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The Zooarchaeology of Fats, Oils, Milk and Dairying

Edited by
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17. The white stuff, milking in the Outer Scottish Isles

Jacqui Mulville, Julie Bond and Oliver Craig

The Northern and Western Isles of Scotland have some of the best bone preservation in the United Kingdom, with neonatal material surviving to a level unsurpassed at other sites. This survival rate, coupled with total recovery strategies has allowed us to examine in detail the age structure of cattle and sheep populations on sites dating from the Bronze Age through to the Norse period.

These Atlantic Islands have evidence of a high level of neonatal mortality from the Bronze Age onwards, and this has been linked to milk production. In general, the situation on the various islands differs; over time the proportion of neonates decreases in the Western Isles and increases in the Northern Isles. Organic residue analysis has demonstrated the presence of milk in pottery from the Bronze Age, and this in conjunction with the age profiles has been used to suggest a dairy economy. The counter argument is that cattle died due to a paucity of fodder. However at a number of sites it is possible to demonstrate that arable and fodder production were well developed from the Iron Age. Thus the rise in neonatal mortality for the Northern Isles suggests that deliberate calf slaughter increased. There are also other factors beside food production that we have to consider for example social storage & redistribution. Milk and butter would play a role in this, with herds of cattle a visible statement of wealth.

This paper brings together the evidence from all the Atlantic Islands to consider the analysis and interpretation of the aging data, changes in the age structure of the stock herds over time and the advantages that can be gained from using an holistic approach to zooarchaeological interpretation.

Introduction

The outer islands of West and North Scotland (the Western Isles and Northern Isles) lie out in the Atlantic and their archaeology is spectacular in its preservation. The combination of a lack of modern development, a stone building tradition, a climate ameliorated by the Gulf Stream and in some cases, burial by calcareous windblown sand, has produced a series of sites with upstanding architecture, deep stratigraphy and remarkable preservation of artefacts and biological material. The archaeological record on the islands spans the Neolithic to post-medieval period and interpretations of the past are informed by both historical and ethnographic accounts.

One notable characteristic of these Atlantic islands is the predominance of neonatal calves within zooarchaeological assemblages (McCormick 1998; Halstead 1998; Mulville 1999). For example, anything up to 60% of mandibles and 30% of long bones from the Norse phases at Pool in Orkney are derived from animals in their first few weeks of life (Serjeantson and Bond *forthcoming*). The prevalence of neonates within the assemblages has been attributed to a number of factors ranging from natural mortality to deliberate slaughter, and the intent behind the latter has also been contested. This paper examines the assemblages from the Atlantic Islands with regard to the possibility that the kill-off patterns derive from milking.

Location

The Western Isles are located on the extreme northwest

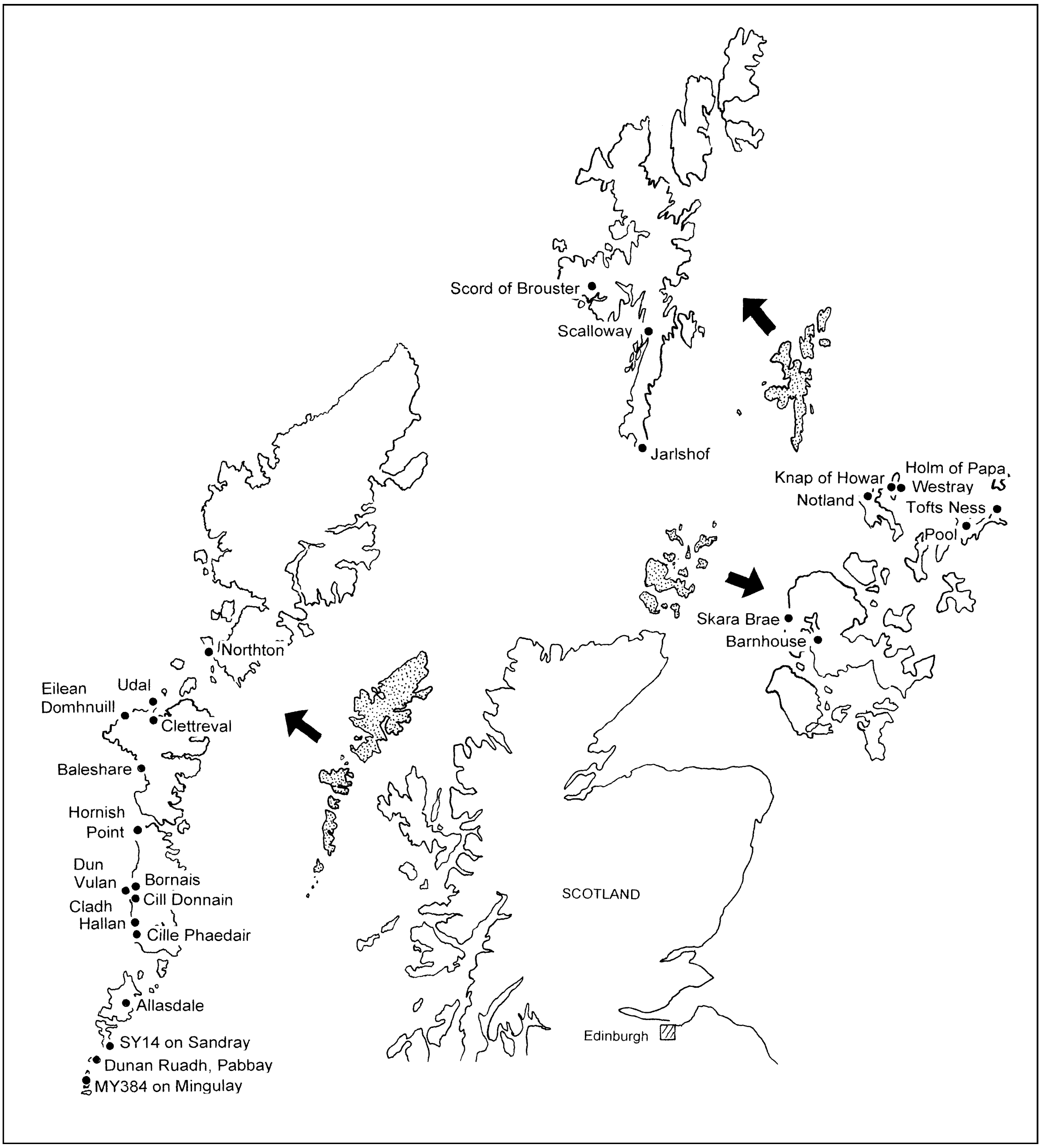

Fig. 1. A map of Atlantic Scotland indicating the sites mentioned in the text.

edge of Britain, whilst the Northern Isles (Orkney and Shetland) lie to the north (see Fig. 1); both sets of islands have an impoverished wild terrestrial fauna. Sea level reconstructions of the late Devensian and early Holocene suggest Orcadian fauna may have crossed the Pentland Firth before 10 000 BP, but neither Shetland nor the Western isles were directly connected to the mainland after the Windermere Interstadial (13–11 000 BP), and the cold period that followed would have resulted in the loss of any endemic fauna (McCormick and Buckland 1997). The distance across the waters to either Shetland or the Western Isles from the nearest land is considered a swim too treacherous for land mammals (Serjeantson 1990; McCormick and Buckland 1997). As a consequence re-colonisation since the Ice Age has been slow and to this day the islands have a reduced wild mammal population. It is probable that humans introduced all the larger terrestrial mammals to the islands, including the wild species.

Island archaeology

The archaeology of these islands starts in the Mesolithic, but the earliest zooarchaeological assemblages recovered date to the Neolithic. The quantity of Neolithic material varies across the island groups. Neolithic sites are rare in Shetland, being represented only by early deposits at Jarlshof (Hamilton 1956) and at the Scord of Brouster (Whittle 1986). The Neolithic is better represented in Orkney, with sites such as Skara Brae (Clarke 2000), the Knap of Howar on Papa Westray (Ritchie 1985), Noltland on Westray (Clarke and Sharples, 1985), Barnhouse (Richards forthcoming) and Pool and Tofts Ness on Sanday (Hunter *et al.* forthcoming, Dockrill *et al.* forthcoming). Many of these sites are not yet fully published, but the general pattern from this time onwards is that cattle were the most important domestic animal, with a lesser proportion of the assemblage made up of sheep and small quantities of pigs. Red deer and fish formed a smaller, but still important, part of the diet. There was little reliance on other wild animals, such as seals and cetaceans.

On the Western Isles few Neolithic sites have been excavated (Smith and Mulville 2004; Parker Pearson et al. 2004) and only three have produced small amounts of animal bone; the Udal (Crawford 1986: Serjeantson 1984), Northton (Finlay 1984), and Eilean Domhnuill (Hallen 1992). *Contra* the Orcadian assemblages, these Neolithic sites are dominated by sheep rather than cattle (by number of identifiable specimen counts, NISP). In later periods the number of sites increases reaching a peak in the Iron Age (see Smith and Mulville 2004 for details). Cattle predominate at some sites, but sheep remain the most numerous species at the majority using both the number of identified specimens (NISP) and minimum number of individuals counts (MNI). As with the Northern Isles, the wild terrestrial, aerial and marine fauna form a small but significant proportion of the assemblages, supplementing the domestic stock. This continuing exploitation of wild and marine animals makes the island sites unusual when compared to mainland Neolithic sites (e.g. Richards and Schulting 2000).

Differences in the archaeology of the Northern and Western Isles, and in the history of the research agendas pursued, have led to the production of dissimilar data sets, which this paper attempts to reconcile. The activities of early antiquarians in the Northern Isles mean that many of the most spectacular sites, such as Jarlshof, have no usable zooarchaeological data. These characteristic multiperiod settlements have produced large data sets which may stretch over millennia but, as already noted many remain unpublished. Recent work in the Western Isles has produced zooarchaeological data from a large number of sites which is utilised in this work.

These Atlantic islands raise a number of issues with regard to faunal exploitation strategies. They can be viewed as places with limited terrestrial resources which, along with the cool and wet nature of the climate, have lead to island life being described as marginal. On the other hand the extensive marine resources available can be seen as offering a diversity in food sources that made it easier to guarantee a sufficiency of food in an unstable environment. The introduction of domestic livestock to the islands may have improved the food supply compared to the Mesolithic or it could have introduced species that were ill fitted to living in these northern maritime conditions. Stable isotope analysis of the diet of Neolithic people elsewhere in Britain reveals a focus on terrestrial resources (Richards and Schulting 2000) but due to a lack of human remains and/or stable isotope evidence from the isles, it is possible only to speculate what effect the introduction of domesticates had on the diet and health of the islanders. There is however considerable evidence for domestic animal exploitation.

As noted in the introduction, one of the most striking aspects of these assemblages is the high proportion of neonatal calves. Why did so many cattle die so young? Was this a deliberate policy to intensively exploit milk (Legge 1981), or was it a product of the poor environment and poor husbandry (McCormick 1998)? Halstead (1998) has suggested that the Scottish isles are one of the few areas in Britain where neonatal culling is a favoured strategy. This paper considers all the evidence for animal husbandry strategies on the islands, examining the taphonomic and methodological issues raised in assessing zooarchaeological evidence and drawing upon other sources of evidence such as historical accounts, ethnographic records and biomolecular analyses.

The zooarchaeological evidence

The number of identified specimens of domestic food animals for each of the assemblages considered in this paper is listed in table 1. The majority of these assemblages have been recently studied by the authors and provide comparable datasets. Other species and sites not studied by the authors have been excluded for the purposes of this paper, but for a fuller account of the Western Isles data see Smith and Mulville (2004) and for Pool see Serjeantson and Bond (forthcoming). These datasets are being added to all the time from a series of on-going excavations. This large range of sites, reaching from prehistory through into historic times, allows the changing role of animals over time to be considered.

Quantifying Neonates

The age profile of an archaeological population can be examined through both epiphysial fusion and dental evidence. These two methods have different advantages and disadvantages as is discussed elsewhere in this

Table 1. Percentage abundance of main food animals and total NISP.

Period	Island	Group	Site name	Sheep	Cattle	Pig	Total
Neolithic	Sanday	*Northern Isles*	Pool	44	55	<1	4079
Bronze Age	South Uist	Western Isles	Cladh Hallan	67	32	1	830
Iron Age	South Uist	Western Isles	Cill Donnain	43	47	10	4553
	South Uist	Western Isles	Dun Vulan Midden	49	29	22	553
	South Uist	Western Isles	Platform	39	47	14	2299
	South Uist	Western Isles	Bornais (LIA)	49	45	6	1619
	Pabbay	Western Isles	Dunan Ruadh	84	15	1	2271
	Mingulay	Western Isles	MY 384	39	60	0	414
	Sanday	*Northern Isles*	Pool (LIA)	43	43	13	5119
	Sandray	Western Isles	SY14	60	37	3	144
Norse	South Uist	Western Isles	Cille Pheadair	56	34	10	6861
	South Uist	Western Isles	Bornais	55	37	8	756
	Sanday	*Northern Isles*	Pool	51	39	10	13359

LIA = Late Iron Age

References

Pool	Bond and Searjeantson forthcoming
Cladh Hallan	Mulville *in prep* .; Scales 2001
Cill Donnain	Ul Haq 1989; Hanshaw-Thomas 1991; Mulville 1997, 1999
Dun Vulan	Mulville 1999
Bornais	Mulville 1997 and *in prep*
Pabbay	Mulville and Ingrem 2000
Mingulay	Mulville and Ingrem 2000
Sanday	Bond
Sandray	Mulville and Ingrem 2000
Cille Pheadair	Mulville forthcoming

volume (see Legge and Greenfield this volume). One factor that biases the representation of the fragile remains of young animals is preservation. The majority of assemblages from the Western Isles sites lie within calcareous shell sand, a substrate that is both chemically and physically ideal for the preservation of bone and teeth. The excavated bone is rarely eroded; retaining intact surface features and the less robust foetal, neonatal and juvenile remains survive undamaged. Excavated sites on the Northern Isles lie on varied geology, hence preservation is more variable; some sites, such as the Scord of Brouster, Shetland (Whittle 1986) have poor preservation due to the local soil chemistry and hydrology.

Even in conditions of excellent preservation, less robust bone can still easily be fragmented by butchery, consumption and disposal methods: butchery, trampling or animal gnawing etc., leading to a bias towards older bone. Indeed, there is extensive evidence for the latter with many canid coprolites recovered from the majority of sites on the Western Isles and at Pool, although the proportion of bone that bears evidence of gnawing is relatively low.

Neonatal and foetal bone was recorded as a separate category at some sites. The criteria of Prummel (1987a, 1987b, 1988 and 1989) were used to identify foetal/neonatal bone based on its size, shape, development, texture and fusion. Foetal bone is particularly easy to identify in the form of longitudinally unfused 3rd and 4th metapodia of cattle and sheep. The fusion of the diaphyses of 3rd and 4th metapodia in cattle begins at day 200 after conception and by day 210 this process should be completed (Prummel 1987). As the average gestation is c.285 days any longitudinally unfused metapodia must come from foetal individuals. Post parturition the earliest fusing bones in cattle are those of the scapula and pelvis which fuse at about 7–10 months.

The eruption and wear of mandibular teeth was also used to identify neonatal animals. As mentioned above, the individual teeth and jaws of very young animals are more prone to destruction than those of older individuals. This differential destruction should result an under-representation of neonatal animals, however as teeth are more robust than bones any analysis that considers both loose teeth and those within jaws should be less prone to biases.

Newly born animals have both deciduous incisors and premolars erupted, and the first molar erupting. Although some authors consider the fourth deciduous premolar (Dp4) to only come into wear after birth (e.g. Halstead 1985), Serjeantson (*pers. comm.,*) recorded slight *in utero* wear on the teeth of modern newly born calves. Dp4s showing only slight wear (e.g. on the first cusp only) were recorded as wear stage a/b (after Grant 1982) and are considered to belong to animals less than one month old. Those with the second and third cusps of Dp4 in early wear were assigned to wear stage b (after Grant 1982) and placed in the older class of 1–8 months old.

The recovery methods used on the majority of sites considered here include extensive sieving programmes, resulting in the recovery of many loose teeth and smaller bones, such as accessory carpals, tarsals and unfused neonatal epiphyses. The excellent recovery has led to some methodological experimentation. The large number of loose dP4s recovered have both been excluded and included in the analyses of mortality profiles: for example, at Dun Vulan 58% of the loose Dp4s came from animals of less than one month old (Mulville 1999). The quantity of neonatal bone recovered has also necessitated the recording of only unfused neonatal shafts with loose neonatal epiphyses excluded from the analyses. Finally, if we compare the proportions of neonates represented by the different methods of assessing animal age we find that the results sometimes differ (see below).

Ideal conditions – unusual assemblages?

As already noted the preservation and recovery conditions found on many of the Atlantic island sites will inevitably lead to the preservation and recovery of more neonatal bone than on most other archaeological sites. It is hard to put a figure on how inflated the level of neonatal bone is but if we compare the island assemblages to other British sites few show the same high proportions. One exception is Grimes Graves, another site with excellent preservational conditions and recovery (Legge, this volume) and a second is Danebury (Grant 1984, 1991) where over 20% of cattle died at mandibular wear stage A, i.e. under one month. Grant (1991) has suggested that this pattern is associated with the trade, exchange or movement of adult cattle away from the site or young animals to the site. Conversely, Hambleton, in her 1999 review of the Southern British Iron Age, considered this bias to be due to differences in taphonomy rather than husbandry strategies. This implies that without such good preservation the Danebury assemblage would look like the majority of other Iron Age sites, with little evidence for the death of very young animals.

Is it possible to demonstrate that preservation is the major factor affecting neonatal abundance? If we examine other sites with local geologies favourable to bone, such as those on chalk sites, there is little evidence that neonates are more common. A higher level of neonatal mortality is visible at some Southern British Iron Age chalk sites, e.g. at Winnall Down and Burgh 15% and 10%, respectively, of cattle died within the first month (Hambleton *ibid*) and at the chalk site at Rooksdown this figure is 11% (Powell nd). There are four other Iron Age sites that demonstrate neonatal mortality of 10% or more; Mingies Ditch and Watkins Farm in the Thames Valley and Bancroft and Market Deeping in Eastern Britain (Hambleton 1999). These sites are found on alluvium, gravel, peat and clay respectively, which suggests that more than geology is affecting the abundance of neonates. Wider speculations on the dual effects of preservation and recovery biases on estimates of population age structure are outside the scope of this paper and, for sheep at least, have been the subject of research by Munson (2000) and Munson and Garniewicz (2003).

The preponderance of neonates is undoubtedly affected by taphonomic factors and the systematically recovered collection of material from the Atlantic Island sites provides a more accurate representation of life assemblages, and as a result, human intentions than is possible for most other parts of the UK. This pattern is demonstrated at other Atlantic Island sites, even those excavated some years previously, before extensive sieving was routinely carried out; for example Platt's report for the Viking buildings at Jarlshof comments on the high proportion of bones of young calves (Platt 1956: 214) and a similarly high proportion was noted at the Neolithic Knap of Howar (Noddle 1983).

Aging evidence

Table 2 shows the percentage of bones described as foetal/ neonatal (loose epiphyses excluded) as a proportion of the total bone with fusion information recorded. Cattle and sheep are included separately for comparison. There were a few pre-term foetal bones of sheep and the occasional pre-term foetal cattle bone recovered from many of the sites recorded by Mulville but these are not quantified separately.

Table 3 summarises the cattle dental data (after the methodology of Halstead 1985) from the sites, indicating the percentage of jaws falling into each wear stage and the total number of jaws used in the analysis. Dental data are commonly considered to be more reliable for estimating population age structure. The range of neonatal mortality is from 6% to 86%.

We can compare the dental and fusion of information for the larger assemblages. At Dun Vulan, South Uist (Mulville 1999) only 3% of cattle bone is described as neonatal but nearly half the jaws came from newly born animals. Conversely in some phases at Pool and Tofts Ness on Orkney, and Dunan Ruadh on Pabbay there were consistently higher proportions of neonatal long bones than jaws. Other sites have a similar proportion of neonatal bone and jaws e.g. the tiny site MY384 on Mingulay (Mulville and Ingrem 2000) and at Bornais (Bornish) (Mulville 1997 and forthcoming and in prep.).

Table 2. Percentage of Neonatal/Foetal bones.

	Cattle	Sheep
Bronze Age		
Cladh Hallan	60	43
Iron Age		
Dun Vulan	3	13
Cill Donnain	26	0
Bornais	55	5
Dunan Ruadh	22-50	5-7
Mingulay	80	63
Sandray	38	19
Pool	15	2
Norse		
Bornais (Mound 3)	15	18
Pool	27	8

These discrepancies suggest that fusion and dentition data are providing different information (see later).

These data have been grouped by archaeological period and by island group to remove the small sample biases found at some of the sites (Figs 2, 4 and 5) although it should be noted that the Bronze Age evidence is derived from a single settlement area. In the Western Isles there is a decrease in the number of extremely young cattle jaws over time (Fig. 2). The difference between the Bronze and Iron Age groups is most pronounced in the number of animals dying in the first month of life. By the subsequent age group, (i.e. 1–8 months), the difference in the proportion of dead animals is less pronounced, with 72% of animals dead in the Bronze Age and 59% in the Iron Age. Despite the differences in the first age category, neonatal mortality in both periods is high at over 40%. In the later Norse period there is a pronounced drop in neonatal deaths with only 10% dying in the first month of life.

By contrast, sites in Orkney seem to show the opposite response (Fig. 3). The two sites examined here, Pool and Tofts Ness, are both multiperiod settlements on the island of Sanday. Tofts Ness was occupied from the Neolithic to the Iron Age and Pool from the Neolithic to the Late Norse period (Dockrill *et al.* forthcoming, Hunter *et al.* forthcoming). In both occupation sequences, the trend over time is towards a greater number of very young animals.

At Pool in the Neolithic 22% of the jaws were from calves under 1 month old. By the late Iron Age this number had risen to 40%, with a cumulative mortality for animals under 8 months of 46%. In the Norse period 44% of the calves died in the first month of life, the cumulative mortality for the animals under 8 months being 62%. Preservation was poor in the Neolithic levels at Pool and this might account for some of the difference, but the same pattern is evident at Tofts Ness (Bond 1994, Serjeantson & Bond, forthcoming). Noddle also recorded a high proportion of neonates (an average of 30% of the MNI) at the Knap of Howar, Papa Westray, Orkney, though she thought that dairying was an 'unlikely' explanation (Noddle 1983).

The data for sheep are included for comparison (Table 4 and Figs 4 and 5) and their mortality pattern is very different. They generally survive the first few months of life, with the majority dying between 6 months and two years. This discrepancy could be due to differences in their hardiness, in the preservation/recovery of their bones or indicate a differential management system for the two species. The smaller and more fragile neonatal sheep bones may be preferentially destroyed by the scavenging activities of dogs and pigs, although the low numbers of the scavenging species and the small proportion of gnawed bone suggests this is not the case. Although slightly more robust, the presence of many neonatal cattle bones indicates good preservation and recovery at the sites. The lack of neonatal sheep may suggest that lambing took place away from the settlement, or that sheep are hardier/managed better. At present in the absence of firm evidence for either strategy, we can reach no conclusions.

The biases towards extremely young animals is problematic in attempts to establish the sex composition of herds; metrical analysis of the Western Isles data has yet to reveal a preponderance of adult cattle of either sex. At Pool, very few measurable bones survived in any one phase but the values for available cattle metacarpals show a possible female: male (or castrate) ratio of between 4:1 and 7:1 over phases 6 to 8 (Late Iron Age to Norse). Whilst this preponderance of females could be seen as indicating a milk economy, in the majority of herds, apart from those involved in market economies, the adult component is mostly made up of females.

Pottery evidence

New insights into dairying and milk consumption are beginning to emerge from pottery residue analysis of Western Isles material. In a recent study, remnant fats were identified on 16 out of 35 sherds analysed, predominantly from floor layers, from Cladh Hallan, South Uist. Further analysis showed that all of these fats were exclusively derived from ruminant milk and that many of the same sherds also contained bovine milk proteins (Craig *et al.*, 2000 and forthcoming). Similar results were obtained from a much smaller ceramic assemblage from Dun Vulan.

Whilst these analyses unequivocally demonstrate that dairy products were an element of the economies of the Western Isles, since at least the Bronze Age, they provide little information on the scale and intensity of dairying Craig *et al.* 2005. For example, it is hard to determine the number of times that a ceramic vessel was used to process dairy products. Experiments also suggest that

Table 3. Cattle Percentage of jaws in each age stage (after Halstead 1985).

Wear Stage	A	B	C	D	E	F	G	H	I	
Age	*0-1 month*	*1-8 months*	*8-18 months*	*18-30 months*	*30-36 months*	*Young Adult*	*Adult*	*Old Adult*	*Senile*	*Total number of jaws*
Western Isles										
Bronze Age										
Cladh A	25	0	25	0	0	0	0	50	0	4
Cladh C	86	0	0	0	7	0	7	0	0	14
Cladh Hallan Total	72	0	6	0	6	0	6	11	0	18
Iron Age										
Dun Vulan	49	11	3	4	7	1	8	7	11	74
Cill Donnain	37	0	5	5	0	21	16	0	16	19
Bornais	43	14	0	29	0	0	14	0	0	7
Baleshare	34	34	9	0	5	0	9	9	0	44
Hornish Point	38	38	0	0	0	0	0	25	0	8
Dunan Ruadh	17	0	67	0	17	0	0	0	0	6
Mingulay	83	0	0	0	17	0	0	0	0	6
Norse										
Cille Pheadair	6	15	9	3	15	8	6	4	33	78
Bornais	12	18	9	35	12	0	3	3	9	34
Orkney										
Neolithic										
Pool	14	4	12	8	2	4	33	22	0	49
Late Iron Age										
Pool	36	8	13	15	6	6	6	11	0	53
Norse										
Pool	48	10	11	8	6	6	2	5	4	109

milk may form a stable organic residue much more readily than other foodstuffs and therefore be over-represented. In addition, ceramics only represent one of many different forms of material culture that can be used to prepare dairy foods and may even be used to waterproof ceramics. Therefore, the link between the presence of milk in ceramics and intensive dairying is one that has yet to be proven conclusively.

Why do calves die?

The arguments for and against early calf slaughter as a method of liberating milk for human consumption have been well rehearsed, in particular those concerned with the presence of the calf as a necessity to facilitate milk let-down (Greenfield, Legge and Ryan this volume). These arguments will not be reiterated here; instead this paper will focus on the other aspects under debate.

McCormick (1998) has argued that, in the case of the Scottish Isles, high levels of juvenile cattle mortality were the result of poor husbandry, a lack of fodder (particularly in winter) and the marginality of the land rather than a deliberate slaughter strategy to release milk for human consumption. Irish and Scottish historical and ethnographic sources provided evidence of poor feed availability, starving stock and a lack of hay production. The island climates today are described as poor (McCormick 1998), for example the rain and in particular the winds are considered to have 'a severe effect' on livestock in the Western Isles (Boyd and Boyd 1990). McCormick's arguments are considered in greater detail below.

Mortality rates

If winters were hard for stock in the past, it is likely that a certain proportion of calves would be lost due to the poor condition of the mothers. Analysis of ethnographic data collected from unimproved farming systems suggests that between 10 and 40% of all calves are born dead or die within the first few weeks of life (Mulville 1992, Ryan this volume). However this data is mostly derived

Table 4. Sheep Percentage of jaws in each age stage (after Halstead 1985).

Wear Stage	A	B	C	D	E	F	G	H	I	
Age	*0-2 months*	*2-6 months*	*6-12 months*	*1-2 years*	*2-3 years*	*3-4 years*	*4-6 years*	*6-8 years*	*8-10 years*	*Total number of*
Western Isles										
Bronze Age										
Cladh A	0	9	27	9	9	18	9	18	0	11
Cladh C	3	3	47	23	0	3	3	13	3	30
Cladh Hallan Total	2	5	41	20	2	7	5	15	2	41
Iron Age										
Dun Vulan	1	11	42	5	12	18	8	4	0	114
Cill Donnain	0	0	11	11	39	17	22	0	0	18
Bornais	0	10	40	30	10	10	0	0	0	10
Baleshare	6	14	43	0	6	8	2	2	18	49
Hornish Point	0	0	58	0	8	8	8	8	8	12
Dunan Ruadh	15	23	13	13	23	10	3	0	0	39
Mingulay	7	0	21	29	29	0	7	7	0	14
Norse										
Cille Pheadair	7	9	19	14	8	14	26	1	2	205
Bornais	0	8	18	34	18	3	8	5	5	38
Orkney										
Neolithic										
Pool	1	2	10	7	5	0	5	1	0	31
Late Iron Age										
Pool	0	1	15	15	4	12	3	2	1	53
Norse										
Pool	3	9	46	48	27	16	19	4	2	174

from herders living in conditions far removed from the Hebrides, in places such as East Africa, so closer comparisons need to be found. The Soay sheep herd on St. Kilda and the red deer herd on Rhum provide a local example of survival rates in unmanaged herds. It is debatable if unmanaged herds on small islands with cyclical population crashes are a good comparison for the majority of sites, however in the case of the Scottish isles they provide at a minimum a 'worst case' scenario for survival rates.

For the Soays on St. Kilda up to 32% of lambs born subsequently die (Grubb 1974). This figure compares well with data produced from other studies of mountain sheep and goats where between 25 and 50% of new born animals die within a month of birth (Geist 1971 and Schaller 1977). In all cases it is the poor condition of the mother at birth and the resulting poor condition of the lamb that leads either to the mother abandoning the offspring or it perishing shortly after birth. Recent studies of the red deer on Rhum demonstrated a neonatal mortality rate ranging from 14 to 21% for the years 1996–1999. A larger study of 10 species of northern, temperate ungulates revealed an average neonatal (first summer) mortality of 19% in environments lacking predators (Linnell *et al.*, 1995).

Compared to these figures, the levels of neonatal mortality recorded in the island archaeological assemblages are high. Also for most modern populations the mortality statistics represent the proportion of the newborn young that die and not the proportion of the whole population that these deaths represent (e.g. if calves constitute 50% of the population then overall 50% of calves dying would be only 25% of the total population). Thus neonatal mortality in the archaeological population is noticeably higher than that which occurs naturally. Indeed to reach the levels noted at some of the sites, all of the calves born would have to die.

Poor husbandry, poor climate

Is the increased level of mortality in the Hebridean domesticated stock relative to unmanaged wild herd data because stock management was extremely poor with

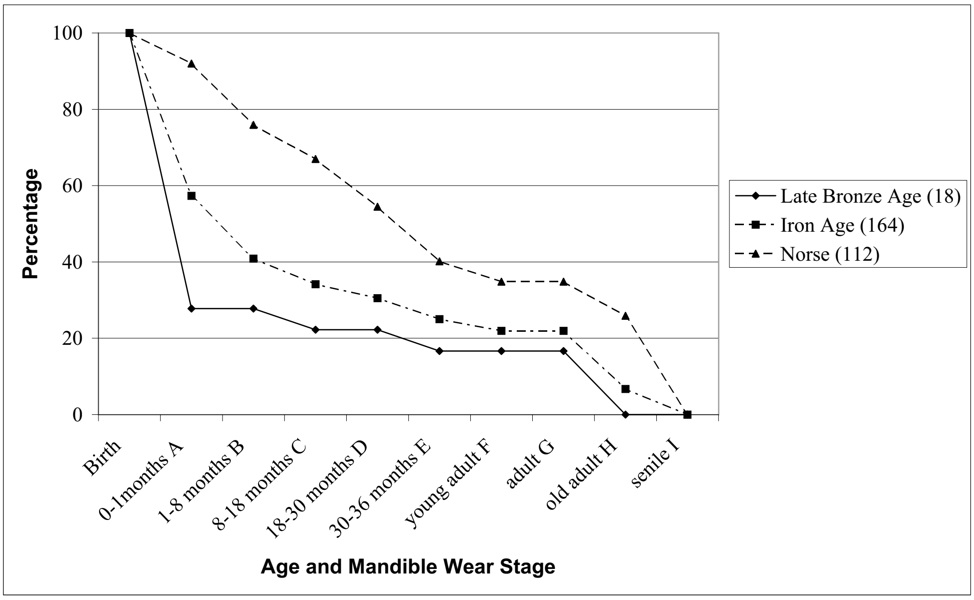

Fig. 2. Western Isles – Cattle mortality profiles based on tooth wear data.

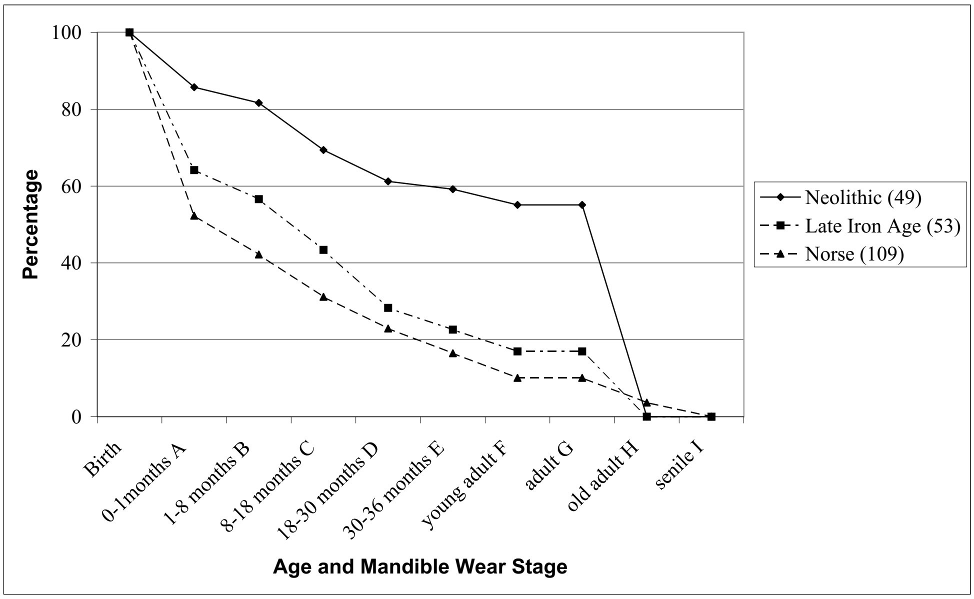

Fig. 3. Orkney (Pool) – Cattle mortality profiles based on tooth wear data.

animals consistently kept on restricted feed and falling prey to disease? If so were these islands the only places in Britain where such poor management occurred? Such explanations have not been invoked for the more southerly examples of high neonatal mortality, which implies that the perceived marginality of the climate is the predominate factor.

The presence of foetal remains of domestic stock could be taken to indicate a high mortality rate over winter. Poor maternal condition results in the loss of calves and/or pregnant females. There are no data to indicate how many pregnant animals were lost in a hard winter – it would be astounding if none died as a result of disease, accident or poor animal husbandry. Alternatively this could reflect a high fecundity rate and a management system that included the slaughter of pregnant animals. There is only a very small amount of foetal cattle bone present, suggesting that, whatever the cause, pre-term losses were not high. The majority of foetal remains on the Western Isles sites were sheep, even on sites with

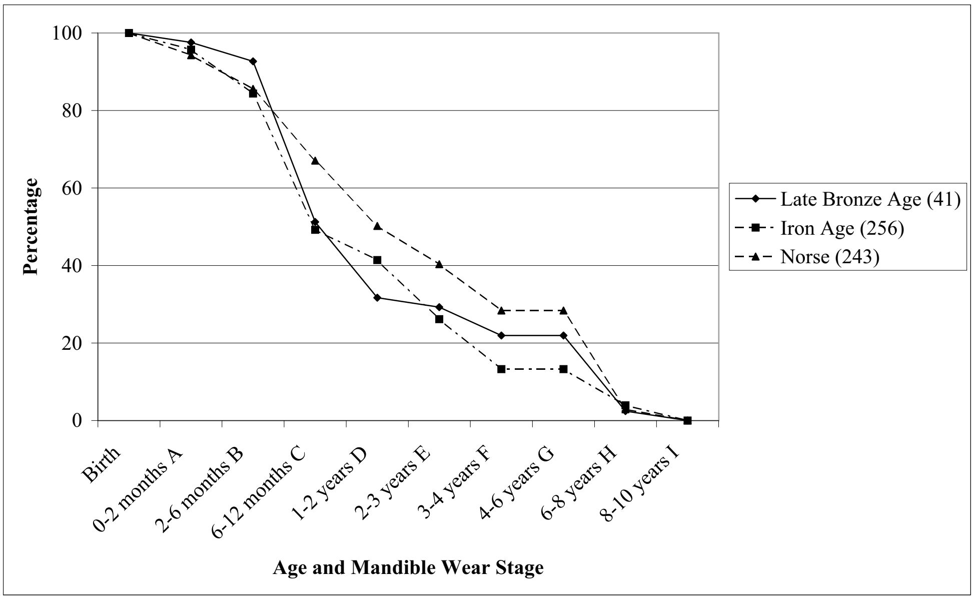

Fig. 4. Western Isles – Sheep mortality profiles based on tooth wear data.

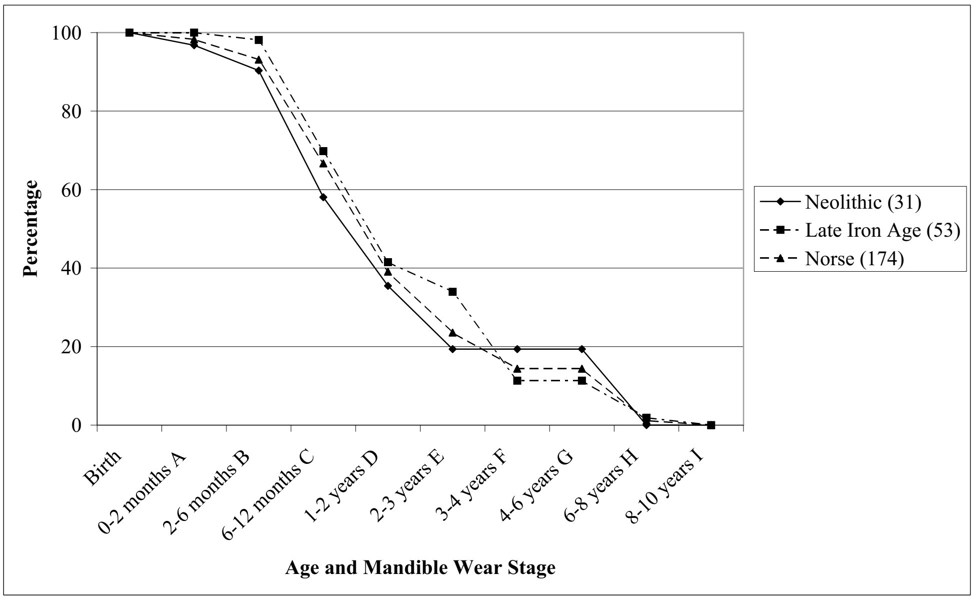

Fig. 5. Orkney (Pool) – Sheep mortality profiles based on tooth wear data.

very high calf mortality (for example Mingulay, Mulville and Ingrem 2000).

Also if mortality patterns are due to poor husbandry or the inclement climate then we might expect high mortality at all sites and in sheep as well as cattle. At the sites considered here, and those discussed by Halstead (1998), cattle and sheep do not have the same mortality patterns. As noted previously, sheep generally survive the first few weeks of life, with the majority dying between 6 months and two years. This discrepancy suggests a differential management system for these two species, with sheep breeding away from the settlements or differences in the hardiness of sheep and cattle.

Archaeological biases

The exceptionally high levels of calf mortality could also be a function of archaeological biases. Sites are not closed systems and entire animals and body parts are probably imported and exported; adult breeding stock may be disposed of offsite or young calves imported. For example, at Pool from the Late Iron Age onwards (3rd century AD) (Serjeantson and Bond forthcoming), and at the Iron Age sites of Dunan Ruadh on Pabbay, SY14 on Sandray and MY384 on Mingulay (Mulville 2000), there are too few breeding age cattle present to sustain the herds. For the latter two sites, SY14 and MY384, the restricted areas excavated and the resulting small samples are likely to bias the representation; however Pool and Dunan Ruadh are more substantial assemblages. The selection of particular body parts of animals of different ages, trade between sites, or the seasonal use of sites are also possibilities.

The low number of adults on settlement sites could indicate that the slaughter and disposal of older animals occurred at other sites. There is historical evidence for the seasonal movement of animals with accounts of summer transhumance to upland sheilings with animals taken to summer pasture and milked, however they were probably returned to settlements for slaughter and consumption. Few sheilings have been excavated, and to date none of the lower lying settlement sites demonstrate seasonal occupation. Finally there are no sites that have less than 10% neonatal mortality, and none with a predominance of older individuals.

Ritual use

Another possibility is the ritual use and disposal of the adult portion of the herd. There is some evidence that prime domestic animals were preferred for deposition as skeletons or cremations in pits and other special contexts (Campbell 1999, Mulville *et al*., 2003). On those sites were such a bias is observed, e.g. Sollas, large numbers of neonates were also recovered (Finlay 1984, Campbell 1999). The predominance of prime cattle within special deposits suggests that, at some points in prehistory at least, herds were able to support the loss of adult animals for ritual purposes.

Farming histories

McCormick (1998) attempted to establish the efficiency of island livestock management in the Hebrides by comparison with the historical and ethnographic record. The accounts of early travellers in the islands are the source for many of the perceived problems with the island climates and the islanders farming methods (McCormick 1998). There are descriptions of starving cattle, little winter feed and poor animal husbandry across all the island groups (e.g. Fenton 1978). Additional evidence indicates that the weather caused problems for stock in Scotland as a whole, with numerous historical accounts of cattle dying as a result of starvation, and it is estimated that in Scotland one in five cattle died over winter during the 18th century (McCormick 1998).

Alternative accounts describe how the mildness of the Hebridean winter helped to save the cattle,

> 'were these winters as cold, and the snow as deep and permanent as in many other parts of Britain, very few stock would escape utter destruction. The mildness of the climate, at least with respect to cold, the assistance of sea-weeds and heather, and the hardiness of the cattle themselves, save them, however, in some measure, and although exposed to the open air all winter and spring, not above one eighth dies of famine or its immediate effects'.
>
> MacDonald (1811, p. 432)
>
> (One eighth would be around 13%)

This diversity in opinions is not unexpected and any use of historical sources has to consider the social system in place at the time they were written. Post-medieval farming methodologies are likely to be very different to those found in prehistory and early medieval times. In the Highlands and Islands in the eighteenth and nineteenth centuries, factors such as human overpopulation, overstocking of farmland, the diminishing areas of land held by crofters and the harsh edicts of landlords, such as those which forbade the collecting of seaweed (see below), all strained an already marginal economy (Napier Commission 1884, Bond 1994; Bond *et al*. 2004).

Winter housing and fodder

If the winters were severe animals may have been housed as they were in the post-medieval period. Byring could have occurred to protect cattle from winter weather, to make dung collection easier, to save the land from poaching or to protect animals from raids (Fenton 1978, Fokkens 1999; Halstead 1998). Alternative fodder supplies would have been necessary for contained cattle, although it may also have been necessary to provide supplementary feeding for animals left on winter grazing. This containment would result in starving animals if they were provided with insufficient feed. The timing of the introduction of byring is debatable. There is evidence for cattle stalling in the Bronze Age houses of Scandinavia (Fokkens 1998) whilst the use of browse as sheep fodder in Switzerland and Denmark has been dated to the Neolithic (Rasmussen 1989). Despite claims that the ground level of brochs may have been used to house cattle (Scalloway, Sharples 1997, 40) the presence of accessory buildings with paved floors and drains at Dun Vulan (Parker Pearson and Sharples 1999, chapter 6), and the possible presence of byres at the wheelhouse of Allasdale and Clettreval (Barber 2003, 29) there is as yet no conclusive evidence for cattle being kept within buildings in the prehistory of the Scottish Isles. By the Norse period accessory buildings are constructed, which have been interpreted as byres (e.g. Jarlshof) but there is little supporting evidence for the keeping of animals within these structures. At Jarlshof there is no structural evidence in the form of drains or stalls and the site was excavated long before other tests for the presence of stock, such as geomorphology, geochemical or micro-environmental analyses (Smith *et al.* 2001, Smith 1994), were routinely used.

Sources of fodder

If supplementary feeding was necessary to over-winter cattle, what could animals have been fed upon? In historical accounts the lack of winter fodder relates most particularly to grass hay (McCormick 1988). There are historical accounts of hay production in the Northern Isles; occasionally it was important enough to be mentioned in a last will and testament, such as that of Gilbert Flett in 1652. Whilst in 1685 scarcity of hay in Orkney was used as an ingenious argument as to why Orcadians should not pay excise on brewing,

> 'the scairsitie of hay and straw and the want of pastures, hills and grassing doeth force the inhabitants to brew for getting draff to feed their cattle.'
>
> (Shaw 1993, 99)

References to hay production in Shetland are mixed; some saying there was good meadowland yielding abundant hay, whilst others reported it could be badly affected by the weather, presumably because of the wide local range of possible soil types and differences in other factors such as exposure to the salt winds (Shaw 1993, 99). For the Western Isles the hay crop was supplemented by cereal straw and threshing waste.

> 'Most farmers save some meadow hay, and as much straw as they can, and hain or spare some portions of grass growth adjacent to their dwelling houses, for supporting young stock and milk cows during the severity of winter and spring'
>
> (MacDonald 1811, p.432).

Traditionally, oats may have been fed to cattle in the byre, whilst Brand (1833) says that in parts of Orkney they did not shear the corn but pulled it up by the roots so that the straw and root could be used for fodder. In the Western Isles Heron (1794) noted that oat straw was used as winter fodder for cattle.

McCormick (1998) found no records of the use of leafy hay in the Western Isles, and considered the lack of trees to preclude such activity; although in Ireland and the similarly treeless Iceland there is documentary evidence that leafy hay was collected (Lucas 1989, Buckland *et al.* 1996).

There are historical references for further sources of fodder, even if visitors to the isles did not recognise their importance and utility. MacDonald (1811) reported that cattle suffered from the 'want of good food' and that they often ate 'seaweeds, heather, sprats, rushes and other coarse substitutes', whilst Moryson (1617) noted that in the Western Isles seaweed and fish were fed to stock over the winter. The tendency for cattle to know when it was low tide, even when they were out of sight of the sea, and proceed down to the shore to graze was observed by Martin (1981). In Shetland a mash made of boiled and crushed fish bones, and fresh or boiled 'Hinniewaar' (*Alaria esculenta*, a kelp seaweed) was fed to cattle (Hibbert 1822). There are documentary records indicating that vegetable fodder was supplemented with animal proteins and fats in Iceland, by the addition of cod, herring and seal fat.

Recent ethnographic work (Smith 1994) has reiterated the use of hay, chaff, seaweed and possibly heather for winter feed. Even today cattle choose to graze on seaware when other forms of pasture are available. The dismissal of these alternative sources of fodder by eighteenth and nineteenth century writers is probably a reflection on the standard methods of farming employed elsewhere, rather than a comment on the utility of such fodder as cattle feed.

There is also evidence, from the mid to late Iron Age onwards in the Northern Isles, for an important intensification of arable production which may have formed another source of fodder. Cultivated oats (*Avena sativa* and *Avena strigosa*) have been identified as introductions at this time at Pool, Howe on Mainland Orkney, Scalloway broch and Old Scatness broch, in Shetland (Bond 2002, Dickson 1994, 125, Holden & Boardman 1998, Bond *et al.*, 2004). *Avena strigosa* is known as the Black Oat or the Sand Oat, and is even more hardy than its larger relative, being able to live on soil that is virtually pure sand. Common oat (*Avena sativa)* is only identified later, during the Norse period, in the Western Isles (Smith and Mulville 2004). The importance of this new crop is often overlooked; not only might it provide additional human food from previously unproductive land, but it could also provide storable extra winter fodder for animals, including cattle. It may be that the increase in neonates and inferred intensification in dairying, seen at Pool in the late Iron Age and Norse periods, is linked to the introduction of oats at this time. In this case the post medieval period is not a good indicator of previous practice; barley production dropped in the islands, oats became more important as a human staple and only the straw is regularly mentioned as a source of fodder.

Identifying the use of fodder alternatives

There have been attempts to identify the use of different fodder sources from dental microwear and from bone composition analyses (Ambers 1990, Mainland 1997, 1998a, 1998b, 2000, Barrett *et al.* 2000). In the Western

Isles isotopic analysis of the δ13C values for collagen extracted from cattle and sheep from Cladh Hallan, South Uist, were similar to red deer in the same contexts and significantly different from reported values of modern seaweed fed sheep from Orkney (Craig *et al.* 2005), suggesting that for these animals there is no evidence of a significant contribution of marine protein to the diet. On the other hand recent analysis of ovine tooth sections at the Holm of Papa Westray (Dupont *et al.* 2003) revealed δ13C values of -12.6 ‰ and -14.6‰ in two neonatal individuals, which is suggestive of marine fodder consumption. This suggests that the supply of marine resources may have been infrequent, seasonal, or linked to supplementary feeding of animals during lactation/ weaning. Young bone remodels at a high rate and a short term episode of marine based fodder would leave no longer time dietary signal in the bone collagen of adults.

Conclusions

It has now been six years since Halstead (1998) published his paper on milking which referred extensively to Atlantic Scotland. Over this period many more sites have been analysed and they continue to demonstrate the routine slaughter of very young calves from the Neolithic onwards; a pattern of cattle mortality similar to milk mortality models. There is now direct evidence for the presence of milk within ceramic vessels of Bronze and Iron Age date (Craig 2000, Craig *et al.* 2005), but apart from this has the debate moved on? The issues surrounding high calf mortality continue to be discussed, we are still in the process of understanding animal husbandry strategies, the relationship between land availability, fodder and housing. Nor must we forget the social importance of cattle, even within a sheep dominated economy.

The arguments surrounding the let-down of milk in the absence of a calf will continue to be a source of debate. Tani (this volume) has produced a convincing model for development of milking strategies from general herd management to maximise infant survival. Other archaeological, ethnographic and historical work suggests that a number of strategies could be employed to milk cattle in the absence of the calf. If calf slaughter is deliberate, is it a by-product of the marginal nature of the islands? There is a wide range of opinions on the climate, crop production capabilities and animal management expressed in historical accounts of the islands. There is also emerging evidence that the weather, in the Hebrides at least, was better in the past. The Greenland Ice Sheet Project 2 (GISP2) ice core demonstrates a period of reduced ice cover and reduced storminess in the North Atlantic between AD 200 and AD1400. As a result the winter conditions would have been more amenable to crops and animals during this time (Dawson *et al.,* in prep). Most of the historical accounts, after all, are from the end of the 'Little Ice Age'

Data from other wild ungulates suggest that infant mortality on these sites is higher than that found in unmanaged populations, which implies that human intervention is the cause of calf death. Halstead (1998) suggests that a high standard of housing and nutrition is necessary to ensure that lactation is not adversely affected by the slaughter of surplus calves. Stalling is as yet unproven on any Atlantic Scottish site before the post-medieval period, although we have some evidence for the presence of young animals in settlements from their shed deciduous teeth (Halstead 1998, Mulville 1999). By whatever means cattle weathered the winter, indoors, corralled or roaming free on winter grazing, it is the pasture and/or fodder provision that would affect their nutritional and health status. If the North Atlantic climate was better in the past why should the cattle on the islands suffer more excessively from the effects of winter than those on comparable mainland sites? It is unfortunate that evidence from the Scottish Mainland is not more numerous. Over the long time periods discussed here, the quantity and quality of land available to farm would have varied along with the populations and any technological innovations. Whilst the small islands may have suffered from a lack of adequate grazing (Mingulay for example), for the larger islands it is hard to imagine grazing as being limited.

Halstead (1998) has suggested that the patterns of high calf mortality at Grimes Graves, in the early farming communities in Switzerland and in the Atlantic islands is a response to restricted crop production in a short and poor growing season or on poor soils. Hence dairying for consumption was an adaptation to marginality in prehistory. It is not as easy to apply the same argument to the entire range of island and mainland Iron Age sites with relatively high levels of neonatal mortality described, but milk may have been produced for other reasons; butter and cheese are after all storable and tradable assets. The lack of adults in the Hebrides could be associated with the predominance of light and easily tillable machair soils, however some adults would have been needed for milking and breeding. There is evidence from pathologies on cattle bones in the Pool and Tofts Ness assemblages that adult cattle were used as traction animals, suggesting the use of a plough (or ard) from the Neolithic onwards (Bond 1994 and Bond, forthcoming).

The ubiquitous nature of the pattern of high calf mortality on the Atlantic islands across hundreds of miles, and over thousands of years suggest that this form of active cattle management was integral to the farming systems employed on the isles. Preservation and recovery are affecting the results, and whilst the predominance of neonates is undoubtedly elevated above that found at most other sites, it is unlikely that taphonomic factors alone are the cause.

Future work in this area will focus on exploring the perceived lack of fodder, the identification of dietary stress in stock and the use of fodder alternatives as well as more detailed consideration of taphonomic effects on the preservation of neonatal bone. Animal management, diet and health are to be examined through more detailed analysis of the seasonality of slaughter in adult stock, dental microwear, isotopic analysis and palaeopathological indicators.

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