Marked local variation in the relative abundance of cattle and of pigs is noted in certain regions. In the latter case, the association of pigs with more easterly sites is tested and discussed. Evidence from York and its region are discussed in more detail, including an association between chalk uplands and sheep husbandry in the Middle Saxon period.

Keywords: zooarchaeology, northern Europe, medieval, NISP, mortality profiles

Introduction

The aim of this review paper is to consider the quality and quantity of the data that we have to hand relating to animal husbandry across northern Europe from the North Sea to lands around the southern Baltic through the 8th to 11th centuries AD. This is a period in which the social, economic and religious bases of modern Europe were emerging, yet one which is virtually prehistoric in terms of the available evidence. Although there is a body of documentary and iconographic evidence, much of it is of ambiguous interpretation or deals with events of questionable historicity. The archaeological evidence is that familiar from later prehistory: structures, artefacts and the animal bones from which this paper seeks to infer something about the people who deposited them.

Bones are an abundant source of evidence for the early medieval period in Europe, with notably large assemblages from sites such as York (O'Connor 1989; 1991; 2004), Haithabu (Reichstein and Thiessen 1974) and Birka (Wigh 2001). Research into these assemblages has often taken a primarily zoological direction, concerned to understand the animals represented by the bones, and to look for variation between sites or through time (e.g. Johansson 1982; Lie 1988). Others have sought a different paradigm, using the bones as a reflection of socio-economic structure beyond subsistence (e.g. Bourdillon 1994; Crabtree 1990; 1996; Roskams and Saunders 2001). The aim of this paper is to undertake an examination of evidence from eastern England, then to widen the geographical scope to see whether animal bones can contribute to our investigations of the social and economic map of northern Europe during its formative centuries.

The geographical range of this review is primarily from eastern England, along the Atlantic margin of continental Europe to southern Scandinavia and the northern lowlands of modern Germany and Poland (Fig. 1). This is taken to be the region affected by Scandinavian expansionism and trade, wider and more loosely defined than any 'Viking homeland'. Some additional sites are added as comparanda, from eastern Ireland, from Orkney and from European Russia, without attempting thorough coverage of those regions. The sites represented here were excavated over a period of several decades and under different constraints, the bones were recorded and published by different specialists with different research agendas, and the raw data is of variable accessibility. For that reason, the most detailed part of this analysis focuses on the author's own data from sites in eastern England, and uses other published

Terry O'Connor, University of York, Kings Manor, York YO1 7EP, UK; e-mail: tpoc1@york.ac.uk

Published by Maney
DOI 10.1179/146141010X12640787648612

Figure 1 Northern Europe, showing the approximate location of sites. Where site names are abbreviated, they follow Table 1

sources as comparanda at varying levels of detail. The aim has been to draw together a range of sites across the region in order to address a restricted set of questions, not to attempt an all-embracing catalogue.

The review focuses on the three main domesticates; cattle, sheep and pigs, in part because they constitute the overwhelming majority of the available evidence, and in part because of their close, but differing, connections with agri-pastoral economics. To have included horses would have widened the economic discussion to include pack transportation and riding for display, and would have complicated any comparisons to be made between Christianised and non-Christian regions. To have included the smaller livestock, such as chickens and geese, would have raised significant questions of differential recovery and reporting, and would also have shifted the level of analysis from regional economic strategies to the economics of individual farms.

Methods

Sources

A review of this nature requires the bringing together of animal bone data from sites of differing geographical and social contexts, subject to different taphonomic contingencies and analysed under the constraints of different research agendas. It would be easy to despair, and to regard any cross-comparison of data published under such circumstances as futile and probably misleading. Nearly all of the material investigated here was collected by hand during excavation, a notoriously unreliable and inconsistent means of recovering small bones (O'Connor 2000, 31; 2001b). However, by focusing the study on three relatively large-bodied livestock taxa (cattle, sheep, pigs), the worst effects of preferential recovery are somewhat ameliorated, though some research has shown that sheep may still be under-recovered compared with cattle (O'Connor 1991, 236–40). This study is not concerned with the relative abundance of different skeletal elements, so preferential recovery of large or distinctive elements is not a factor except to the limited extent that it could differentially affect three anatomically similar taxa. Although the comparanda used in this analysis are far from ideal, they constitute a very large body of data, much of it dating from decades in which excavations were undertaken on a scale that is unlikely to be repeated in the foreseeable future. In other words, these assemblages and the published data are what we have, and it behoves us to make what cautious use we can of them, always keeping in mind that we are seeking the overarching economic signal, not the context-specific noise. A bone assemblage from a single context may well reflect some butchery or disposal practice more clearly than it reflects the husbandry system that produced the livestock in the first place. This review therefore focuses on relatively large assemblages, each compiled from numerous excavated contexts, in which form much of the available data has, in any case, been published. By so doing, the intention is to average out the biostratinomic detail in order to see the larger picture. That is not to suggest that the contextual detail is not significant, only that this survey has broad aims at a regional, not site-contextual, scale, and must structure the dataset accordingly. That said, some of the data in this paper have of necessity been obtained from small, incompletely published or unpublished studies. Apart from the needs of this project, the use of small datasets in a synthetic review serves to make the point that the small assemblages produced by the restricted interventions that are typical of much commercial archaeology can make a research contribution if (and perhaps only if) they can be articulated with larger research questions.

Table 1 lists the sites and assemblages that constitute the main dataset for this study. Some, principally those for which the writer holds the original records, are more finely time-resolved than others. For some published sites, time resolution has been achieved by selecting for this analysis only one particular phase from a sequence of deposits, keeping in mind the need to maintain an 'averaged' result across a number of contexts (above). For others, the material was grouped into chronologically broad periods at the original point of recording, making it impossible to reanalyse the data in finer detail. As Table 1 makes clear, data for some of the more easterly sites included here were obtained from Benecke (1986), focusing on the 'frühmittelalter' (FMA) sites in his expansive survey, and some otherwise unpublished Swedish examples have been drawn from Wigh (2001). Most of the Anglo-Saxon sites listed here are further discussed by O'Connor (in press).

Analysis

Selection of sites for inclusion was essentially on the basis that NISP (cattle+sheep+pig)>1000. A few slightly smaller assemblages have been included, largely in order to allow greater chronological precision. Number of Identified Specimens (NISP) has been used to quantify the absolute abundance of taxa on the grounds that it is a relatively uncontroversial expression of the composition of the recovered assemblage, and a parameter that is routinely presented in published work, regardless of whatever other quantification methods the author has used. Direct comparison of the diverse assemblages in Table 1 necessitates the selection of an appropriate numerical procedure to convert absolute to relative abundance. The most obvious would be to re-express the NISP for each taxon as a percentage of the total. The resulting three percentages can then be plotted on a tripolar graph, a procedure used by King (1999). There are two objections to this approach. The first is the simple fact that some people find tripolar graphs very difficult to read. The second lies in the percentages themselves. The three values obtained for each sample are fully interdependent: a high percentage for one taxon must necessarily depress the percentages for the other two. The degree of interdependence can be reduced by expressing the abundance of each of two of the taxa as a ratio relative to the abundance of the third. For the present purposes, the ratios NISPcattle/NISPpig (abbreviated to C/P) and NISPsheep/NISPpig (S/P) will be used, thereby generating two ratios for each sample and allowing the data to be plotted on a conventional graph. This procedure does not fully overcome the interdependence problem, which is inherent in any relative abundance quantification, but the resulting ratios and graphs are comparatively simple to comprehend.

A problem arises with the term 'sheep'. The osteological separation of sheep and goats is almost legendary (e.g. Boessneck *et al.* 1964; Rowley-Conwy 1998). Although the difficulty of distinguishing the two species can be overstated, there is appreciable inter-observer variation in the confidence and regularity with which the species are distinguished in published material (O'Connor 2003, 114–15). Fortunately, goats are infrequent in bone assemblages from eastern England and northern Europe for the period under review here, including assemblages that have been reported by colleagues confident and experienced in the distinction of sheep and goats. It is likely, therefore, that the great majority of specimens reported as 'sheep', as 'sheep/goat' or as 'caprine' (or its taxonomically redundant siblings 'ovicaprid' or 'caprovine') are, in fact, sheep *sensu stricto*. Accordingly, the taxon 'sheep', as used in this paper, subsumes all reported identifications to the level of caprine or below other than those specifically identified as goat. That compromise can only be

Table 1 Sites and sources used in this survey

	Site and date	Source of data
Århus	Århus; early town; C10–12	Benecke 1986
Bandlund	Bandlundeviken, Burs, Gotland; 800–1050	Wigh 2001
BevLurk4	Beverley, Lurk Lane phase 4; C9	Scott 1991
BevLurk5	Beverley, Lurk Lane phase 5; C10	Scott 1991
Birka 6	Birka; Phase 6; 860–900	Wigh 2001
Birka 7	Birka; Phase 7; 900–930/40	Wigh 2001
Birka 8	Birka ; Phase 8; mC10	Wigh 2001
Bischofs	Bischofswarder, Ostholstein; 'burg'; C8–10	Benecke 1986
Brand1	Brandon, Suffolk; Period 1; lC7	Crabtree and Campana 1991
Brand2	Brandon, Suffolk; Period 2; C8	Crabtree and Campana 1991
Brand3	Brandon, Suffolk; Period 3; C9	Crabtree and Campana 1991
Buckquoy	Buckquoy, Orkney; C9–10	Noddle pers. comm.
Dorestad	Dorestad, Hoogstraat I & settlement; *c.* 700–850	Prummel 1983
DubFish	Dublin, Fishamble St plots 2&3; C10–eC11	McCormickand Murphy 1997
Eketorp III	'Burg'; C11th	Boessneck *et al.* 1979
Elisenhof	Elisenhof; 'wurt'; C8–12	Benecke 1986
Flix3b	Flixborough phase 3b; C8	Dobney *et al.* 2007
Flix4–5b	Flixborough phase 4–5b; C9	Dobney *et al.* 2007
Flix6	Flixborough phase 6; eC10	Dobney *et al.* 2007
Gårdstång	Gårdstånga, Skania; 800–1200	Wigh 2001
Gdansk	Gdnask, early town; C10–12	Kubasiewicz 1975
Haithabu	Haithabu/Hedeby; early town; C9–11	Johansen 1982, table 2
HartleCC	Hartlepool, Church Close; C8	Rackham 1989
IpsVern	Ipswich, Vernon Street; C8	Jones and Serjeantson 1983
Legnica	Legnica, 'burg'; C10–12	Benecke 1986
LFxgTIII	Flaxengate, Lincoln; phase TIII; *c.* 930–970	O'Connor 1982
LFxgTI–II	Flaxengate; phases TI–TII; *c.* 870–930	O'Connor 1982
LFxgTIV–V	Flaxengate; phase TIV–V; 970–1040	O'Connor 1982
LondPea	London, Peabody Buildings; C8	West 1993b
LondML	London, Maiden Lane; C8	West 1993a
LondJub	London, Jubilee Line; C8	West 1993a
LondNG	London, National Gallery Extension; C8	West 1993b
Lübeck	Alt-Lübeck; C9–eC12	Rheingans and Reichstein 1991
Lund	Lund; early town; 1020–50	Beneecke 1986
Menzlin	Menzlin; C9–10	Benecke 1988
NElm1	North Elmham Park, Period 1; C8–e9	Noddle 1980
NElm2	North Elmham Park, Period 2; eC10	Noddle 1980
Novgorod	Novgorod, early town; C10–12	Benecke 1986
Opole	Opole, early town; C10–12	Benecke 1986
Oslo 1	Oslo, Mindets Tomt; Period 1; 1025–1125/50	Lie 1988
Påviken	Påviken, Vastergarn, Gotland; 800–1050	Wigh 2001
Pollista	Pollista, Overgran, Uppland; 800–1050	Wigh 2001
Poznan	Poznan, early town; C10–12	Benecke 1986
Ralswiek	Ralswiek, Rugen; port-of-trade; Group 1	Benecke 1986
Ribe	Ribe; C8	Hatting 1991
SigGert1	Sigtuna, St Gertrud; phase 1; 970–980	Wigh 2001
SigGert2	Sigtuna, St Gertrud; phase 2; 980–1010	Wigh 2001
SigTrad	Sigtuna,Tradgardsmasteren; phases 0–3; 970–1100	Wigh 2001
Skaill	Skaill, Orkney; C9–10	Noddle 1997
SotonMS	Southampton Melbourne Street C8	Bourndillon and Coy 1980
StLadoga	Staraya Ladoga, early town; C7–10	Benecke 1986
Szczecin	Szczecin, early town; C9–11	Benecke 1986
Teterow	Teterow, 'burg'; C9–11	Benecke 1986
Thetford	Thetford; C10	Jones 1984
WfordPS1	Waterford, Peter St; Group 1; mC11–eC12	McCormick 1997
WHMidS	West Heslerton, Mid Saxon	Richardson pers. comm.
WickenB	Wicken Bonhunt, C8	Crabtree 1994
Wołin	Wołin, early town; C9–12	Filipowiak 1979
WP2+3	Wharram Percy, South Manor phases 2, 3, C8–9	Pinter-Bellows 2000
YCop 3	York, Coppergate, York; Period 3; m–l C9	O'Connor 1989
YCop 4	York, Coppergate; Period 4; *c.* 900–975	O'Connor 1989
YCop 5a	York, Coppergate; Period 5a; *c.* 975	O'Connor 1989
YCop 5b	York, Coppergate; Period 5b; *c.* 975–eC11	O'Connor 1989
YCop 5c	York, Coppergate, York; Period 5c; m–l C11	O'Connor 1989
YCop AScan	York, Coppergate unphased Anglo-Scand; mC9–mC11	O'Connor 1989; 2004
YFish3	York, Fishergate; Period 3 C8	O'Connor 1991
YQHotel	York, Queen's Hotel; C10	O'Connor 2004

'C/P' – NISP cattle/NISP pig; 'S/P'=NISP sheep/NISP pig
'e (m, l) C11'=early (mid, late) 11th century

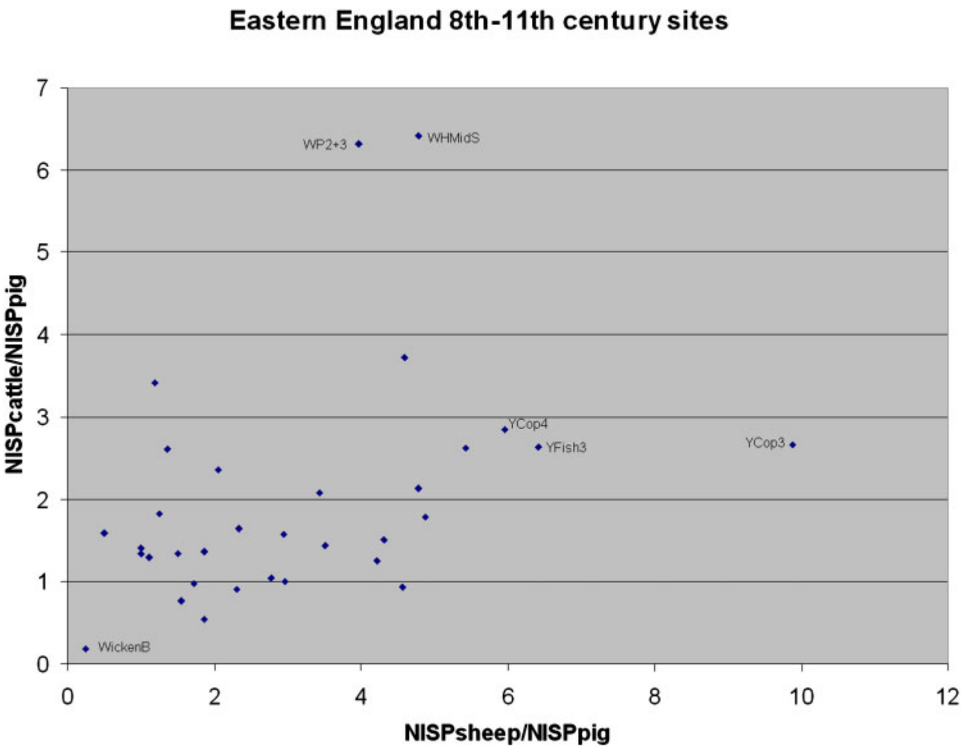

Figure 2 Scattergram of NISP ratios for 8th- to 11th-century sites in eastern England, derived from data in Table 2

justified because goat appears to be genuinely scarce in these assemblages. The listing of caprine species also varies considerably in the published sources used here, making it difficult to apply a more particular tabulation of sheep, goat and undifferentiated caprine consistently. However, any subsequent survey that included the North Atlantic region would have to differentiate caprines more particularly, as goats are more abundant at medieval sites from the North Atlantic islands.

For comparisons of mortality profiles, investigations undertaken by different authors for different purposes can be difficult to reconcile. Mortality profiles derived from epiphysial fusion and from dental eruption and attrition can be difficult to directly compare. For the purposes of this paper, comparisons have been made either by quantifying maturation 'landmarks' that all authors will have recorded, or by recalibrating age at death data into broad calendar-age groups. The latter approach is seen in Table 4: the former in the use of, for example, 'first year sheep' in discussion of the results, below.

Relative abundance of taxa

Table 2 gives the NISP and ratio results for 8th- to 11th-century sites in eastern England, thus including sites that are culturally Mid-Saxon, Late Saxon and Anglo-Scandinavian, these last two being roughly contemporaneous. Fig. 2 shows the NISP ratios as a

Table 2 Eastern England dataset used in this survey

	NISP cattle	NISP sheep	NISP pig	Total	C/P	S/P
BevLurk4	2162	882	614	3658	3·52	1·44
BevLurk5	1921	651	649	3221	2·96	1·00
Brand1	337	1063	670	2070	0·50	1·59
Brand2	401	1148	336	1885	1·19	3·42
Brand3	491	563	240	1294	2·05	2·35
Flix3b	2939	2166	1582	6687	1·86	1·37
Flix4–5b	2557	3440	2559	8556	1·00	1·34
Flix6	2567	2277	1702	6546	1·51	1·34
HartleCC	612	1173	450	2235	1·36	2·61
IpsVern	3408	1934	1973	7315	1·73	0·98
LFxgTI–II	3647	1763	673	6083	5·42	2·62
LFxgTIII	1094	489	229	1812	4·78	2·14
LFxgTIV–V	491	398	107	996	4·59	3·72
LondJub	843	329	365	1537	2·31	0·90
LondML	2898	850	1547	5295	1·87	0·55
LondNG	475	661	470	1606	1·01	1·41
LondPea	2292	1118	1466	4876	1·56	0·76
NElm1	2424	2808	2182	7414	1·11	1·29
NElm2	1046	1503	827	3376	1·26	1·82
Portch	5074	2695	1719	9488	2·95	1·57
SotonMS	23888	14477	6949	45314	3·44	2·08
Thetford	919	650	394	1963	2·33	1·65
WHMidS	3155	4216	658	8029	4·79	6·41
WickenB	5138	3853	20954	29945	0·25	0·18
WP2+3	1170	1863	295	3328	3·97	6·32
YCop 3	2255	606	228	3089	9·89	2·66
YCop 4	5541	2645	930	9116	5·96	2·84
YCop 5a	3382	1006	802	5190	4·22	1·25
YCop 5b	7257	2757	2616	12630	2·77	1·05
YCop 5c	1095	384	254	1733	4·31	1·51
YCop AScan	31872	11722	6536	50130	4·88	1·79
YFish 3	8296	3421	1295	13012	6·41	2·64
YQHotel	727	149	159	1035	4·57	0·94

'C/P' – NISP cattle/NISP pig; 'S/P'=NISP sheep/NISP pig

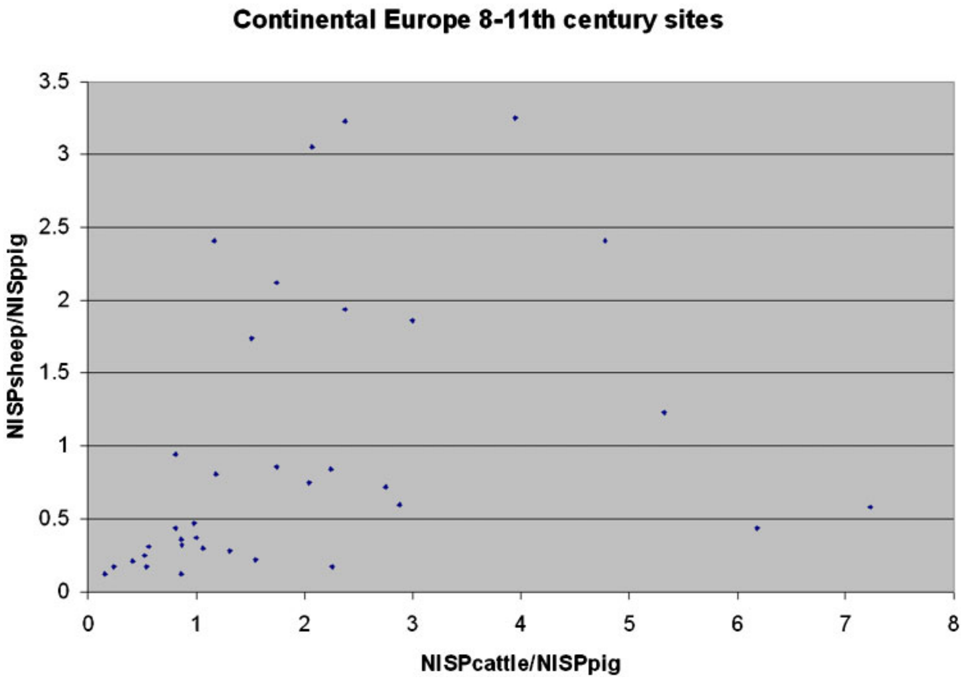

Figure 3 Scattergram of NISP ratios for 8th- to 11th-century sites in northern continental Europe, Orkney and Ireland, derived from data in Table 3

scattergram, from which a few immediate observations can be made. Wicken Bonhunt immediately stands out as the point closest to the graph origin: i.e. with very low values for both ratios reflecting a high proportion of pig. This is not remarkable. The unusual nature of the assemblage from this site is well known, and has been linked with the status of the site (Crabtree 1996). Fig. 2 also shows some distinction between Danelaw and non-Danelaw sites. Granted, the Anglo-Scandinavian data are mostly from the formative periods of the towns of York and Lincoln, but some of the mid-Saxon examples are from nucleated settlements, too. To summarise the comparison, the Saxon sites are generally relatively higher in pig or sheep bones than the Anglo-Scandinavian examples. Conversely, the Anglo-Scandinavian examples are relatively higher in cattle. A notable exception is the result for 8th-century Fishergate, York. This is a conspicuously high-cattle Mid-Saxon assemblage, resembling the late 9th-century assemblage from Coppergate, a few hundred metres away. The quality of bone preservation and rigour of recovery preclude the possibility that the Fishergate result derives mainly from diagenetic and sullegic factors (O'Connor 1991). There is the possibility of observer bias: the results for York and Lincoln sites generally show proportionally higher values for cattle than most other sites in this series, and most of the York and Lincoln data were collected by the present author. However, some of the Coppergate data, and all of the Queens Hotel data, were recorded by other researchers, and those results are consistent with the author's own. Furthermore, this author's own data from Coppergate show a range of NISP ratio values from the 'high cattle range' down into the range seen in others' work. It is unlikely, therefore, that the distinctiveness of some of the York and Lincoln results arises simply from inter-observer variation, and genuinely reflects a higher relative abundance of cattle in assemblages from this part of eastern England than from more southerly regions.

To set the English data in context, Table 3 presents results from a range of sites in Ireland, Orkney and continental Europe, with the corresponding ratio scattergram in Fig. 3. What really stands out in Fig. 3 is the concentration of sites with low values of both ratios: i.e. a high proportion of pig bones. This group can be conveniently defined by the co-ordinates C/P $<=1{\cdot}0$; S/P$<=0{\cdot}5$, and includes sites in modern Denmark (Århus, Haithabu), Sweden (Birka, Bandlundeviken) and northern Germany through Poland (Gdansk, Legnica, Menzlin, Ralswiek, Szczecin, Wołin amongst others). Although early towns feature prominently in the 'high pig' group, Poznan is a notable exception, and the 'high pig' sites include the rural farmstead at Banlundeviken on Gotland. Simple explanations of pig abundance will not suffice, and we return to this parameter below. High C/P ratios comparable with those seen in York assemblages occur at Dorestad and Novgorod, of which only Novgorod could be said to have any cultural (i.e. 'Viking') affiliations with York, and in any case the high-cattle ratio at York was apparent in 8th-century material as well. Three sites stand out by virtue of a high S/P ratio, namely Eketorp and Sigtuna, both in Sweden, and Skaill in Orkney, though the other Orkney site here, Buckquoy, is not distinctive.

The 'high pig' group includes most of the urban (at least *sensu lato*) centres of early medieval date outside the British Isles, and it would be easy to see the provision of pigs as an efficient way to feed a burgeoning population of artisans and traders: pigs breed copiously, fatten quickly and eat anything. There may be some merit in this interpretation. However, as discussed below, there is also a distinct geographical cline in the relative abundance of cattle and pigs across northern Europe, and the mortality profiles shown by the pigs in these sites are far from the consistency that we might expect if they were reflecting much the same need to feed the urban populations. Furthermore, the group includes the Swedish farmstead site of Bandlundeviken, and other farmsteads, Påviken and Pollista, fall only just outside this group as defined above.

An essentially *circum*-North Sea cluster, with sites in eastern England, the Netherlands and northern Germany, form a 'moderate pig' group (for want of a better term). One of the phases at Coppergate, period 5b, falls into this group, contrasting with the 'high cattle' assemblages otherwise typical of York. The period 5b sample represents roughly the last quarter of the 10th century, a period in which York was particularly dynamic and prosperous: indeed, the archaeological phase is defined by the construction of large plank-walled buildings. York was in English hands during that quarter-century, so the more 'Scandinavian' appearance of the bone assemblages might be seen as coincidental. However, there was a marked Scandinavian influence in and around York, whatever the historically recorded facts of kingship,

Table 3 Continental European, Orcadian and Irish dataset used in this survey

	NISP cattle	NISP sheep	NISP pig	Total	C/P	S/P
Århus	3510	1692	3572	8774	0·98	0·47
Bandlund	1031	1187	1268	3486	0·81	0·94
Birka 6	1380	743	1694	3817	0·81	0·44
Birka 7	1369	506	1365	3240	1·00	0·37
Birka 8	1073	457	1254	2784	0·86	0·36
Bischofs	1904	538	1790	4232	1·06	0·30
Buckquoy	1396	868	466	2730	3·00	1·86
Dorestad	3619	833	680	5132	5·32	1·23
DubFish	25785	1932	11394	39111	2·26	0·17
Eketorp III	67495	91570	28362	187427	2·38	3·23
Elisenhof	5044	2544	1056	8644	4·78	2·41
Gårdstång	828	1008	476	2312	1·74	2·12
Gdansk	5500	3050	9770	18320	0·56	0·31
Haithabu	86524	31666	99963	218153	0·87	0·32
Legnica	2046	294	2387	4727	0·86	0·12
Lübeck	3217	694	2458	6369	1·31	0·28
Lund	1780	880	1021	3681	1·74	0·86
Menzlin	8861	2799	16394	28054	0·54	0·17
Novgorod	8577	687	1186	10450	7·23	0·58
Opole	3412	1635	6514	11561	0·52	0·25
Oslo 1	6814	1783	2474	11071	2·75	0·72
Påviken	900	186	312	1398	2·88	0·60
Pollista	1267	874	1074	3215	1·18	0·81
Poznan	3573	4136	2372	10081	1·51	1·74
Ralswiek	9826	4980	23778	38584	0·41	0·21
Ribe	3120	1146	1526	5792	2·04	0·75
SigGert1	393	807	335	1535	1·17	2·41
SigGert2	316	467	153	936	2·07	3·05
SigTrad	8334	6805	3505	18644	2·38	1·94
Skaill	2751	2263	696	5710	3·95	3·25
StLadoga	6840	958	4418	12216	1·55	0·22
Szczecin	2741	2085	17262	22088	0·16	0·12
Teterow	29555	2110	4785	36450	6·18	0·44
WfordPS1	1005	375	448	1828	2·24	0·84
Wołin	4908	3454	20355	28717	0·24	0·17

'C/P' – NISP cattle/NISP pig; 'S/P'=NISP sheep/NISP pig and there may have been distinct benefits in catering for both sides. The data from Fishamble Street, Dublin, a good cultural comparandum for later 10th-century York, show rather similar NISP ratios to Coppergate 5b other than a distinctly lower relative abundance of sheep at Dublin. Of the data from Flaxengate, Lincoln, it is phase TIV-V, again the later 10th to early 11th century, which stands out. In this case, however, TIV-V is distinguished by a higher proportion of sheep, a trend that continues in Lincoln through into the medieval period.

Coppergate period 3, a 'high cattle' outlier, also deserves a mention. Bones from this period were generally as well preserved and carefully excavated as the other periods, so preferential recovery of cattle cannot be invoked as an explanation. The archaeology of the site in period 3 indicates rubbish disposal, the apparently casual burial of several human corpses, and possibly some nearby craft or industrial activity. That contrasts rather with the close-packed buildings of later periods, at least some of them domestic. In other words, the period 3 sample may stand out for contextual reasons, even though this sample combines data from a number of separate contexts within the phase. The finer chronological subdivision of the Coppergate assemblage has begun to show the contextual detail through the broader 'site' characteristics.

It is possible that the York area was particularly given over to large-scale arable cultivation in the 8th to early 9th century, requiring large numbers of cattle to be maintained for manure and traction power, thus yielding abundant adult cattle for meat. Alternatively, if we accept for the moment the proposal that *Eoforwic* was indirectly provisioned through a local command economy (O'Connor 1991; 2001a; but see also Roskams and Saunders 2001) it is possible that the focus on cattle reflects redistribution decisions more than agrarian production. We are reminded of the status role that cattle held in societies such as Early Christian Ireland. Furthermore, we currently have no useful zooarchaeological data at all from York for the 5th–7th centuries, and therefore cannot investigate whether *Eoforwic* continued a long-standing emphasis on cattle in the region.

In sharp contrast, Anglo-Saxon assemblages from sites in East Yorkshire, within 50 km of York, have yielded assemblages in which sheep are abundant. In this analysis, West Heslerton and Wharram Percy stand out. In addition, a nearby Early Saxon site at Kilham has yielded a high-sheep assemblage (Sue Archer, unpublished data), and a Middle Saxon site at Burdale, yet to be fully analysed, gave a substantial bone assemblage in which sheep are conspicuously abundant. It would appear that the chalk hills of East Yorkshire were especially conducive to sheep-based pastoralism during the Saxon period, despite the contrasting high-cattle assemblages from York.

Other high-sheep sites include assemblages from Orkney and from Sweden. Gårdstånga (Fig. 3; 1·74, 2·12) is interpreted as an aristocratic manor site, so its differentiation from the other rural Swedish sites in this analysis is unsurprising. Wigh (2001, 102) summarises a number of (mostly small and unpublished) assemblages from other 'manor' sites in Sweden, and most have a higher proportion of sheep than is typical of other rural Swedish sites, as do the two assemblages here from the early town at Sigtuna. The ring-fort at Eketorp, too, yielded a high proportion of sheep in all phases (Boessneck *et al.* 1979), showing that the simple equation of 'eastwards=more pigs' holds only superficially. The two Orkney sites included here were excavated by different teams, and it is unlikely that they were subject to the same bias, raising the recovery of sheep relative to pigs and cattle. The relative abundance of sheep is appreciably higher at Skaill than at Buckquoy, probably reflecting more of a mixed livestock economy for Viking Orkney. Husbandry strategies in these islands merit their own study: recent research has tended to focus on the economic role of fish (e.g. Barrett 2008), and a thorough review of pastoral systems based on assemblages excavated more recently than the two considered here is to be encouraged.

Benecke (1988) offers a principal components analysis of relative abundance data (including less abundant domestic taxa) from 9th- to 11th-century sites from Schleswig-Holstein eastwards to northern Poland. A cluster analysis derived from that analysis (1988, 42) shows a predominance of 'high pig' assemblages (Wołin, Szczecin, Menzlin, Mecklenburg) to the east, with some 'higher cattle' assemblages (Bardowick, Lübeck, Schastorf) further west. Sheep generally constitute less than 25% of mammal NISP, but the higher proportion at the ritual complex at Arkona points up the importance of site context. By inspecting the PCA loadings (1988, 42–43), it is clear that the ratio between cattle (high negative loading in component 1) and pigs (high positive loading in component 1) is the crucial parameter, with sheep/goat (high positive loading in component 2) as the 2nd order parameter. Benecke's fig. 10 arrays sites from 'high cattle mostly westerly' to 'high

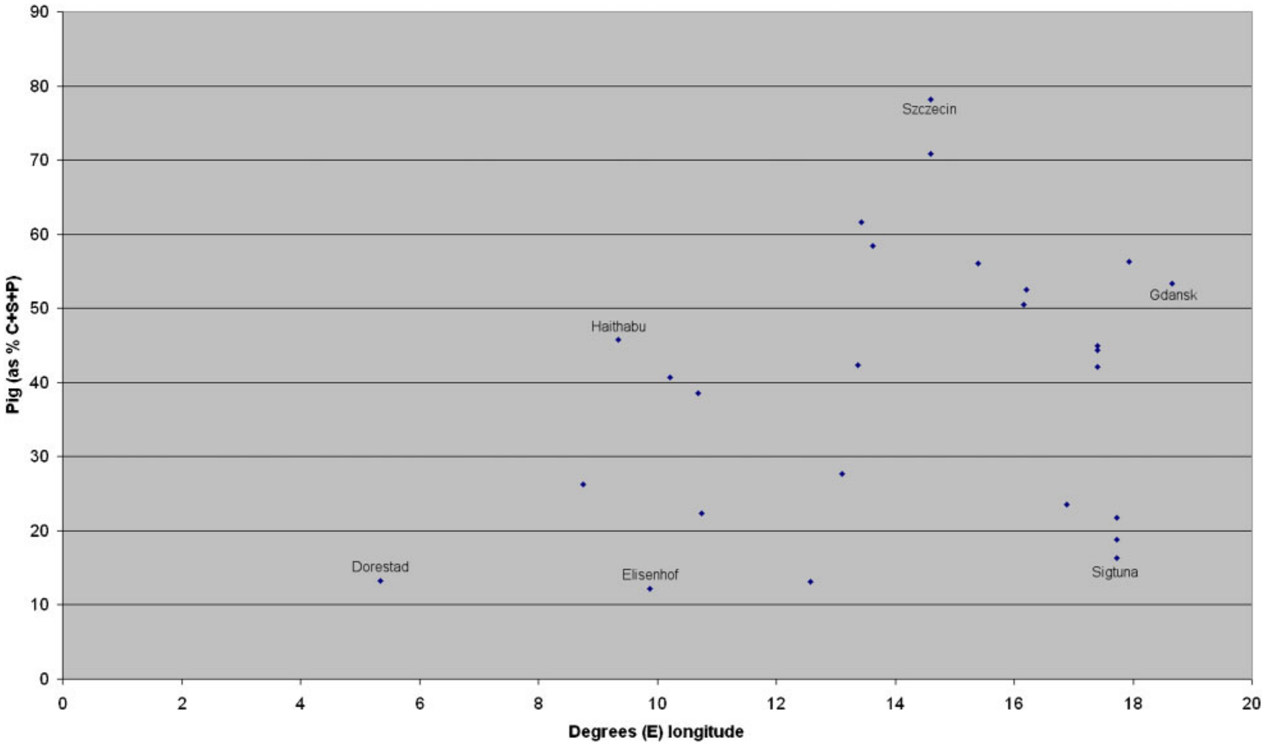

Figure 4 Relative abundance of pig bones (as 100*pig/(cattle+sheep+pig) plotted against easterly longitude of continental sites from Dorestad to Gdansk

pig mostly easterly'. A more precise assessment of this trend is given in Benecke (1986), which particularly notes the high proportion of pigs in assemblages from Brandenburg Anhalt, Sachsen and Thüringen. Even within this region, attention is drawn to some exceptions: high cattle at Dessau-Mosigkau (61·4% of NISP) and Dabrau (56·6%), and relatively high sheep at Cösitz (32·5%). In the region of north-eastern Germany and northern Poland, Benecke (1986, 12) notes that cattle bones dominate in most assemblages, exceptions being the early town sites ('frühstädtischen Siedlungen') such as Wroclaw and Opole, in which pigs predominate. An important comparison here is with Haithabu and Bischofswarder, which are high in pig but westerly compared with most of the sites in Benecke's analysis. Wroclaw and Opole are also far inland, well away from the 'Baltic littoral'.

To test the apparent association between longitude and the relative abundance of pig bones, Fig. 4 plots the percent relative abundance of pigs against the East longitude for a number of the sites in the current survey, ranging from the lower Rhine region to northern Poland. Although the exact position of individual points is subject to the familiar constraints regarding %NISP data and inter-observer variation in identification, the overall distribution generally confirms the points made above. Very high proportions of pig are more likely to arise further east, but not all easterly sites necessarily show a high proportion of pig.

Should the Baltic region be more conducive to pigs than the lands around the North Sea? One conventional explanation is to link pigs with the utilisation of woodland, proposing that the more easterly parts of northern Europe had greater areas of woodland for pannage than did, for example, eastern England (e.g. see Wigh 2001, 104). Although perhaps valid locally, this argument is hard to sustain as a generalisation. It requires, for example, that the land around Birka and Sigtuna, in one of the most densely settled parts of southern Sweden, retained appreciably more productive deciduous woodland than did the land around York. Late in the 10th century, as noted above, York was extensively rebuilt in oak-planks derived from large, mature trees. That said, new discoveries in the city as this paper went to press have revealed late 10th-century buildings constructed largely of reworked ships' timbers. The extent of woodland around the city in the 10th century is far from well established (e.g. see Hill 1994), but the current evidence is not consistent with a largely cleared, open landscape. Given that much of York's hinterland is alluvial floodplain and gently undulating glacial till and coversand, the survival of substantial areas of woodland well into the medieval period must be considered probable, and there is a lack of evidence to the contrary.

An alternative explanation arises if we pursue the idea that pigs are a convenient means of quickly producing meat, and if we bear in mind that cattle and sheep have other productive capacities that might outstrip their value as meat. In order to feed a major settlement such as Dublin, York or Menzlin largely on cattle and sheep, the hinterland would need to provide sufficient areas of grazing, and sufficient areas of arable land to justify keeping the cattle (i.e. tractors) in the first place. Furthermore, the settlement would need to have sufficient access (and sufficiently reliable access) to that hinterland to move the livestock into the town. If hinterland access were unpredictable or restricted, whether by geographical or political factors, it would be wiser to assure the settlement's meat supply by raising pigs in or close to the settlement, rather than relying on vulnerable or unpredictable supplies of cattle and sheep. Perhaps, then, what the east–west trend actually reflects is not the availability of woodland for pannage, but generally less grazing and arable land in the more easterly parts of the study area. Exceptions to the geographical cline can then be discussed in terms of restricted hinterland access. Haithabu is quite far west for a 'high pig' site, but it was a tightly constrained settlement, very much looking seaward rather than to its hinterland. Much the same could be said of Viking Dublin and Waterford, each of them little more than an elaborate beach-head, hence their higher proportions of pig bones than in most phases at the more secure and regionally integrated York. On this interpretation, the timing of the highest proportions of pigs at York takes on a new significance, perhaps indicating a few decades that required an enhanced degree of risk-management. At the eastern end of the study area, we might note that cattle are abundant in 8th-century assemblages from Wolin, but the proportion of pig bones rises sharply as the town grows, to be predominant by the beginning of the 10th century (Filipowiak 1979). A little later, in 11th-century Gdansk, the proportion of pig bones in assemblages from the relatively constrained Burgstatte area is higher than in contemporary material from elsewhere in the town (Kubasiewicz 1975, 241–43). There is obviously some scope for extending this discussion to the high abundance of pigs at some medieval castle sites in England, but that lies beyond the remit of this paper.

Another possibility that merits consideration is that an abundance of pig bones may represent ship-borne provisioning, on the basis that sides of bacon would be a manageable and durable cargo. This model of pigs as ships' cargo integrates quite plausibly with the notion of pigs as risk-management, uncertain access to agrarian resources being mitigated in part by pigs raised in or immediately around the settlement and in part by bacon arriving by sea and river routes. Maritime communication was evidently not the only factor, however, as pigs are relatively scarce at the Orkney sites.

Clearly, neither hinterland-access nor ship-borne provisioning can be argued for the rural Swedish sites in Table 3, and the high ratio of pigs at Påviken, Pollista and Bandlundeviken needs a different explanation. The argument that pigs indicate woodland pannage may be applicable to these rural sites. On the premise that the identification of the sites as farmsteads is correct, the bone assemblages represent consumption and other mortality at the point of production, rather than end-user consumption. Consideration of that distinction brings us to matters of livestock husbandry, and to the interpretation of mortality profiles.

Mortality and husbandry

To start with cattle, the observation has already been made that they were the tractors of pre-industrial Europe, and no doubt valued for milk, hide and horn as well. We might expect, therefore, to find mostly adult cattle in death assemblages unless there were overriding local pressures for earlier slaughter. Table 4 summarises the age distribution in cattle based on dental eruption in some of the assemblages discussed here. The predominance of adults in most of these larger assemblages is notable. The sample

Table 4 Percentages of cattle mandibles in broad age classes for a selection of the larger assemblages, across the region. Definition of age classes is:
J – from birth to eruption of first molar
I – from initial attrition of first molar to eruption of second molar
S - from initial attrition of second molar to eruption of third molar
A – from initial attrition of third molar to dentine exposure confluent across all columns
E – third molar showing advanced wear

Site	*J*	*I*	*S*	*A*	*E*
Coppergate, York	2	5	25	53	15
Flaxengate, Lincoln	0	0	6	38	56
Fishamble St, Dublin	14	12	20	---- 53 ----	
Menzlin	17	--- 23 ---		45	15
Haithabu	16	3	13	52	16
Ralswiek B	--- 32 ---		33	34	1
Ribe	19	43	29	9	0
Dorestad	--- 20 ---		30	--- 50 ---	

from Ralswiek appears more reminiscent of a 'rural producer' site than a 'town', with quite a high proportion of younger cattle. However, Benecke (1986, 18) notes that juvenile cattle are particularly a feature of Ralswiek Phases A and B, early in the town's development, and he suggests that calves and young cattle were of considerable significance in meeting the meat requirements of the urban population. We should note that Ralswiek is one of the 'high pig' sites discussed above, so maybe demand was high enough to require the production of numerous pigs and the slaughter of such young cattle as could be spared from breeding stock and secondary production. The profile for Haithabu includes 16% juvenile cattle: of those, most are estimated to have been under three months old, and so died in their first summer, making them surprisingly young to have been slaughtered for meat, even if demand was high. Their presence at a 'consumer' site is thus unexpected, unless the calf-skin was particularly valued, making it worthwhile to walk surplus calves into town for slaughter (i.e. had calf-skin been collected in the rural hinterland, the calf bones would not have been present in the town). A similar component of 'suckling calves' was noted at the Tradgårdsmasteren site in Sigtuna, in contrast with a peak mortality of four to eight years at other late 10th- to early 11th-century sites in the same town (Wigh 2001).

In general, cattle seem to have entered the food supply predominantly, though by no means only, as adults. This pattern was also noted by Müller (1973) in a survey of protohistoric period evidence from the 'slavic' region of Germany. Where a finer subdivision of the adults can be made, the majority are generally aged between about three and five or six years, with a minority of appreciably older cattle, other than at Flaxengate. In fact, of the admittedly small number of sites in Table 4, the two English sites stand out by virtue of the low proportion of very young cattle. The general paucity of really old cattle argues against the keeping of specialised dairy herds, unless we assume that none of the 'surplus' male calves entered town food supplies. The mortality profile suggests, too, that the balance between productivity and demand was such that cows and steers could be slaughtered after just a couple of years' yield of secondary products. At four to five years old, it is reasonable to suppose that even relatively slowly maturing cattle would have yielded perhaps two cycles of calving and lactation, and a couple of years pulling the plough. In all, cattle look to have been a multi-purpose resource throughout the region.

An important exception to that generalisation is the Orkney sites. Both Buckquoy and Skaill include a high proportion of young calves, giving a mortality profile that has been argued to be characteristic of dairy herds. Discussing the cattle from Haithabu, Johansson (1982, 23) notes a generally higher proportion of juvenile cattle on rural sites, and links this with dairy production. Although Elisenhof shows a mortality profile similar to that from the Orkney sites (Benecke 1986, table 10), comparisons with the wider Viking region should not be drawn too readily. A mortality profile consisting of young calves and old cows is typical of sites on the northern and western isles of Britain from the Iron Age onwards (Craig *et al.* 2005; Mulville *et al.* 2005) and the two Viking Age examples from Orkney seem to reflect a long-standing regional husbandry strategy, rather than the strategy typical of the Viking 'homelands' or of mainland Britain. Again, a thorough review of evidence from this archipelago is warranted.

Ribe, too, is a little different. The sample from this site is quite small, but with 13 out of 21 cattle mandibles being from first- and second-year animals, the age distribution is distinctly different to the generally later Viking Age sites. Date alone does not account for the difference, as Carolingian Dorestad shows a predominance of adults similar to the Viking Age sites. The Ribe age-profile therefore possibly indicates a husbandry regime targeted towards beef more than towards secondary products. That in turn might indicate that the 8th-century settlement was growing rapidly and putting pressure on local livestock supplies, as discussed for Ralswiek.

To sum up the cattle mortality data, a predominance of adults, though mostly not very old adults, is typical of the region, indicating the importance of secondary products. We may surmise that traction was valued more than milk as only a few assemblages, mostly in Orkney, have the 'young plus elderly' mortality thought to be typical of dairy herds (i.e. surplus male calves plus worn-out dairy cows). Some sites (Ribe, Ralswiek) show the regular slaughter of sub-adult cattle, perhaps in response to local high demand.

Turning to the sheep, there is less consistency across the region and too few substantial datasets to tabulate. A number of sites show only a minority of sheep (or caprines) surviving to adulthood. At Birka, for example, about one-third of caprines died in their first year, and another third in their second year. Late 10th- to early 11th-century assemblages from Sigtuna are generally similar, with a rather diffuse 'peak' of slaughter between nine months and two years. Ralswiek again stands out, with a predominance of first-year sheep. Second-year sheep predominate at Dublin and Dorestad, and third-years at Oslo, though the basis of this analysis (whether teeth or epiphyses or both) is not given. Adult sheep predominate in assemblages from York, most particularly in late 9th-century samples, with an appreciable minority of first- and second-year sheep in early–mid-10th-century samples. There is something of a contrast with assemblages from Wharram Percy and from Flixborough, in both of which rather older sheep predominated. Data from Menzlin may give a hint of seasonal culling. Benecke (1988) reports a peak of sheep showing the eruption and early wear of LM1, another with early wear on LM2, then the majority with LM3 in early to mid-wear stages. Using the data given by Jones (2006), this pattern could be consistent with a mid-summer cull, giving a death assemblage of sheep around three, 15 and 27 months old. Perhaps, though, we are too ready to infer husbandry decisions. At Wolin, Filipowiak (1979) notes that groups of skeletons of *c.* 18-month-old sheep were found: were these the remnants of feasting or of that familiar stand-by 'ritual'?

Difficult though it is to generalise about the sheep mortality, the relatively low proportion of old adults at most sites suggests that the production of wool was not the highest priority. A sheep slaughtered before three years of age will probably only have yielded two clips of wool. Although these two fleeces are likely to be the best quality that the sheep will produce, it should go on to produce several more years' worth of wool before quality and quantity seriously decline, giving a cull of, perhaps, five- to seven-year-olds. A high proportion of first- and second-year sheep would seem to indicate culling for meat, perhaps as a means of adjusting flock size in relation to autumn grazing and fodder. It would be a credible form of flock management to reduce numbers around mid-summer, when the culled sheep would have benefited from spring grazing, keeping only breeding stock and reserving the great majority of autumn grazing and fodder for the cattle that seem to have dominated the pastoral economy. It is possible, of course, that a first-year cull of animals aged around three to four months indicates some use of sheep for dairying, those lambs being the culled surplus males. If so, that may account for the differences between Birka, Ralswiek and Menzlin (with first-year cull) and Dublin and Dorestad (predominantly second-year cull).

At most of the sites in this analysis, pig remains are predominantly sub-adult, with a spread of ages between about 12 and 30 months, and relatively few adults. In Müller's (1973) survey, on average about half of the pigs were dead by 24 months; 80% by 3·5 years. This is hardly surprising, and reflects the use of pigs for primary, not secondary, products. The most details and substantial dataset comes from Dublin, at which 45% of 965 pig mandibles were aged as one to two years old. The data from Sigtuna differ a little from the general pattern, with both phases at St Gertrud showing a predominance of adults. At Tradgardsmasteren, the pigs showed two age peaks: adults, and piglets under six months old. Bearing in mind that this site also gave an unusual cattle assemblage with a quantity of young calves, one wonders whether Tradgardsmasteren was a site at which calf-skin and pig-skin were being collected. What the regional comparison does *not* show is any association between the age at death distribution of pigs and the relative abundance of pigs in the assemblage: the age distributions of high-pig and low-pig sites are broadly similar. In Benecke's cluster analysis (1986, 18–19), the main contrast to arise from pig age at death was between centres of population such as Szczecin, Wolin and Haithabu (mainly sub-adult, mostly males based on canine morphology), and coastal hinterland sites such as Elisenhof (mainly adults, mostly female). Data from sites in Yorkshire hint at a possible urban/rural contrast. The pig remains from Fishergate, representing 8th-century York, show two 'peaks' in the age at death distribution, one just over one year old, the other just over two years old. Contemporaneous material from West Heslerton shows a peak late in the first year, i.e. exactly complementary to the York data. We should be careful not to over-interpret this complementarity, as the social and economic connections between the two sites are not known, and we may just be seeing the difference between the culling and deposition pattern at a rural producer site and that at a largely consumer site with multiple sources.

Conclusions

Cultural practices in early medieval Europe and the deposition of animal bones are many steps apart. None the less, this simple survey has demonstrated that the copious bone assemblages can allow some ideas concerning husbandry and regional distinctiveness to be addressed. Within what could be characterised as 'Viking' Europe, there is a great deal of variation in animal husbandry and consumption. There are some indications, discussed above, of an increase in cattle husbandry in the English Danelaw, in contrast to mid-Saxon sites in England. This general trend towards more cattle under the Danelaw could be argued to be rooted in a shared identity more than in arable/pastoral management. Given the diversity of husbandry regimes evidenced across northern Europe through the 9th to 11th centuries, however, the cultural explanation seems improbable: a high proportion of cattle is certainly not a general characteristic of assemblages from the 'Viking' region, though negligible evidence survives from much of Norway. That said, we should note that cattle typically outnumber sheep bones in assemblages from the Initial Settlement period in Iceland, to be quickly outnumbered by sheep and goats during the Commonwealth (Amorosi 1991, 279–81). That abrupt change could be interpreted as a 'cultural preference' for cattle being rapidly modified by the exigencies of farming in Iceland, or by the emergence of the distinctive church-driven grazing economy of that particular colony. Across the wider region, however, the diversity is such, and the exceptions to major trends sufficiently numerous, that we cannot identify a distinctively 'Viking' pattern of livestock husbandry. The association of high-pig assemblages with early towns in the more easterly regions just about holds, but it is argued above that the concentration on pigs might have had more to do with ensuring meat supplies in agriculturally or politically difficult regions, or during periods of unrest, than with simple geography or regional ethnic identities.

The one regional pattern that does emerge strongly is the persistence of an earlier cattle husbandry tradition in Orkney, perhaps indicating either that the challenging agrarian environment imposed tight husbandry constraints, or that the command economy structure of the Earldom predisposed a husbandry system quite different to that of mainland Britain. That interpretation will merit re-examination as a number of large assemblages from Orkney, Shetland and the Hebrides come through to eventual publication. Otherwise, the high-pig assemblages cluster more by site type than by geographical location, and other groupings are hard to find. Ribe, a little earlier in date than many of the other sites in this survey, and Ralswiek show some hints of a pressure to feed a rapidly expanding settlement. At Sigtuna, the Tradsgardsmasteren site shows distinct differences to broadly contemporary material from elsewhere in that town or from elsewhere in this survey, suggesting some quite context-specific activity, perhaps associated with calf- and pig-skin collection.

It is in the nature of the available data that this survey has sought to make comparisons at quite a coarse level. The challenge for future studies will be to undertake more precise contextual analysis, in part to understand deposition processes and thence human activity within sites, but also with the aim of detecting context assemblages that consistently recur from site to site. Some of that consistency will reflect similarities of taphonomic outcome, and some will be the signature of specific livestock-related activities. In either case, recognition of the distinctive signatures may not lie with the bones alone. Taphonomic pathways may best be resolved by comparing the condition of bone fragments with ceramics and other materials from the same contexts and, of course, with the sediment matrix itself. Given the almost factional division of specialisations within archaeology, and the general neglect of sediment matrices by all but geoarchaeology specialists (Canti 2001), this may be a counsel of perfection. None the less, far better integration of forms of evidence at the contextual level would take forward the fine-grained analyses that are needed in order to elucidate the generalisations discussed here.

What this survey has shown is the practicability of deriving some broad comparisons from diverse published and archived sources, and applying those comparisons to specific archaeological questions. Although the data quality and direct comparability might not have been ideal, by keeping the methods of analysis simple and broad-brush, at least we can do something useful with the copious available evidence. And we can implement quite simple, unsophisticated means of comparison with more confidence if our initial research questions are clear and simple. The archaeological archives of northern Europe are cluttered with zooarchaeological data: by finding out what we can and cannot do with those data, we can inform and direct future research in this area, and ensure that the more complex research objectives can proceed from a firm foundation.

Acknowledgements

This paper has slowly grown out of a more restricted synthetic study undertaken in conjunction with the York Archaeological Trust (Hall *et al.* 2004). I am grateful to Richard Hall and Cluny Johnstone for their collaboration on that project, and to English Heritage for their financial support. My thanks go to Jane Richardson and Sue Archer for permission to use their data from West Heslerton and Kilham respectively. Colleagues too numerous to mention have discussed and argued about medieval bones over the years; I thank them all, as I thank two anonymous referees for their helpful comments.

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