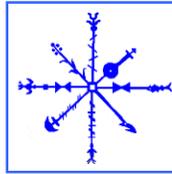


The Hofstaðir Archaeofauna

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Zooarchaeology Chapter in Gavin Lucas (ed.) 2008, *Hofstaðir: a Viking Age Center in Northeastern Iceland, Oxbow*, in press

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Hofstaðir : A Viking Age Center in Northeastern Iceland

Gavin Lucas

University of Iceland
Monograph in Press, August 2008

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Early stages of the investigations at Hofstaðir directed by the Archaeological Institute Iceland revealed that substantial amounts of well-preserved animal bone were present in contexts throughout the site, with a major concentration in the fill of the large sunken featured structure G. The site directors kindly involved the NABO zooarchaeologists (led through various seasons by Tom McGovern and Sophia Perdikaris), and the zooarchaeology team was able to participate directly in the field excavations from 1996 onwards. The modern open area excavation of this major Viking Age hall and its associated buildings offered a unique opportunity for North Atlantic zooarchaeology, allowing comparisons of bone assemblages from fully excavated middens and structures and the combination of horizontal and vertical stratigraphic perspectives on the interpretation of site formation processes. The close cooperation between excavators and specialists continued from fieldwork through post-excavation analysis, and has unquestionably improved the quality of this report.

The analysis and interpretation of the Hofstaðir archaeofauna has also greatly benefited from comparative zooarchaeological evidence from contemporary nearby sites in the Mývatn area (Mývatnssveit) carried out under the larger *Landscapes of Settlement* project, and this analysis will make use of comparative zooarchaeological data from the contemporary sites of Sveigakot (SVK) and Hrísheimar (HRH). Both of these sites are on the southern side of the Mývatn basin, near the present boundary of the interior erosion desert. Both were settled before Hofstaðir, with cultural deposits directly upon the AD 871+/-2 Landnám tephra. Sveigakot appears to have been initially a relatively low status site which achieved modest prosperity in the mid-10th c before declining in the 11th c and being finally abandoned in the 12th century. This site probably saw several cycles of abandonment and re-occupation, possibly by households of declining status. The site of Hrísheimar (just across the Kráká River from Sveigakot) by contrast seems to have been of solid upper-middle status, and is associated with a pre-Christian burial and higher status artifact assemblage (including a bronze sword chape and a knife handle made from a walrus penis bone). Hrísheimar was heavily involved in iron production, and may represent a comparatively wealthy household with wide economic contacts. Hrísheimar was apparently abandoned prior to the H1104 tephra fall, possibly due to depletion of bog iron sources nearby or to the opening of better settlement opportunities elsewhere in Iceland

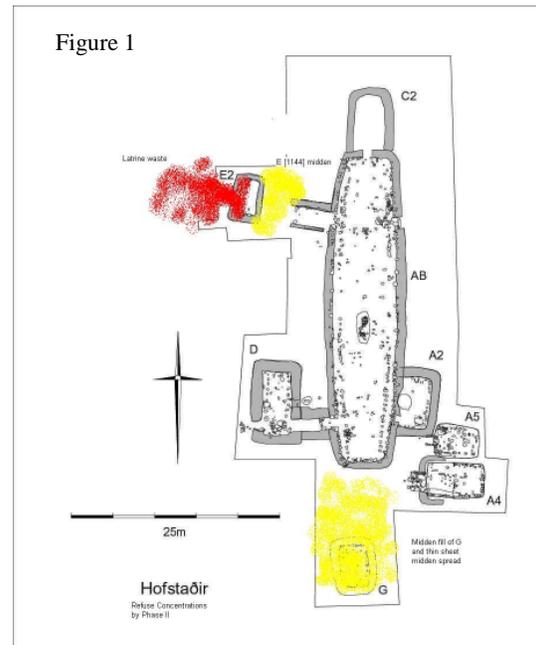
or Greenland by the later 11th century. Both tephra isochrones (Veiðivötn ~940AD & the Landnám sequence AD 871+/-2) and multiple AMS radiocarbon dates confirm that Sveigakot and Hrísheimar were occupied at the same time, with their later phases precisely contemporary with Phase I and II at Hofstaðir. While the archaeofauna from the productive midden deposits at Sveigakot has been fully analyzed, the exceptionally large archaeofauna from Hrísheimar is still under analysis and comparative data presented here is still preliminary. This chapter will thus make use of the comparative perspective provided by the contrasting small/ medium farm at Sveigakot and the medium/ large farm at Hrísheimar.

Recovery & Preservation: Except for re-deposited spoil of the 1907 Bruun excavations and deposits of pure structural turf, all contexts at Hofstaðir were sieved through 4 mm mesh, with substantial whole-soil samples retained for flotation. The silty andisols of the Mývatn area are comparatively easy to dry-sieve, the international crews were uniformly keen eyed and enthusiastic about bone, and the spoil heaps were commendably sterile throughout. The other archaeofauna collected from contemporary sites in the Mývatnssveit area were excavated using the same methods (and often the same crews). Soil acidity in Mývatnssveit generally varies between a pH of 6.25-6.75 (7 neutral). This range provides for generally excellent conditions of bone preservation, and all sites and site areas compared here have closely similar soil pH levels. While any archaeological excavation will inevitably introduce its own set of patterns into any data set recovered, we feel that the Hofstaðir and other Mývatnssveit archaeofauna are excavated to a consistently high standard and that comparability in recovery has been achieved as far as is possible.

Bone Fragments by Phase: Table zz1 presents an overview of the total Hofstaðir archaeofauna, presenting the total number of bone fragments (identified and unidentified) for each of the site phases. While the total archaeofauna (including re-deposited Bruun spoil and medieval to early modern deposits in the area of the ruins) comes to 109,373 fragments, this chapter will report only the Viking Age archaeofauna (totaling 102,761 fragments). As the table indicates, the majority of these fragments come from Phase I (mainly from midden material deposited in sunken featured structure G) and from Phase II (G fill plus midden material from area E). The small collection coming from either phase I or II has not been included in most analytic work, but the material from phase III (which must be made almost entirely of material from Phase II) has been regularly included in a combined Phase II-III.

Table zz 1 Period/Association	Bone Fragments by Phase Phase	Total Fragments	%
	<i>Viking Age</i>		
c AD 940-1000	I	34,983	31.99
c AD 1000-1050	II	59,669	54.56
c AD 940-1050	I-II	1,310	1.20
c AD 1050	III	6,799	6.22
<i>total Viking Age</i>		102,761	93.95
	<i>Medieval - Post Medieval</i>		
Medieval- E Modern	III-VII	212	0.19
Medieval- E Modern	V-VI	252	0.23
Medieval- E Modern	IV-VII	758	0.69
c AD 1850	VII	283	0.26
Bruun Excavation	VIII	1,259	1.15
c AD 1850 + Bruun	VII-VIII	3,780	3.46
<i>total Medieval/Post Med/Bruun</i>		6,544	5.98
<i>unstratified contexts</i>		68	0.06
<i>total all periods</i>		109,373	

Site Formation Issues: The span of time covered by the whole Viking Age archaeofauna at Hofstaðir is short; probably somewhere around a century, possibly only three or four human generations. The substantial amounts of bone and other refuse deposited during this period is an indirect measure of the intensity of the site's occupation and the number of activities carried out in and around the excavated buildings. Bone has accumulated on floors, in sheet middens around the structures (the largest of which is context [1144] in area E) and in the fill of sunken featured structure G, which seems to have functioned as a general refuse dump for the farm following its abandonment. Figure zz 1 illustrates the distribution of major midden concentrations by Phase II at Hofstaðir, indicating the position of the E [1144] sheet midden outside the Northwest skali (A/B) door, and the midden in sunken featured structure G (by later Phase II associated with a thin sheet midden spread to the north). Abandoned sunken featured structures at the nearby sites of Hrísheimar and Sveigakot were also used as refuse dumps, and this seems to have been a widespread practical solution to both the problems of household refuse disposal and the infilling of an inconveniently steep sided pit in the farmyard area. The sunken featured



structures also seem to have provided particularly favorable conditions for the preservation of bone, especially the more fragile elements.

The middens were not simply bone dumps; they contain large volumes of ash, charcoal, and fire damaged stones as well as burnt bone indicating fireplace cleaning activity. The middens regularly received refuse from both outdoor and indoor activities, and bone element distribution analysis indicates that mammal bone from all stages of butchery (from slaughter and initial dismemberment through cooking, consumption, dog scavenging and final deposition) has been included in the same midden deposits. Cut and polished bone fragments and segments of horn core representing craft working debris, as well as lost or discarded finished artifacts are found in the same midden contexts. Some midden deposits derive from large scale (perhaps seasonal) cleanings which deposited large volumes of refuse accumulated over the course of a year or more from many different activities. Other midden contexts represent smaller discard events, such as a group of apparently spoiled, still un-gutted trout (complete with stomach contents) dumped in one small area in a corner of the G fill. Such contrasts of depositional scale in terms of both space and time are particularly important to address for zooarchaeology, where the contrast between high-volume, “activity averaged” cleaning events where chances of articulation and interdependence are low may mix with small one-off discard events where such chances of articulation are high (Binford 1976, Bigelow 1984, Crabtree 1996, Dobney et al 2007). Since the middens as well as the structures were peeled down stratigraphically, it has been possible to positively identify definite articulations and concentrations of bone and bird egg shell during excavation. These potential skeletal articulations have been bagged together in the field, and investigated closely in the lab for actual articulation and evidence of number of individuals present. Where articulation is present, the NISP per taxon count is reduced to one to avoid skewing relative abundance by counting a single individual over and over (NISP counts implicitly assume that each bone fragment comes from a different individual animal, unless articulation can be demonstrated; Lyman 2007, Grayson 1984). In the case of the spoiled trout, a potential NISP count in the hundreds could be reduced to less than a dozen individual fish. Close cooperation in the field has been critical to attempts to cope with such issues, and to bring the zooarchaeological analysis in line with the realities of depositional scale on site.

Laboratory Methods & Data Curation

Analysis of the collection was carried out at the Brooklyn College and Hunter College Zooarchaeology Laboratories and made use of extensive comparative skeletal collections at both laboratories and the holdings of the American Museum of Natural History in New York. All fragments were identified as far as taxonomically possible (selected element approach not employed) but most mammal ribs, long bone shaft fragments, and vertebral fragments were assigned to “Large Terrestrial Mammal” (cattle-horse sized), “Medium terrestrial mammal” (sheep-goat-pig-large dog sized), and “small terrestrial mammal” (small

dog-fox sized) categories. Only elements positively identifiable as *Ovis aries* were assigned to the “sheep” category, with all other sheep/goat elements being assigned to a general “caprine” category potentially including both sheep and goats. Murre and Guillemot are not distinguishable on most bones and are presented together as *Uria sp.*, except where positive identification of *Uria lomvia* (Guillemot) could be made. Fish identifications follow the most current ICAZ Fish Remains Working Group recommendations (including most cranial and vertebral elements), with only positively identified fragments being given species level identification (thus creating the usual large cod-family or *gadid* category and an equally substantial freshwater *salmonid* category as well as a substantial number of unidentified fish bones). Following NABO Zooarchaeology Working Group recommendations and the established traditions of N Atlantic zooarchaeology we have made a simple identified fragment count (NISP) the basis for most quantitative presentation. Total fragment counts (TNF) which include both identified and unidentified bone fragments are used for some comparisons of bone depositional patterns on different parts of the site. Where corrections for the different frequencies of bones in a skeleton are required, an MAU (minimal animal unit) measure which divides the count for a species’ bone element by the number of times it appears in the skeleton is employed (terminology follows Grayson 1984). All bone measurements follow Von den Dreisch (1976), and age assessments for tooth eruption and wear and long bone fusion follow the well supported presentation by Enghoff (2003), dental terminology follows Hillson 1986). Digital records of all data collected were made following the 8th edition NABONE recording package (Microsoft Access database supplemented with specialized Excel spreadsheets, see discussion and downloadable version of NABONE at www.geo.ed.ac.uk/nabo) and all digital records (including archival element by element bone records) and the bone samples will be permanently curated at the Icelandic National Museum, Reykjavik. The archive of the bone-by-bone data set (in MS Access, with metadata) is downloadable ([instructions here](#)). CD R versions of this report and all archived data are also available on request from nabo@voicenet.com.

Taphonomy and Spatial Distribution of Bones

Before discussing the relative abundance of identified animal taxa or attempting reconstruction of past economy, a discussion of taphonomic indicators and spatial patterning of bone distribution across the site may be helpful. Table zzz 2 presents the species present in the structure floor layers and the three major midden concentrations. As the table indicates, the great majority of bone fragments come from the three midden deposits. Phase I midden material is almost entirely contained within sunken featured structure G (G I), while by Phase II midden material had accumulated in both G (G II) and area E ([1144]).

Table zzz 2

Taxa by deposit type (NISP)

	Floors					Middens			E [1144]		
	A/B	D1	E2	A2	A4	A5	C2	G I		G II	
Domestic Mammals											
Cattle (<i>Bos taurus dom.</i>)	5		1					5	532	660	373
Pig (<i>Sus scrofa dom.</i>)									85	165	23
Horse (<i>Equus caballus dom.</i>)			1						8	32	4
Goat (<i>Capra hircus dom.</i>)									33	36	16
Sheep (<i>Ovis aries dom.</i>)	1								267	193	46
Caprine sp.	33	1	1	8			3		1547	1732	896
Wild Mammals											
Arctic fox (<i>Alopex lagopus</i>)									1	1	4
Mouse	12									1	
Seal species										11	
Common Seal (<i>Phoca vit.</i>)									1		
Small cetacean									1		
Whale species									2	5	
Birds											
Mallard (<i>Anas platyr.</i>)										5	
Scaup (<i>Aythya sp.</i>)									1	1	
Swan (<i>Cygnus sp</i>)									1		
Duck sp. (<i>Anatinidae sp.</i>)										1	
Ptarmigan (<i>Lagopus mutus</i>)				1					18	125	2
Gull species (<i>Laurus sp.</i>)										6	
Eider duck (<i>Somateria mol.</i>)										2	
Shag or cormorant (<i>Phalacro. Sp.</i>)										2	
Razorbill (<i>Alca torda</i>)									1		
Guillemot or Murre (<i>Uria sp.</i>)									6	4	
Little auk (<i>Alle a.</i>)										3	
Bird species indeterminate				6					44	107	3
Fish											
Charr (<i>Salvelinus alpinus</i>)									717	1406	2
Trout (<i>Salmo trutta</i>)									3582	4063	31
Salmon (<i>Salmo salar</i>)										4	53
Salmonid sp									2084	3446	
Cod (<i>Gadus morhua</i>)									481	873	12
Haddock (<i>Melanogr. aeglel.</i>)									204	252	2
Saithe (<i>Pollachius vir.</i>)									22	36	
Ling (<i>Brosme b.</i>)									3	5	
Gadid sp									1090	1552	16
Halibut (<i>Hippogl hip.</i>)										3	
Wolf fish (<i>Anarch. lupus</i>)									2	1	
Flatfish sp.									2		
Fish species indeterminate									1761	4190	55
Mollusca, Arthropods, Gastropods											
Mussel (<i>M edulis</i>)									307	32	
Clam (<i>Mya sp</i>)									30	17	

Snail (<i>Radix peregra</i>)								34	1	
Barnacle (<i>Cirripedia</i> sp.)									1	
Mollusca sp								46	437	
total NISP	51	1	3	15	0	0	8	12913	19411	1538
Large Terrestrial Mammal	12		3	3			1	595	894	338
Medium Terrestrial Mammal	28			38	9	2	6	2640	3641	805
Small Terrestrial Mammal								16	87	
Unidentified Mammal										
Fragment	138		12	154	34	10	24	12013	22072	3623
total TNF	229	1	18	210	43	12	39	28177	46105	6304

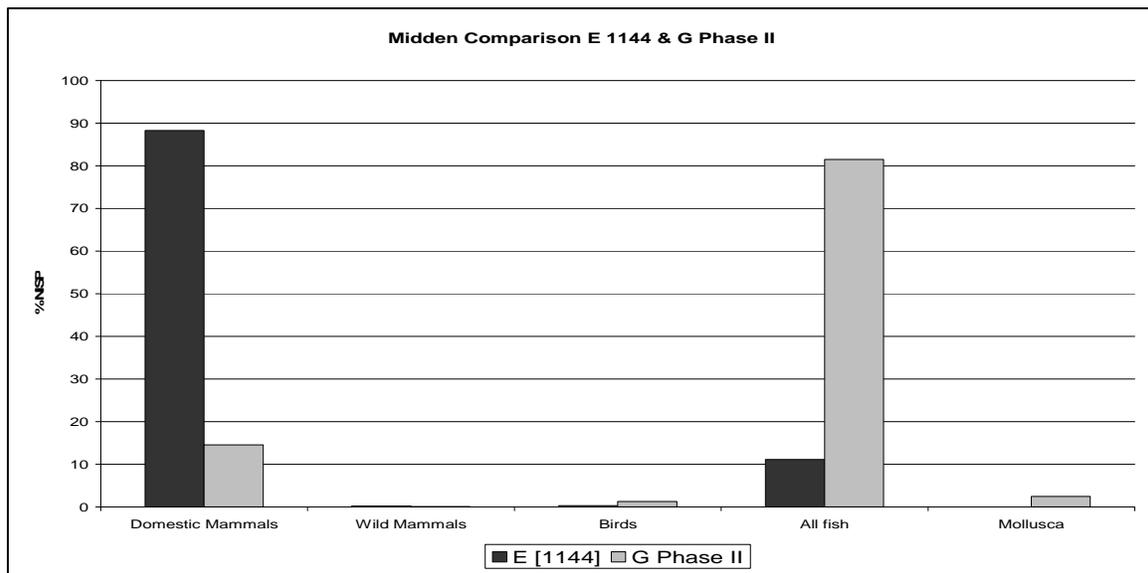


Figure zzz 2

Beyond the great difference in total bone count, the floor layers of the great hall (A/B) contain most of the mouse bones recovered, and there seems to be a near-absence of fish, bird, or shellfish fragments from the floor layers. There are also some differences between the contents of the much larger midden deposits, and these are not easily dismissed as sample size issues. Figure zzz 2 illustrates the relative proportions of the major taxa in the two contemporary Phase II middens. Like the much smaller floor deposits, the area E [1144] midden contains few fish and no shellfish remains. The relative proportions of domestic mammals show no marked differences between the G sunken featured structure fill and the E sheet midden, and the fish bones in both cases are made up of both freshwater species (charr and trout) and some marine species. However, the overall proportions of mammals vs. fish are almost exactly reversed in the two contemporary midden deposits. Is the marked difference in the relative amount of fish bone vs. domestic mammal bones between the floors and the E sheet midden and the G fill the result of some activity-specific depositional pattern, post-depositional differential bone attrition, or some combination of factors? Several different indicators of taphonomic attrition may provide some useful

perspective upon this question. Figure zzz 3 compares the identification rate (NISP / TNF) for the three middens and the two larger floor collections. Given comparable standards of excavation and recovery, identification rates by the same analytic team are largely tied to the condition of the bones themselves—fragmentation, burning, carnivore chewing and other forms of mechanical and chemical attrition tend to remove osteological markers allowing for species level identification as they destroy bone (Dobney et al. 2007, Ervynck 2004). As figure zz3 indicates, both phases of the G midden produced identification rates between 40-50% (typical for sieved midden deposits elsewhere) while both the E midden and the A/B and A2 floors have identification rates 25% or below. This pattern suggests a different taphonomic or depositional history for these deposits. Soil acidity is fairly uniform across the site, ranging from pH 6.25-6.5, and both G and E midden deposits scored at the upper (more basic) end of this range, so additional taphonomic indicators need investigation.

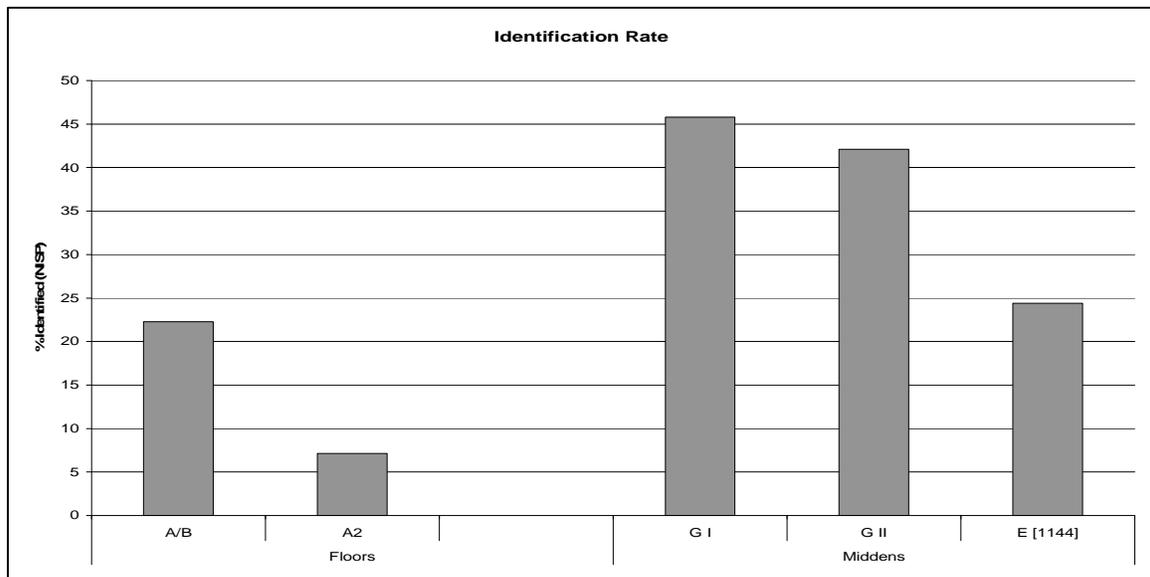


Figure zz3

Fragmentation is a valuable indicator of both intensity of bone processing (Outram 1999, 2001, 2003) and post-depositional attrition. In the NABONE recording system, bone fragments are grouped into five size ranges (<1 cm, 1-2, 2-5, 5-10, >10 cm), allowing tracking of fragmentation patterns in different periods and localities.

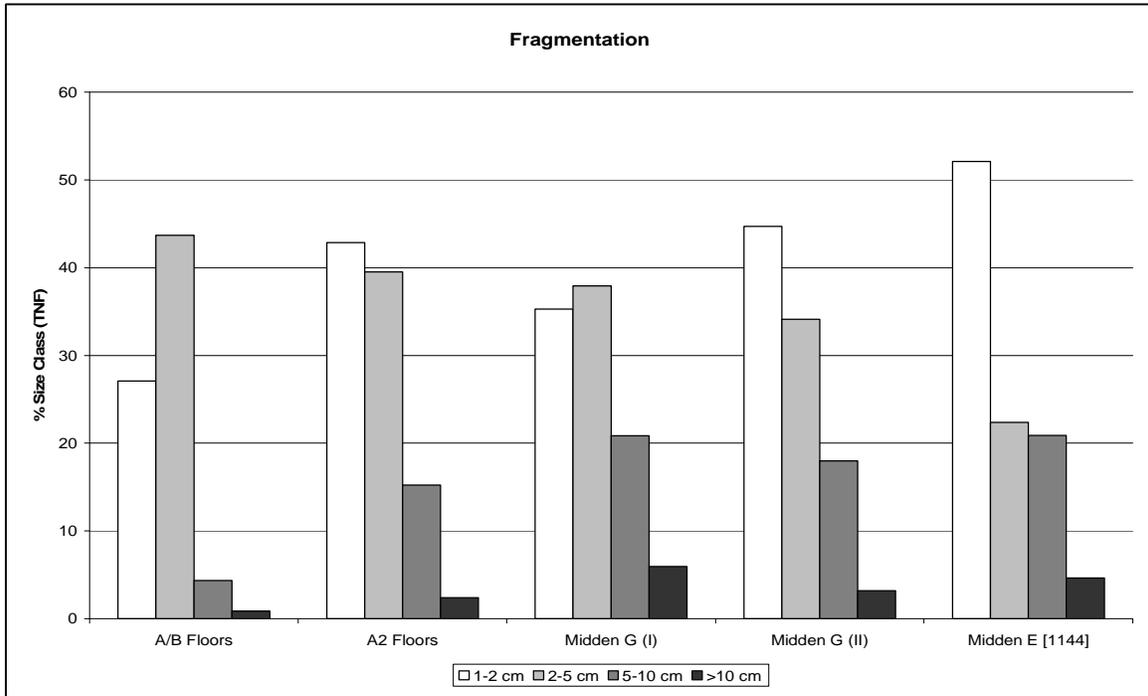


figure zz 4

Figure zz4 presents the distribution of fragment sizes in the middens and larger floor layer contexts. Note that the floor deposit in A2 has highly fragmented bones, with around 80% below 5 cm in maximum dimension. This heavy fragmentation may explain the very low identification rate in A2. The two phases in area G show more or less similar patterns of mostly small-medium fragments, but again the E [1144] midden is different, with more fragments at the lowest end of the distribution.

Burnt bone (esp. white calcined bone which has lost most of its organic component) is very brittle, and both fireplace cleaning dumps and *in situ* hearths

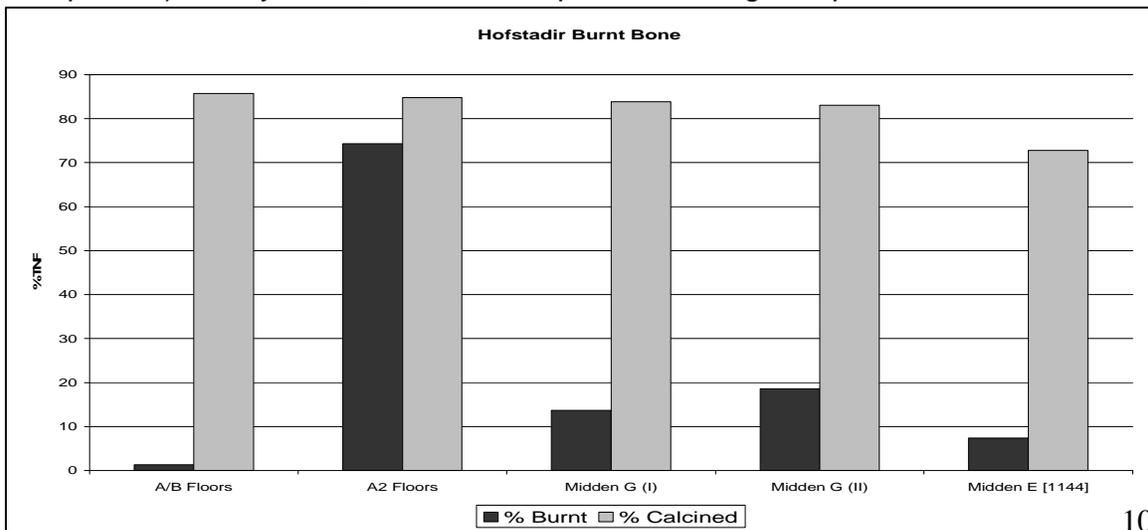


Figure zz 5

tend to be full of very small bone fragments. Is the variability in fragmentation the result of different amounts of burnt bone in the different deposits, and is burning differentially removing fish bone from the E sheet midden deposit? The NABONE package records burning state for all bone fragments, scoring them as un-burnt, scorched, blackened, and white calcined. Figure zz 5 compares both total percentage burnt (first bar) and the percentage of burnt bone which is fully calcined. The A2 floor deposit shows both a very high percentage of burnt bone and a very high proportion of calcined bone, and overall resembles an uncleaned hearth deposit in its taphonomic signatures. By contrast the A/B skali floors have far less burnt bone and only the smallest fragments are calcined- this would appear to be a fairly clean surface not dominated by fire place contents. The middens are all similar in that they have some burnt bone (mainly in the well defined fireplace cleaning deposits which also have lots of ash, charcoal and fire cracked stones), but most bone in the middens is not burnt at all. Note that while midden in E [1144] is highly fragmented, unlike the A2 floors it is *not* strongly burnt. The E sheet midden in fact shows less burning and less calcined bone than either phase in G, and we cannot blame differential destruction of fish bone in the E midden on burning.

Bone density varies by skeletal element and by species, and certainly affects the resistance of individual fragments to mechanical damage. Many authors have developed bone density scores for the elements of a range of mammals (Binford & Bertram 1977, Lyman 1994, Ioannidou 2003, Symmons 2002). While the precision of any bone density score is limited by intra-specific variability due to age, nutrition, and individual variation, there are regularly recurring, substantial differences in bone density in different areas of the mammalian skeleton. The NABONE package pools published mammal element scores into quartiles (1st = most dense bones, 4th= least dense) to somewhat homogenize the results of different authors' published element density estimates and reduce the appearance of spurious precision. Figure zz 6 presents the pooled bone density results for the caprines (sheep and goat together) and cattle bones from the contemporary midden deposits G II and E 1144. While there is a comparative reduction in the least dense bones (4th quartile) of both cattle and caprines in the E 1144 deposit, there is no radical difference in bone density distribution between the G and E deposits for these mid-sized and large mammals. Whatever forces were producing the notably higher rates of fragmentation in the E 1144 midden and the lower concentrations of fish bones, they were not intense enough to produce a distinctive "ravaged" bone density profile made up of nearly entirely first and second quartile (very dense) elements. Similar density scores are not available for fish bones, but experimental work has demonstrated conclusively that fish bone is substantially less dense and mechanically resistant than mammal bone (Jones 1986, Barrett et al. 1997, Bigelow 1985, Perdikaris 1999).

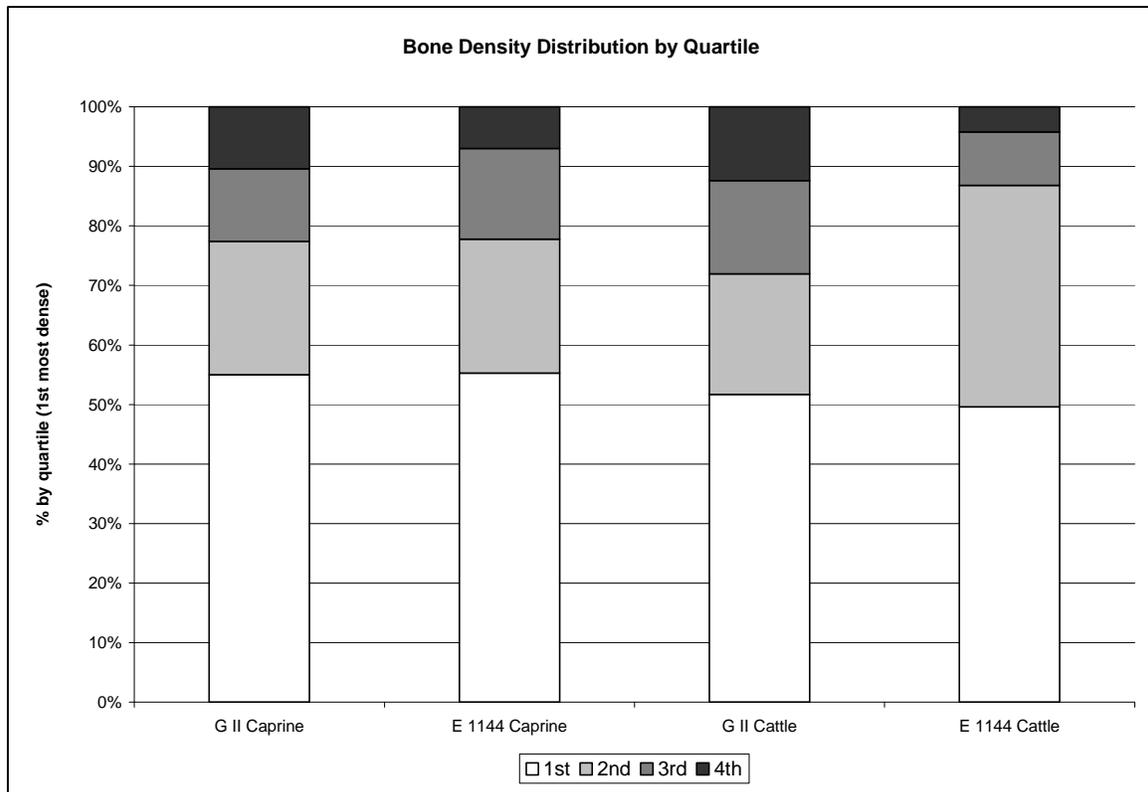


figure xxx 6

Gnawing by animals and humans is a significant agent of bone attrition, and most studies have indicated a general correlation between bone density and resistance to gnawing (Binford & Bertram 1977, Jones 1986, Lyman 1994). Dogs are major agents of bone destruction on most sites, and even small breeds are capable of totally destroying the largest and densest mammal bones given time and motivation. Concentrations of canine-gnawed bones in urban or household contexts tend to accumulate in “dog yard” areas where dogs habitually congregate and have regular access to bones. Concentrations of gnawed bones thus to some degree can spatially track past dog behavior, but are somewhat challenging to quantify effectively. The Hofstaðir archaeofauna shows a highly variable amount of dog gnawing marks by context, phase, and area. Figure xxx 7 presents the distribution of gnawed bone by area, phase, and context. In Phase I no context shows more than 10 gnawed elements. By Phase II there is a marked concentration of dog chewed bones in area E in the context [1144] sheet midden. By Phase III (abandonment), this concentration of dog gnawing in E has shifted to room A, particularly the [159] infill. In the subsequent post-occupational Phases VII-VIII, bone gnawing seems to continue to concentrate in the room A area. Note that the midden fill of the sunken feature structure G has a dispersed pattern of gnawed bone fragments in both Phase I and Phase II, perhaps suggesting that this are simply absorbed refuse from the wider site, including some already gnawed fragments.

in the E and G middens.

Rodents (almost certainly mice) also had access to bones at Viking Age Hofstaðir, and the distinctive marks of their chisel like incisors are present on a small number of bones from several contexts. Figure ZZZ 9 presents the distribution of rodent-chewed bone fragments by area, phase, and context at Hofstaðir. The rodent gnawing presents a different pattern of concentration from the canine tooth marking, concentrating in the Phase II contexts of area A. This may reflect use of area A as a food store or other function particularly attractive to mice.

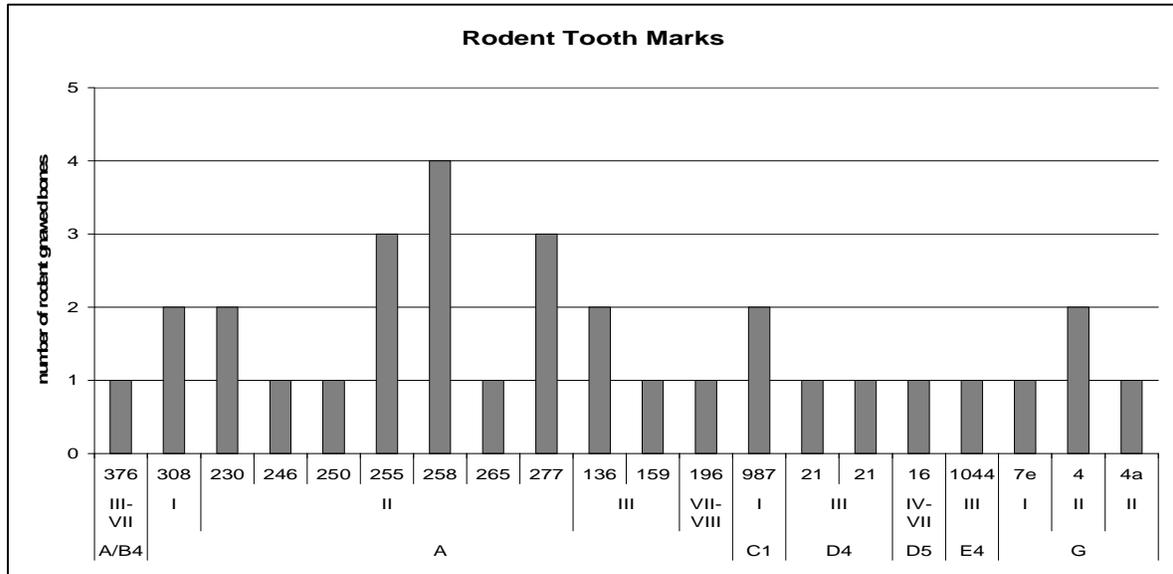


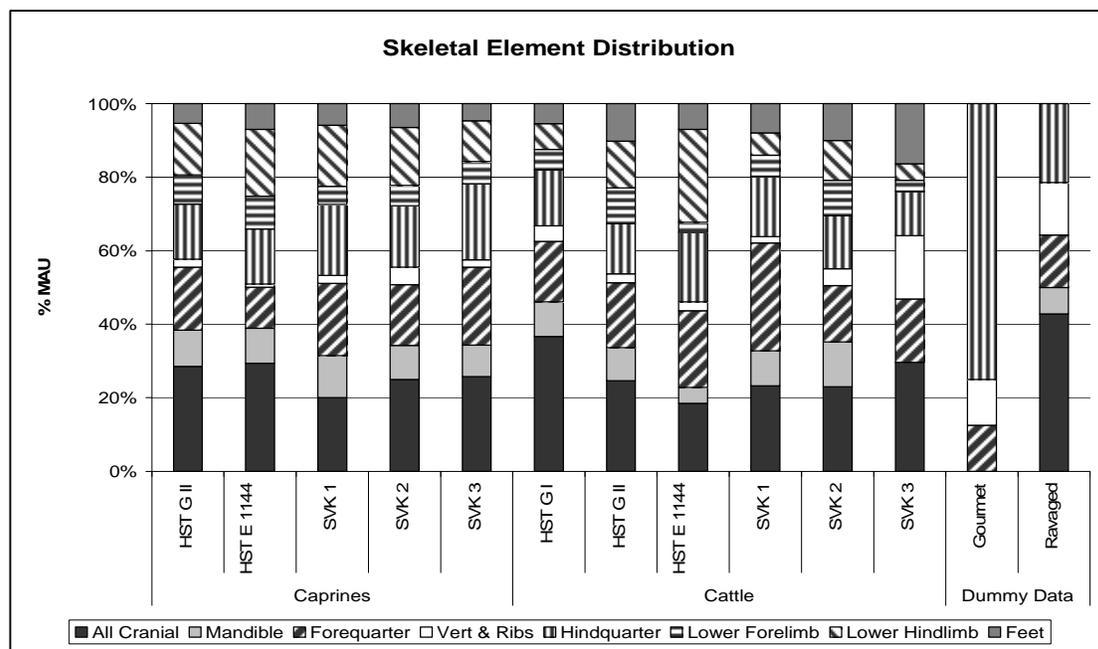
Figure zzz 9

Trampling by humans and domestic stock also results in bone destruction, and this may be another factor differentially affecting bone deposition in the two major midden areas. Area E [1144] context was directly outside what was probably a very active doorway connecting the skali with the latrine. The sheltered area provided by the wall extensions added to the NW doorway may have provided a comfortable area for outdoor work as well as for dog congregation, and it is probably accurate to reconstruct this area as a fairly high traffic zone. By contrast, the fill of the depression in area G remained un-compacted, and excavators regularly reported their feet sinking into the soft deposits during work in this midden area.

It would appear that there were major differences between the taphonomy of the two midden concentration areas in terms of trampling and traffic as well as dog activity during at least Phase II, and it seems likely that these factors of mechanical destruction have differentially removed fish bone, though they do not seem to have been intense enough to radically affect the proportions of mammal bones in the two middens.

Skeletal Element Distribution Patterns

Zooarchaeologists have long worked to identify and explain patterns in recovery of different bones of the skeleton from different sites and contexts. Sometimes, clear concentration of bone elements, and butchery marks in well defined contexts (usually in urban deposits) can allow an unambiguous identification of specialized butchery and craft waste disposal. (Dijkman & Ervynck 1988, Maltby 2006, O'Connor 2003, Rackham 1994, Alen & Ervynck 2005). More commonly, complex interactions of bone density and differential survival, over-lapping activity areas, and multiple phases of human use of animal carcasses for food and raw material produce patterns of skeletal element survival that are far more



difficult to interpret. Rural Icelandic site middens tend to receive bone from all stages of butchery and consumption, and as a result usually do not provide a clear “gourmet” (only high meat value elements) or “ravaged” (only very dense elements) pattern (Binford 1976). Figure zzzz_10 presents the generalized distribution of body parts for cattle and caprines at both the Hofstaðir midden areas and the three phases of the Sveigakot middens and provides idealized gourmet and ravaged distributions for reference, making use of the MAU % measure to normalize for skeletal element frequency (Lyman 2007). While there is some variability between sites and phases, overall proportions suggest similar patterns of home butchery and midden formation processes; there is no clear signature for specialized deposition of craft debris or isolated primary butchery waste.

Butchery Marks are present on many bone fragments and are recorded as part of the NABONE package. Figure zzz 11 presents the percentage of bone fragments showing butchery marks by area at Hofstaðir (mammal bone only).

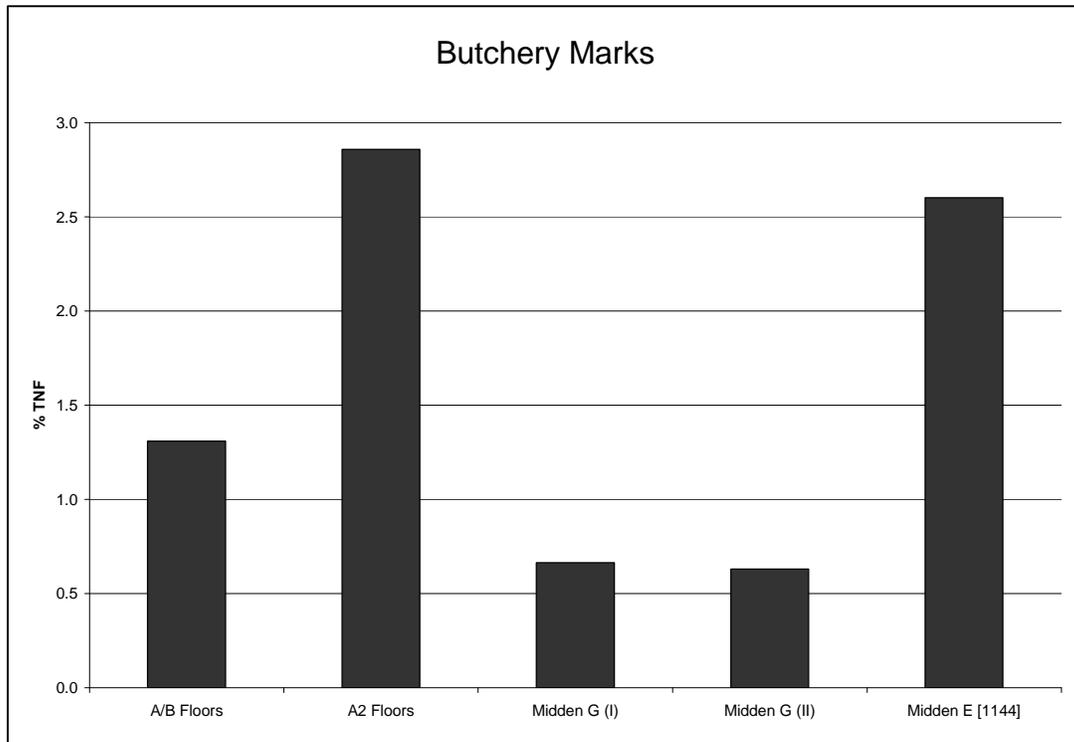


Figure 11

The greatest concentration of butchery marks on the larger floor layer contexts is in room A2, which may be consistent with some role in food preparation and storage. There is also an apparent difference in the proportion of butchery marks present in the area G and area E midden deposits.

Different types of butchery activities tend to leave different marks on bone fragments. In the NABONE package standard, “chopping” marks are heavy blows from an axe or heavy cleaver which definitely were delivered with full force, causing shearing and crushing impact on compact bone surfaces. These tend to be associated with dismemberment of an animal carcass in initial butchery or the early stages of cooking where cooks are reducing a large piece of meat (like a haunch or forequarter) to something they plan to serve at table. Presumably full-force chopping was less common at the table, even in the Viking Age. “Knife marks” are slicing marks left by much more controlled cuts by lighter blades. These can accumulate at any stage in the process of reduction of a complete carcass to the consumption of an individual meal. “Splitting” is marrow extraction from long bones by splitting the bone lengthwise, and it leaves very distinctive fragments. In later Medieval times Icelanders and some of the other N Atlantic communities (but not Greenland) adopted the dual-perforated marrow extraction

method (biperforation) for sheep metapodial bones, but this seems to post-date 1100 (Bigelow 1985, McGovern 1985, Arge 1995, Harrison 2006). Biperforation of caprine metapodials did appear in the post-medieval contexts at Hofstaðir but not in the Viking Age contexts. Marrow extraction can come at any stage in the butchery process, but is probably most associated with kitchen/table activities. “Other” marks are varied and most relate to craft work (polish, drilling etc.). Figure 12 presents the relative abundance of these different butchery marks on the bones from the middens in area E and area G.

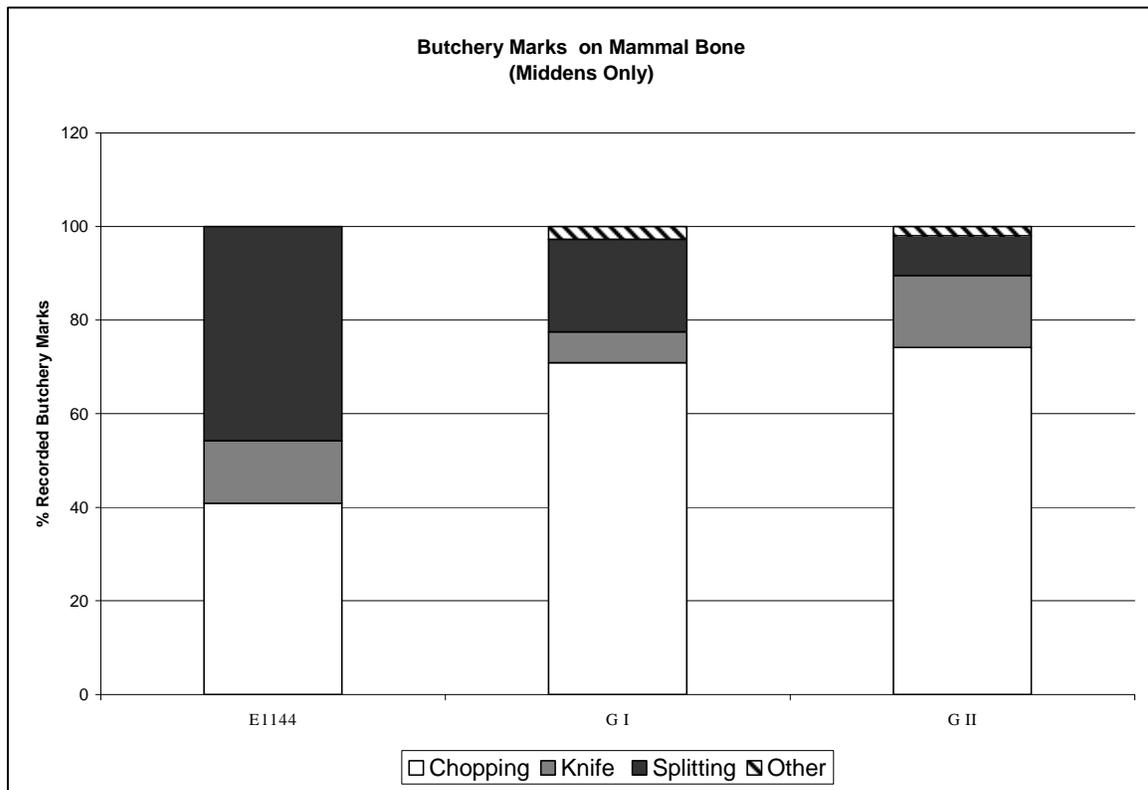


Figure 12

Not only do the bones in the E [1144] midden deposit have more butchery marks in total than the bones in the G sunken feature structure fill, but they have a different proportion of different types of marks. The area E bones have less heavy chopping, and lack the bits of bone craft waste found in G. They have much higher proportion of splitting marks, indicating fairly intensive marrow extraction somewhere nearby. It would appear that the area E midden has had a slightly different taphonomic history from the area G deposit even before the effects of dogs and trampling. It is possible that these differences in amount and nature of butchery marks may relate to different “refuse streams”. If the midden debris entering the pit at G received refuse from the whole farm and from a very wide range of activities (primary butchery, cooking, meal consumption, industrial and craft waste, fire place cleaning etc.), it may be that the sheet midden in area E may have received a slightly different refuse stream, perhaps more weighted towards meal preparation and consumption.

Discussion and Interpretation of Taphonomic Evidence

While any interpretation of taphonomic processes on any site must be tempered by the inherent limits of zooarchaeological indicators and recurring problems of equifinality (Maltby 1985), it may be possible to draw some broad conclusions that affect subsequent efforts to reasonably quantify the different portions of the Hofstaðir archaeofauna. Thanks to a very large scale (effectively total) open area excavation combined with consistent stratigraphic recording and recovery, zooarchaeologists at Hofstaðir have been provided with a far broader picture of deposition and attrition than is possible from the more usual trenches and isolated excavation units which often provide most of our basic material. There do appear to be regularities in the different pictures presented by analysis of bone identification percentages, fragmentation, burning, animal gnawing, skeletal element distribution, and butchery markings. Some seem to point to past human and animal behaviors, but others seem to reflect the differential impact of attritional forces (mainly dog gnawing and effects of trampling) upon parts of the archaeofauna (especially fish and shellfish) in different parts of the site. While large-medium sized mammal bones do not seem to have been profoundly affected, there seems little reason to doubt that the shortage of fish and shell fish fragments on floor layers and in the area E [1144] sheet midden relative to the fill of unit G is the direct result of differential destruction and probably not the product of any past economic pattern. In the presentation of data and discussion that follows, most comparisons of domestic mammal bone will thus make use of all phased bone deposits, but where comparisons of fish and shellfish are involved only the stratified deposits in area G will be used.

Overview of Species Present

Species Present: Table zzz 3 presents a list of the species and species groups identified in the Hofstaðir Viking Age archaeofauna and the identified fragment count (NISP) for each taxon. The human remains in the demolition layers are deciduous molars, and were presumably lost by living children. The full range of domestic mammals imported by the early settlers is present, including dog and cat and some mouse bones. The identified mice are all *Mus musculus*; apparently the Viking house mouse (also recovered from Greenland: Vebaek 1992), though *Apodemus sylvaticus* (also probably a Viking Age introduction, see Nicholson et al. 2005) is now the dominant mouse species in Mývatnssveit. Arctic fox bones are present in small numbers, as are seal bones. The single seal that could be identified to species level is the harbor or common seal (*Phoca vitulina*), widespread along the Icelandic coast and common in Skjalfandi bay to the north. The “small cetacean” bone identified could come from a porpoise (porpoise bone has been identified at the nearby site of Sveigakot) or any of the smaller toothed whales. Whale “species indeterminate” fragments may be the product of craft working rather than food preparation, as whalebone was a widely

employed raw material for many artifacts. The single whale fragment from Phase III is in fact a fragment of vertebra used as a chopping block.

Birds include a very small number of migratory waterfowl and some sea birds (all summer visitors to Iceland), but the great majority of birds in all phases are the non-migratory ptarmigan / grouse (*Lagopus mutus*) common on upland moors and easily taken with snares at all seasons. The many indeterminate bird bones could all easily be ptarmigan as well on size alone. Large concentrations of bird egg shell were recovered during excavation of the G midden fill, and these will be discussed separately (see also McGovern et al 2006).

Fish include both freshwater trout (*Salmo trutta*) and charr (*Salvelinus alpinus*) and a few Atlantic salmon (*Salmo salar*) bones. Surprisingly, the Hofstaðir archaeofauna (like all other Mývatn collections) also contains a range of marine fish, mainly cod-family (Gadidae). In both groups, many fragments could be identified as salmonid or gadid but not to species level. The many unidentifiable fish fragments are also probably salmonid or gadid. Mollusca include many mussels (*Mytilus edulis*) of very small size (most one to two centimeters maximum length), many were burnt and most were recovered from ashy deposits also rich in wood charcoal. These are probably not the result of human meals, but of gathering sea weed with attached root balls cast up by storms along the coast. Clam shell fragments tend to come from larger individuals and are normally recovered in very battered and eroded condition. There was widespread use in Iceland of clam shells as scoops and spoons down to recent times, and these fragments are more likely to represent such artifacts rather than the remains of meals. Gastropods are represented entirely by the small freshwater snail *Radix peregra*, a species regularly appearing in the gut contents of trout (Gislason & Steingrímsson 2004), and again probably does not itself represent human food. A single arthropod barnacle fragment may have been brought to the site attached to driftwood or even a boat timber. All of the unidentified Mollusca are probably mussel or clam fragments too small to identify securely.

Table 3
Viking Age Archaeofauna Summary

	Phase I	Phase II	Phases I-II	Phase III
Domestic Mammals				
Human (<i>Homo sapiens</i>)				2
Cattle (<i>Bos taurus</i> dom.)	646	1,163	29	276
Pig (<i>Sus scrofa</i> dom.)	86	199	1	13
Horse (<i>Equus caballus</i> dom.)	12	42		19
Goat (<i>Capra hircus</i> dom.)	36	58		6
Sheep (<i>Ovis aries</i> dom.)	274	282	2	62

Caprine sp.	1,820	3,083	83	716
Dog (<i>Canis familiaris</i> dom.)				2
Cat (<i>Felis dom.</i>)				13
Wild Mammals				
Arctic fox (<i>Alopex lagopus</i>)	1	5		
Mouse (<i>Mus musculus</i>)		1	12	
Seal species		11		
Common Seal (<i>Phoca vitulina</i>)	1			
Small cetacean	1			
Whale species	2	6		1
Birds				
Mallard (<i>Anas platyr.</i>)		5		
Scaup (<i>Aythya</i> sp.)	1	1		1
Swan (<i>Cygnus</i> sp.)	1			
Common scoter (<i>Melanitta nigra</i>)				1
Goldeneye (<i>Bucephala clangula</i>)				1
Duck sp. (<i>Anatinidae</i> sp.)		1		
Ptarmigan (<i>Lagopus mutus</i> L.)	20	132	2	3
Gull species (<i>Larus</i> sp.)		6		
Eider duck (<i>Somateria mol.</i>)		2		
Shag or cormorant (<i>Phalacr.</i> sp.)		2		
Razorbill (<i>Alca torda</i>)	1			
Guillemot or Murre (<i>Uria</i> sp.)	6	4		1
Little auk (<i>Alle alle</i>)		3		
Bird species indeterminate	50	118	3	4
Fish				
Charr (<i>Salvelinus alpinus</i>)	717	1,467		26
Trout (<i>Salmo trutta</i>)	3,586	4,259	1	101
Salmon (<i>Salmo salar</i>)		5		
Salmonid sp	2,084	3,585	1	91
Cod (<i>Gadus morhua</i>)	481	889		1
Haddock (<i>Melanogr. aeglef.</i>)	209	256		8
Saithe (<i>Pollachius virens</i>)	22	36		1
Ling (<i>Brosme brosme</i>)	3	5		
Gadid sp	1,108	1,572	1	18
Halibut (<i>Hippoglossus</i> sp.)		3		
Wolf fish (<i>Anarcho. lupus</i>)	2	1		
Flatfish sp. Indet.	2			
Fish species indeterminate	1,782	4,301	9	176
Mollusca, Arthropods & Gastropods				
Mussel (<i>Mytilus edulis</i>)	307	32		
Clam (<i>Mya</i> sp.)	30	18		

Mollusca sp. indet.	46	438		
Snail (<i>Radix peregra</i>)	34	1		
Barnacle (<i>Semibalanus balanoides</i>)			1	
total NISP	13,371	21,993	144	1,541
Large Terrestrial Mammal	727	1,366	30	259
Medium Terrestrial Mammal	3,172	4,934	128	816
Small Terrestrial Mammal	19	91		2
Unidentified Mammal Fragment	17,694	31,285	1008	4179
total TNF	34,983	59,669	1,310	6,797

While each major group will be discussed in more detail and placed in a comparative regional context below, it may be useful to first emphasize the strong continuities between phases shown by the Hofstaðir archaeofauna. Figure zz 13 presents a comparison of relative percentages of the major taxa in the two Viking Age phases.

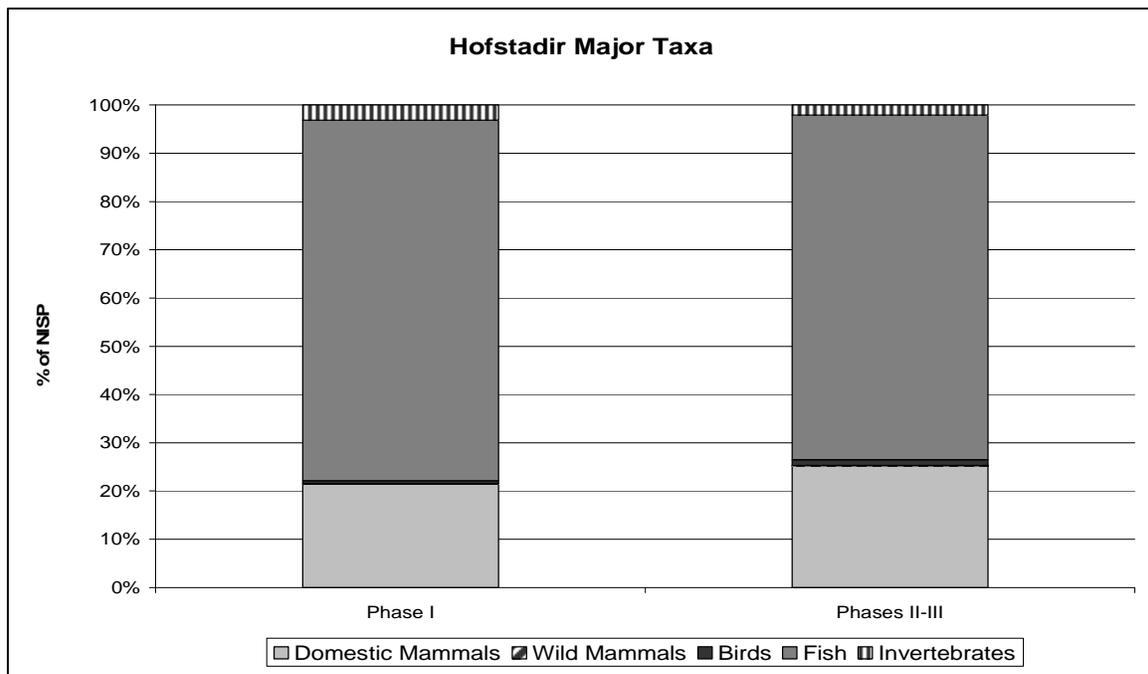


Figure 13

Figure zz 14 presents the domestic mammal relative percentages.

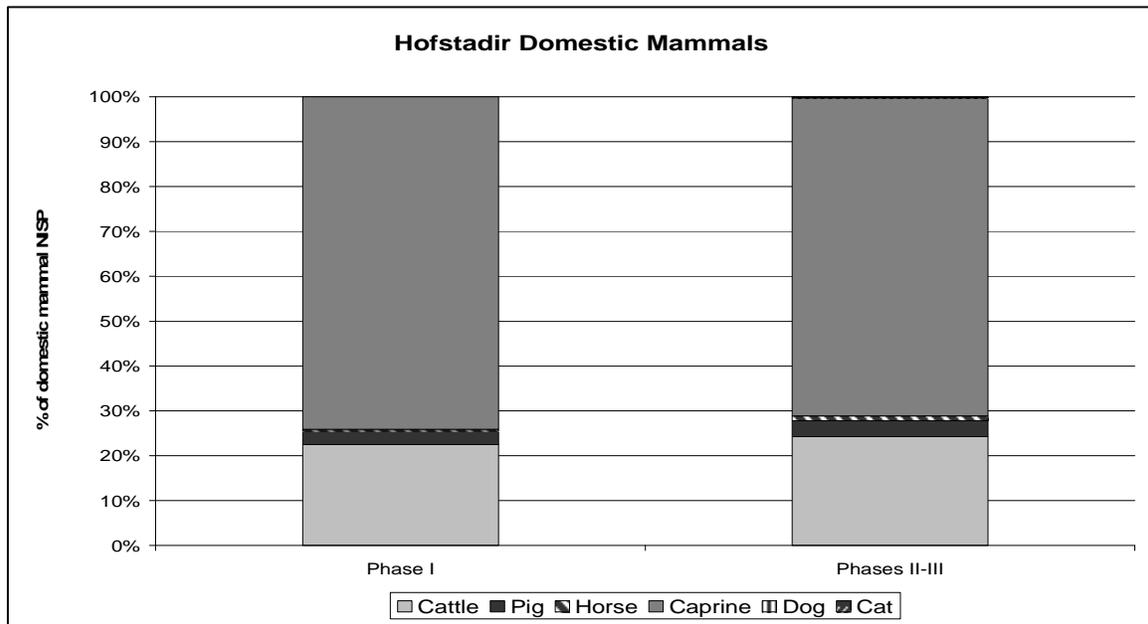


Figure 14

As these comparisons indicate, a major theme in this archaeofauna is stability through the relatively short period of occupation. There are no indications of a major change in economic strategy at Hofstaðir during the Viking Age, but there are some potentially significant differences between Hofstaðir and the neighboring farms in Mývatnssveit. It thus seems most productive to expand the presentation to compare patterning in the Hofstaðir collections with other sites.

Domestic Mammals

Cattle

Cattle were some of the most important animals in the Viking Age farmyard, and cattle keeping certainly reflected status not conferred by caprines alone:

One's own house is best, though small it may be;
 each man is master at home;
 though he have but two goats and a bark-thatched hut
 'tis better than craving a boon. (*Havamal* v 36, Olive Bray trans)

Cattle bone relative percentages show little change through time in the Hofstaðir archaeofauna, increasing from around 23% (Phase I) to around 25% of domesticates (Phase II-III). This pattern of stability contrasts with declining percentages of cattle bones relative to caprines at the nearby site of Sveigakot, where cattle bone relative percentages decline from a high around 35% in the earliest deposits (AU 1 ca. AD 875-930) to 20% in the 11th century (AU3).

Multiple taphonomic agents greatly reduce the number of measurable elements in most archaeofauna, but it is clear from what remains that the Hofstaðir cattle

were similar in size and conformation to other North Atlantic cattle of the Viking age- small in stature, large headed, short horned, and stocky (see digital archive for all measurements). As table zzz4 indicates, stature reconstruction based on the few intact metapodial bones from Hofstaðir and Sveigakot suggest a range in withers height from just below a meter to 120 cm, well within the observed stature range of other Viking Age-Medieval cattle (see Enghoff 2003 for review).

Table 4		Cattle Stature Reconstruction		
Hofstaðir	Bone	GL (mm)	Withers Ht (cm)	
Phase I	Metacarpus	169.50	104	
Phase III	Metatarsus	180.15	98	
Phase III	Metatarsus	196.57	107	
Sveigakot				
AU 2	Metacarpus	174.50	107	
AU 3	Metacarpus	164.90	101	
AU 3	Metacarpus	167.80	103	
AU 3	Metacarpus	168.20	103	
AU 3	Metacarpus	169.50	104	
AU 3	Metacarpus	172.50	106	
AU 3	Metacarpus	173.50	107	
AU 3	Metacarpus	178.70	110	
AU 3	Metacarpus	195.70	120	
AU 3	Metatarsus	197.90	108	
AU 3	Metatarsus	201.80	110	

Some of the skulls recovered from the skali area are naturally polled (hornless), a trait found in low frequency in other North Atlantic Nordic cattle bone collections from both Iceland and Greenland. However, most cattle seem to have carried small forward curving horns, and severed horn cores showing cutting marks associated with horn working are common finds in all phases at Hofstaðir and in archaeofauna from the other Mývatnssveit sites.

Cattle in Viking age Iceland provided meat, milk, bone, horn, hide, and status. Long after the Viking age skali at Hofstaðir was abandoned, the 13th century law code *Grágás* provided a clear definition of a “legal” cow meeting the standards set for payments and compensations reckoned in animal values; “*Also of standard value is a cow three winters old or older, ten winters old or younger, capable of bearing calves, in milk, horned and free from defects, no worse than the average beast, fit enough to be driven from one district to another at the moving days and giving enough for a calf at milking.*” (*Grágás* MS later 13th c, trans. Dennis, Foote, & Perkins vol. 2, 2000, p 208). Zooarchaeology provides another perspective on cattle keeping practices, and can provide some indirect evidence for past management strategies.

Cattle Age Reconstruction

Zooarchaeologists have traditionally used tooth eruption, tooth wear, and the fusion of the ends of long bones to reconstruct the age of death of domestic

mammals (Wilson, Grigson & Payne 1982, see also Hillson 1986, O'Connor 2000, Reitz and Wing 1999). Each approach is limited by natural variability among individual animals in the pace of growth and maturation. Nutrition, activity level, castration, parasitism, disease, and other cultural and environmental factors influence tooth and bone growth as much or more than genetics of the breed in many cases. Attritional loss of bone during the taphonomic changes associated with butchery, consumption, gnawing, burning and decay do not affect all parts of the skeleton equally, and in most cases there is strong selection against the less dense and less fully calcified bones of younger animals (Lyman 1994). While tooth eruption schedules for most domestic mammals vary within a fairly restricted range, tooth wear is dependent upon both age and the abrasiveness of the food eaten. As Mainland (2000) has demonstrated, wear rates increase rapidly when more abrasive grit and soil particles are ingested. Most workers have combined analyses of mandibular tooth eruption and wear with examination of the fusion percentages of selected (dense) long bones (O'Connor 1982; Ervynck 1997, 1998; Dobney et al 1999, 2007). This study follows the well supported and clear presentation of Enghoff's publication (2003) of the Greenlandic archaeofauna from the farm beneath the sand (GUS) in age assignment, terminology, and authorities consulted.

Neonatal Cattle Elements: The bones of new born or very young animals are recognizable by their size and surface texture as well as by their unfused epiphyses. It is usually possible to identify such very young individuals on most bone elements, and thus the neonatal percentage provides a fairly robust age partition based on the largest possible number of fragments, and is not dependent upon the survival of tooth rows or intact long bones. Late foetal elements (longitudinally unfused metapodials etc.) are also often identifiable, but are combined here with the more generalized "neonatal" category. Figure ZZZ_14 presents a comparison of the % of cattle neonatal bones from phases I and II-III at Hofstaðir with a series of other Icelandic sites.

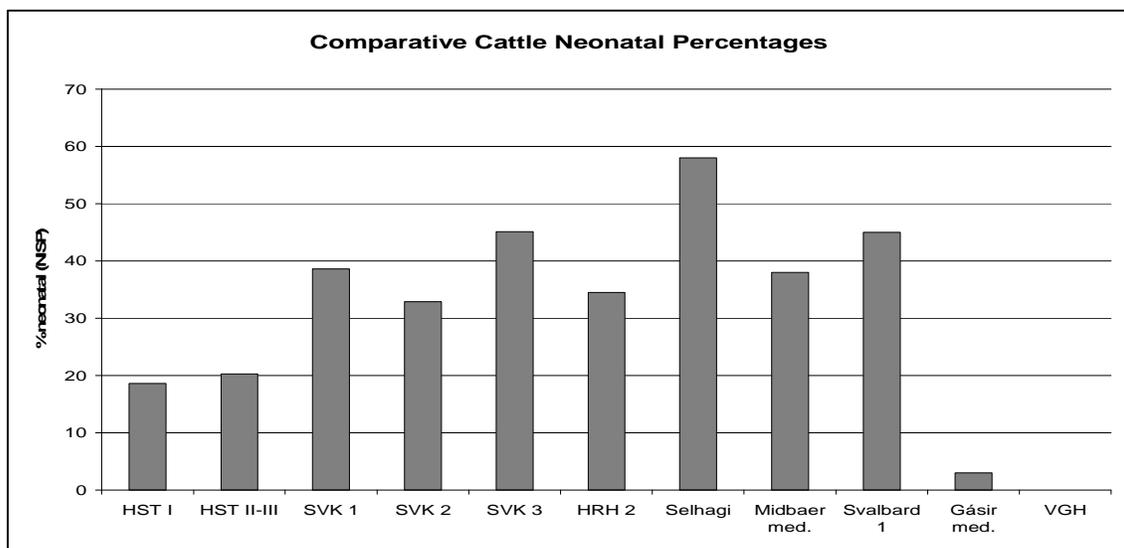
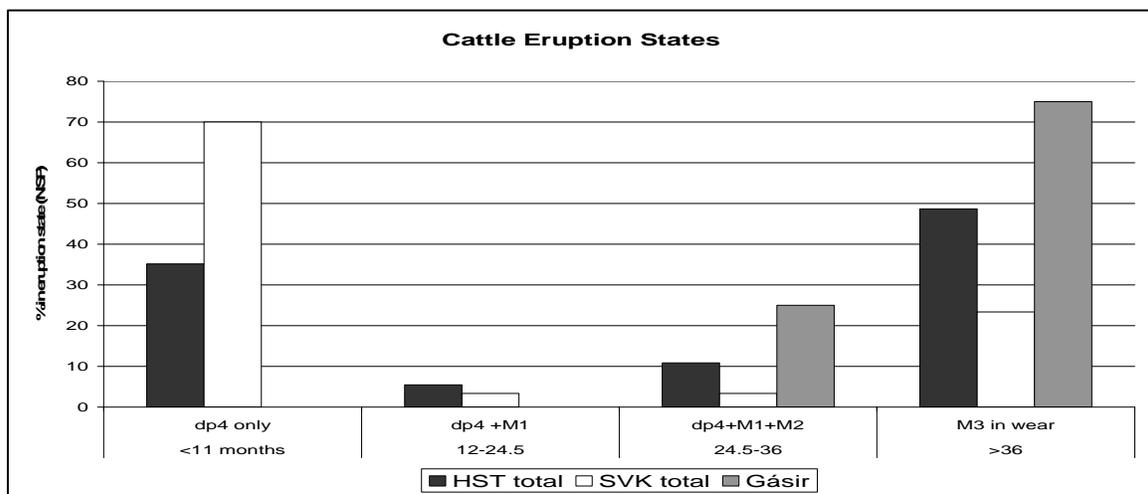


Figure 14

The other Mývatnssveit sites (Sveigakot SVK, Hrísheimar HRH, Selhagi), the 12th century levels at Svalbarð in NE Iceland, and the medieval levels at the site of Miðbær on the island of Flatey in Breiðafjörð all show the typical Icelandic pattern of 30% - 50 % cattle neonatal bone fragments. This widespread pattern is most plausibly associated with a dairy economy operating under typical N Atlantic conditions in which surplus calves are killed very shortly after birth to maximize milk off take for humans, and where pasture resources are allocated to maintaining the health and productivity of the adult cows in the dairy herd (plus a limited number of younger replacement cows). In a context of limited pasture availability, it is far more efficient to maximize dairy production rather than raise young cattle to a larger size, closer to the top of their sigmoid growth curve (Halstead 1998, Mulville et al 2005). Even with 'unimproved' pre-modern dairy cattle, the energy gain for dairy production vs. meat production is on the order of four to one (Legge 2005:12). This pattern of substantial neonatal cattle mortality is also present in Greenland and in Norse and Iron Age archaeofauna from the Northern and Western Isles and seems to be a zooarchaeological signature of North Atlantic dairying (McGovern 1985, McGovern et al 1996, Bigelow 1984, Mulville, Bond & Craig 2005). The exceptions to this widespread pattern in figure zzz 14 may all be economically significant. The outlaw cave deposit at Vigishellir (VGH) in the SW is the product of a band of outlaws raiding nearby farms rather than an actual farming settlement (Olafsson et al. 2006). The site of Gásir was also not a farm, but a medieval seasonal trading settlement which was apparently provisioned with cattle and sheep from surrounding farms (Harrison 2005, 2006, 2007). The Gásir site was consuming substantial amounts of beef from young adult animals, most just reaching the top of their growth curve (around 2.5-3.5 years old). The Gásir traders seem to have been able to afford such specially raised beef cattle, and were not simply consuming the aged, worn out milk cattle that would have been the natural meat off take from the normal dairy economy (Harrison 2006). The Hofstaðir neonatal cattle percentages in both Phases I and II-III thus seem to fall between the extremes of Gásir and Vigishellir on one side and the "normal farm" pattern reflected in the other Icelandic sites.

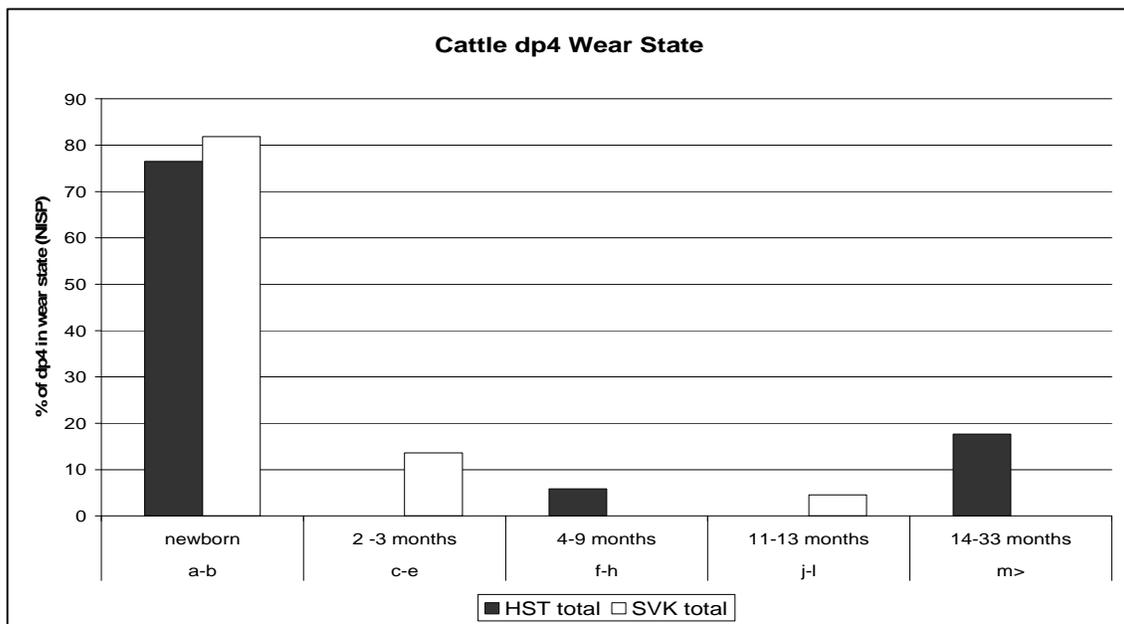
Cattle Tooth eruption schedules vary somewhat among different breeds and



among individuals with different nutritional status, but the sequence and timing of mammalian tooth eruption is probably less affected by local environmental variables than is rate of tooth wear or the precise date of fusion of long bones (Hillson 1986). Tooth eruption stage thus provides a useful guide to mortality patterns from birth to early adulthood in most mammals. Figure zz15 presents the eruption patterns for cattle mandibles and maxillae for cattle from Hofstaðir, Sveigakot, and the Gásir trading site. Lacking any very young animals at all, the Gásir eruption pattern shows a collection dominated by adults over three years old or near adults between two and three years old. The Sveigakot sample shows a substantial number of very young cattle, which parallels the high percentage of neonatal bone illustrated in figure zz 15.

The Sveigakot eruption pattern also suggests that only a few cattle who survived the strong cull in the first year were killed before reaching their full adult dentition (and size) around three years old (three winters old if calves were mainly born in May as in historic times). The Hofstaðir tooth eruption pattern suggests something between the Sveigakot and Gásir patterns. Very young animals were culled in their first year, but far fewer than at Sveigakot. Some Hofstaðir calves were culled close to the top of their growth curve, more than at Sveigakot but less than at Gásir. A substantial proportion of the Hofstaðir cattle seem to have reached adulthood: again more than Sveigakot but less than at Gásir. The patterning in eruption state of the available cattle tooth rows thus supports the pattern indicated by the neonatal calf percentages. Hofstaðir seems to have raised more cattle to adulthood, and slaughtered a lower percentage of very young calves than its contemporary Mývatnssveit sites.

Tooth wear also provides an indication of age at death, but as studies by Mainland (2000 et seq.) have demonstrated, tooth wear is heavily affected by the amount of grit in the animals' diet. While tooth eruption patterns may be largely genetically controlled, tooth wear is at best an indirect proxy for an animal's age. With this caution in mind, tooth wear can be used to provide a potentially useful



view of age structure beyond the limits of the eruption schedule. This analysis follows Enghoff (2003) in making use of the widely applied Grant (1982) tooth wear scoring system, and follows Enghoff's well supported age correlation estimates.

Figure 16

Figure zzz_16 presents the wear states of the deciduous premolar (dp4) to attempt to refine estimates of calf mortality patterns within the first three years of life. At both Hofstaðir and Sveigakot, calf mortality was concentrated in the newborns, with few animals surviving their first month. At Hofstaðir (but not at Sveigakot) some calves seem to have been culled closer to their full adult size, as would be suggested by the cattle tooth eruption data presented in figure zzzz_15 above.

Mandibular Wear State (MWS) is calculated under the Grant system by scoring each molar for wear (on a scale from 0 to over 50) and then adding the individual tooth wear states together. Grant's (1982) system allows a consistent and replicable wear assessment, and despite critiques it remains one of the most widely used approaches to age assessment in zooarchaeology (Ervynck 1997, 1998). Assignment of age to wear state is far more difficult (especially where tooth wear rates may vary) so age labels should be taken as approximations only (assignment follows Enghoff 2003). Since only complete mandibular tooth rows can be used for the MWS approach, sample size is inevitably smaller than that behind the neonatal percentage or tooth eruption graphs. The Grant MWS analysis (figure 17) for the Hofstaðir and Sveigakot cattle confirms the overall impression of the eruption and dp4 wear analysis; more Sveigakot calves were dying very young, and there appears to be mortality in the younger adult Hofstaðir cattle which is not evident in the Sveigakot sample.

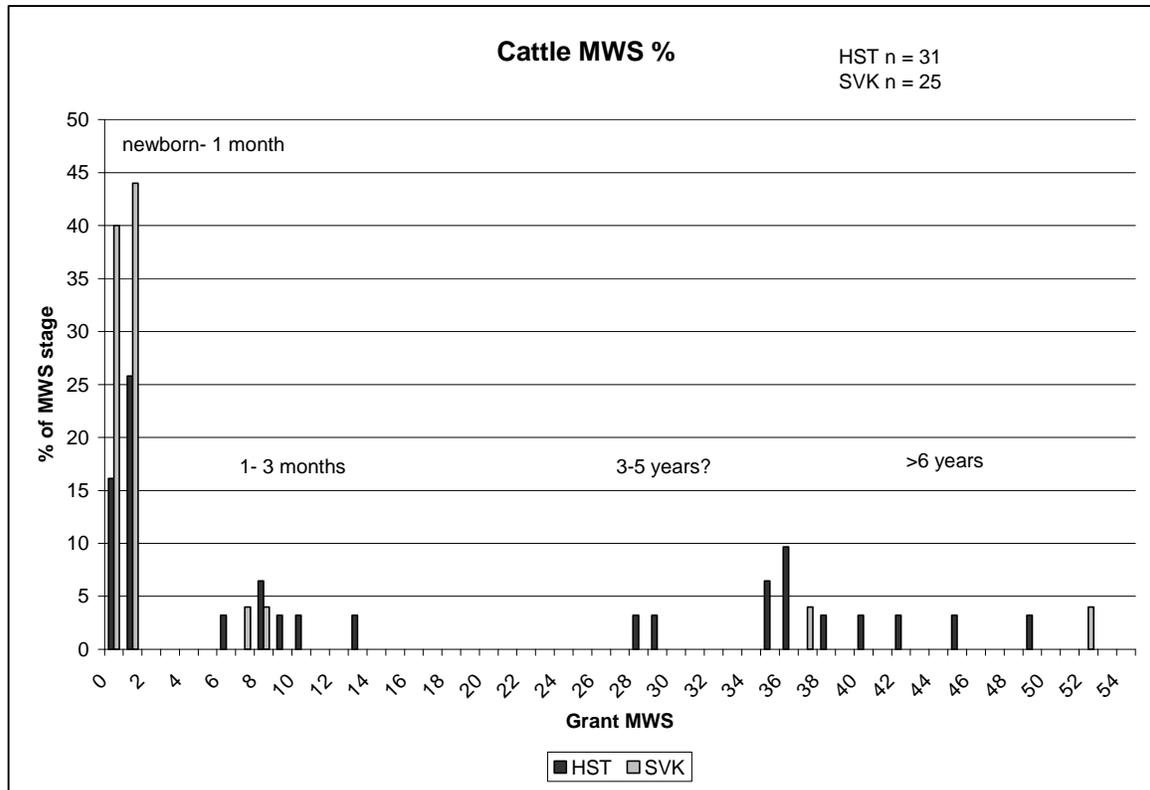


Figure 17

While both Sveigakot and Hofstaðir samples appear to include a number of elderly animals (note that the *Grágás* code apparently anticipated that productive dairy cows could reach 10 years), the smaller sample size of intact adult mandibles limits comparisons (unlike neonatal mandibles, adult cattle mandibles were regularly smashed during butchery). Figure zz18 provides a comparison of the mean wear on the last-erupting adult third molar (M3) in the Grant system in an attempt to crudely quantify the wear state/ inferred age of cattle reaching adulthood at Gásir, Hofstaðir, and Sveigakot. While there are many unresolved issues regarding grazing, rates of dental wear, and time period, the Hofstaðir third molar wear pattern is certainly closer to the Gásir pattern than the Sveigakot pattern. One potential explanation is that the Sveigakot cattle grazed rougher or more eroded pastures and experienced more rapid dental attrition as adults, as there is little question that Hofstaðir enjoyed both richer and far better protected grazing areas (Simpson et al. 2001, 2004). The neonatal percentages and the dental eruption data suggest alternate (or additional) explanation for this pattern. While most cattle at Sveigakot who reached adulthood seem to have gone on to enjoy a long life as milk cows (dying with heavily worn third molars), at Hofstaðir many others apparently did not live long enough past the eruption of their adult molars (around 3 years) to put heavy wear on these last-erupting adult teeth.

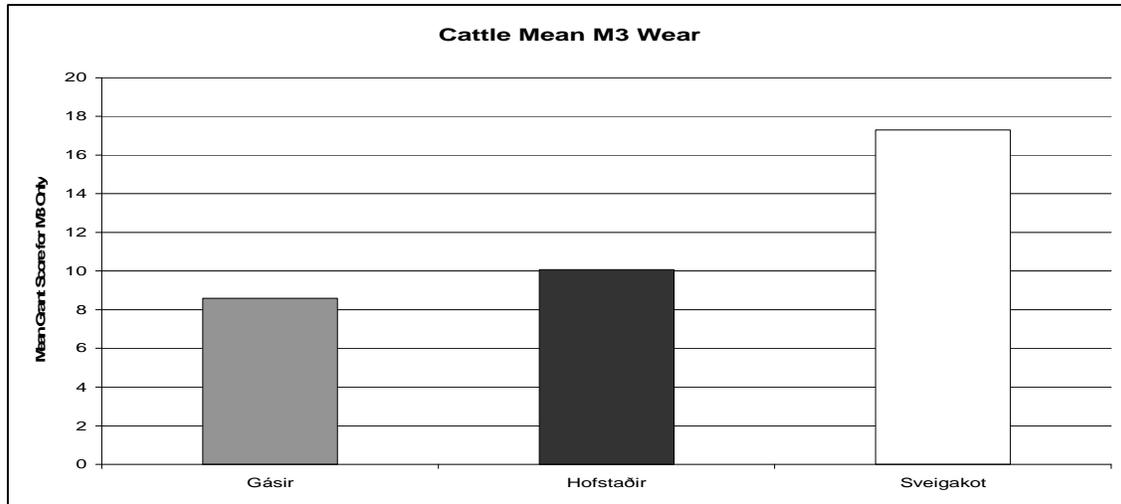


Figure 18

Cattle Long Bone Fusion

The use of fusion of long bones for age assessment is complicated by differential attrition due to different bone densities (proximal humeri are far less dense than distal humeri) and by butchery practices (such as widespread longitudinal splitting of metapodials). In this report four bone ends of roughly comparable density and survival rates which fuse at different ages (1-1.5 years for distal humerus to 3.5-4 years for distal radius) are used to give an indication of the proportion of cattle that lived long enough to reach a particular skeletal fusion state. Figure zzz 19 presents these data, comparing patterns of long bone fusion at Hofstaðir, and Sveigakot. At Hofstaðir, a substantial number of calves seem to have survived their first year, but fewer at Sveigakot. This pattern is again consistent with the proportions of neonatal bones at the three sites (figure zzz14), and with tooth wear patterns suggesting culling close to peak meat production age (ca. 2.5- 3 years). There were apparently substantial numbers of Hofstaðir cattle surviving their second year, and the fall off seems to occur around full adulthood. By contrast, there is only a gradual decline in survivorship at Sveigakot, probably because most culling had already taken place in the first year of life (prior to fusion of any distal humeri).

The long bone fusion data thus appear to broadly support the patterns of cattle neonatal percentages, tooth eruption, and tooth wear, and suggests that differential rates of tooth wear due to different pasture conditions may not be the whole explanation for this pattern in the cattle. Sveigakot fits a pattern that is usually interpreted as a “pure” dairying strategy, and would seem to reflect the culling of most calves soon after birth, a minor secondary cull of surplus or infertile heifers, and a surviving herd made up mainly of reliable milking cows, some of whom reached fairly old age (Halstead 1998). The Hofstaðir pattern seems more complex, with some clear indications of a dairy component (substantial newborn mortality, some aged adults) but with a superposed “meat profile” of young adult mortality. While substantial dairy production was taking place at Hofstaðir, there are definite indications that the farm was sometimes

consuming cattle at their growth peak and not always fully optimizing its herds for most efficient dairy production. While not a specialized “beef consumer site” like Gásir, Hofstaðir appears to have accepted the inherent biological and economic problems involved in regularly generating a limited number of prime beef age cattle for slaughter from a primarily dairy herd.

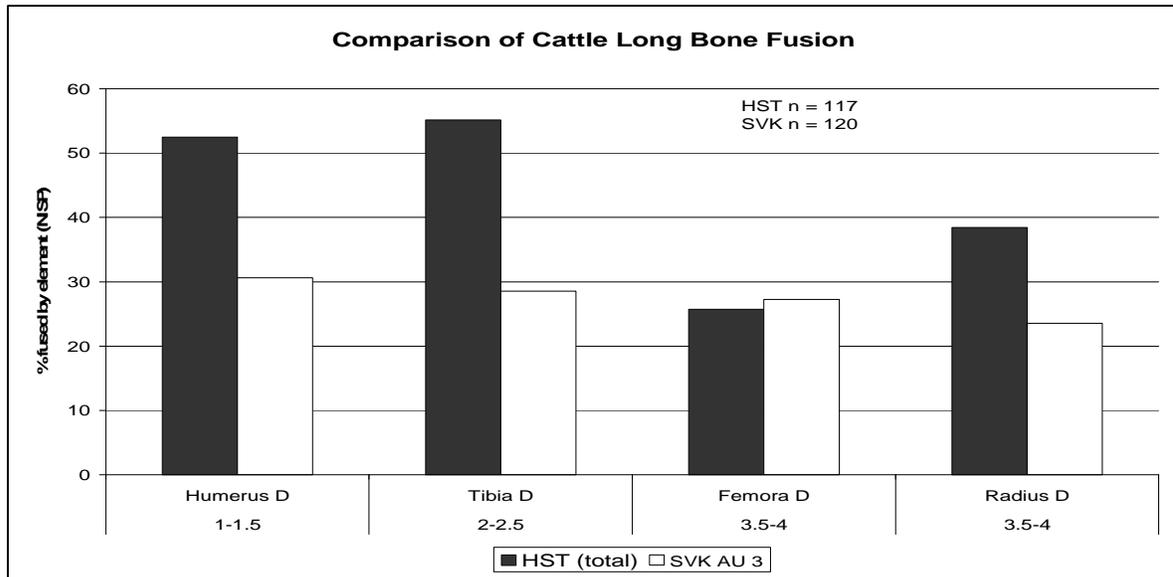


Figure 19

Sheep

Sheep provide a wider range of potential management options, providing wool, meat, milk, horn, and fleeces. The animal valuation section of the later *Grágás* law code may suggest some of the complexities of caprine management and valuation:

“ Six ewes, two of two winters and four older, able to feed their lambs, not losing their wool and with fleece and lambs, equal one cow. Eight ewes completely barren, of three winters or older, equal one cow. Eight two-winter old wethers equal one cow and so do eight yearling ewes able to feed their lambs. Six three winter wethers equal a cow. A four-winter wether and another of two winters is equal two ewes. A two-winter ram is worth one ewe. Twelve winter-old sheep equal one cow. All these animals are to be sound and with their fleeces. A ram of three winters and older and a bellwether (castrate “leader sheep”); their value is subject to assessment.” (Grágás p 208)

As Jón Haukur Ingimundarson has argued, it is usually uneconomic to attempt to extract all possible products from the same sheep, as fertile ewes kept lactating tend to produce less wool, and the best fleeces tend to come from castrated male wethers (Ingimundarson 1995). Icelandic farmers have traditionally maintained a dual flock system which separated the milking ewes and goats (who were close herded around shielings or *sel* fairly close to the home farm

during summer) from infertile ewes and castrate wethers who were driven into the highland common grazing area in spring and left to fend for themselves until an autumn communal gathering and division of the common flock. The flock which summered in the uplands without much human supervision was managed for wool and meat production rather than milk and in practice often depended upon the few older experienced sheep (“bellwethers”) to survive on their own in the highlands. Ewes’ fertility probably varied considerably in pre-modern times, which may be reflected in the very different valuation given to proven fertile ewes over two winters vs. unproven “winter old” sheep in *Grágás*. Wethers tended to produce heavier and better quality fleeces, and by the time of the early 18th century Jarðabók stock census the 18 occupied farms in the Mývatn district kept very substantial numbers of both milking ewes and wethers (table zzz 5). By 1712 sheep milk and meat supplemented by the remnant cattle dairy stock provided most household provisions, while wool production provided most farm income.

Table 5

Myvatnshreppur 1712

	%
Milking Cows	2.83
Calves	0.30
Winter old cow	0.13
Heifers	0.26
Young bulls	0.09
Milk ewes	41.23
lambs	21.35
winter old ewe	
weather/old weather	29.15
ram	
all goats	1.71
all horses	2.96
total stock	2,333

The reconstruction of herding strategy for sheep and goats in Viking Age Mývatnssveit thus provides the challenge of attempting to unravel multiple possible herding strategies, often carried on simultaneously.

Neonatal and late foetal bones of sheep and goats (combined here as caprines due to problems of species level identification in such young animals) are presented in figure z20.

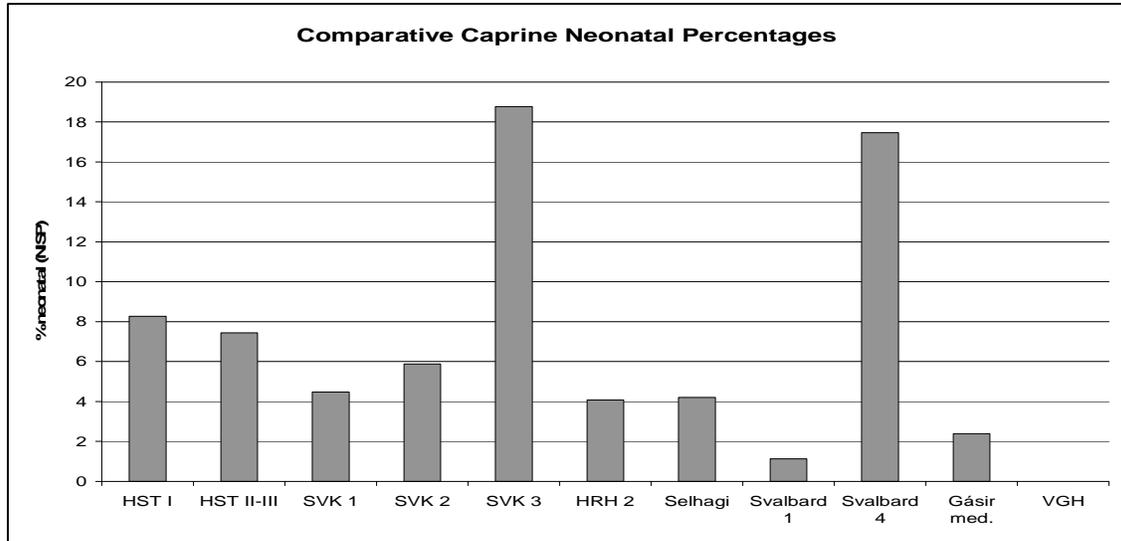


Figure 20

Caprine neonatal bones are normally much rarer in Icelandic collections than are cattle neonates. Newborn lambs can die from harsh weather during the lambing season, or they may be culled by farmers to optimize dairy production or to preserve the health of a ewe who may not be able to raise twins. Great effort was expended to insure that lambs were all born as close to the first week of May as possible to take advantage of first grass growth. Generally caprine neonatal percentages are well below 10 %, but two phases early modern Svalbard and the final phase at Sveigakot in figure zz20 are far higher. The increase in lamb mortality between Svalbard 1 (early medieval) and Svalbard 4 (ca 1636-1800) has been plausibly linked to the impact of drift ice incursions along the coastal lambing grounds of the Svalbard holding (Amorosi 1992). The comparably high percentage of neonatal lamb bones from the final phase at 12th century Sveigakot also seems to be associated with catastrophic adult mortality (multiple semi-articulated sheep carcasses were dumped among the lamb bones in the final midden layers) and may be an aspect of abandonment rather than part of the normal management of the flock. The earlier phases at both Svalbard and Sveigakot may provide a better picture of usual patterns of lamb mortality. The neonatal lamb mortality at Hofstaðir seems more modest, though it is on the upper end of the “normal” range for Mývatnssveit as we now understand it.

Sheep tooth eruption provides a useful measure of juvenile mortality, and these data are presented in figure z21 for Hofstaðir Phases I and II-III and Sveigakot. In contrast to the cattle mandibles, mortality in the first year was low, and significant culls of younger animals in their first and second years of life took place on both farms. The eruption data suggest that Hofstaðir in Phase I harvested more young sheep in the one-two winter old categories than was the practice in Phase II or at Sveigakot.

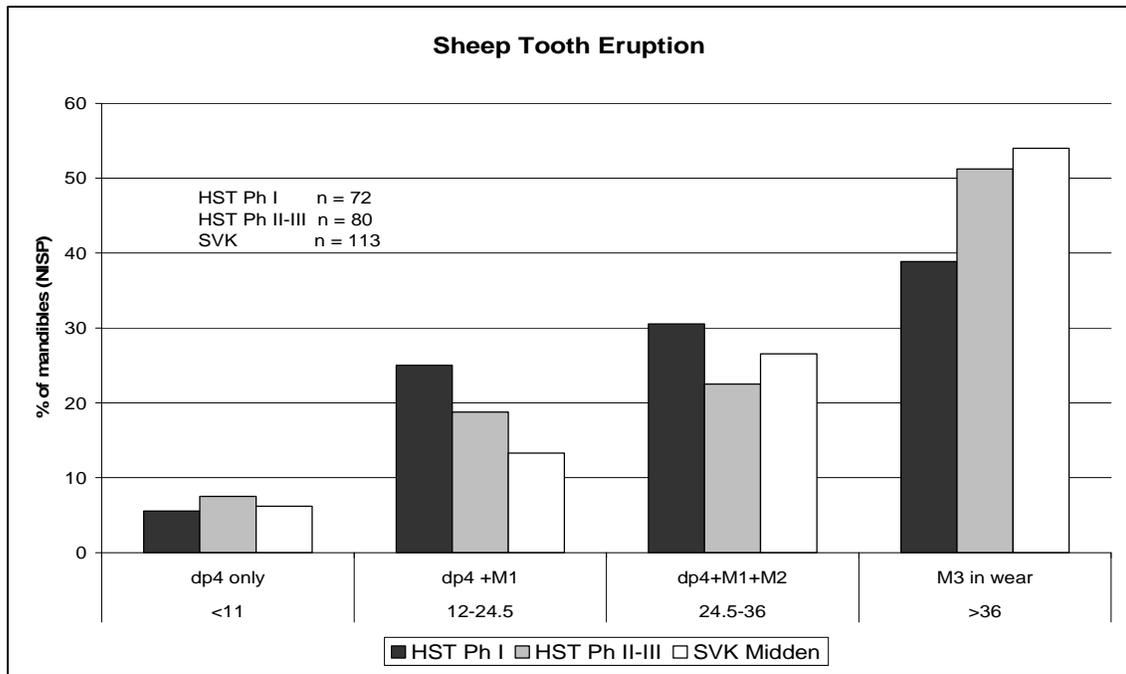


Figure 21

Tooth wear on dp4 again provides a useful measure of the patterns of mortality in young animals, but again requires the caveat that wear states and actual age of the animal may not track precisely.

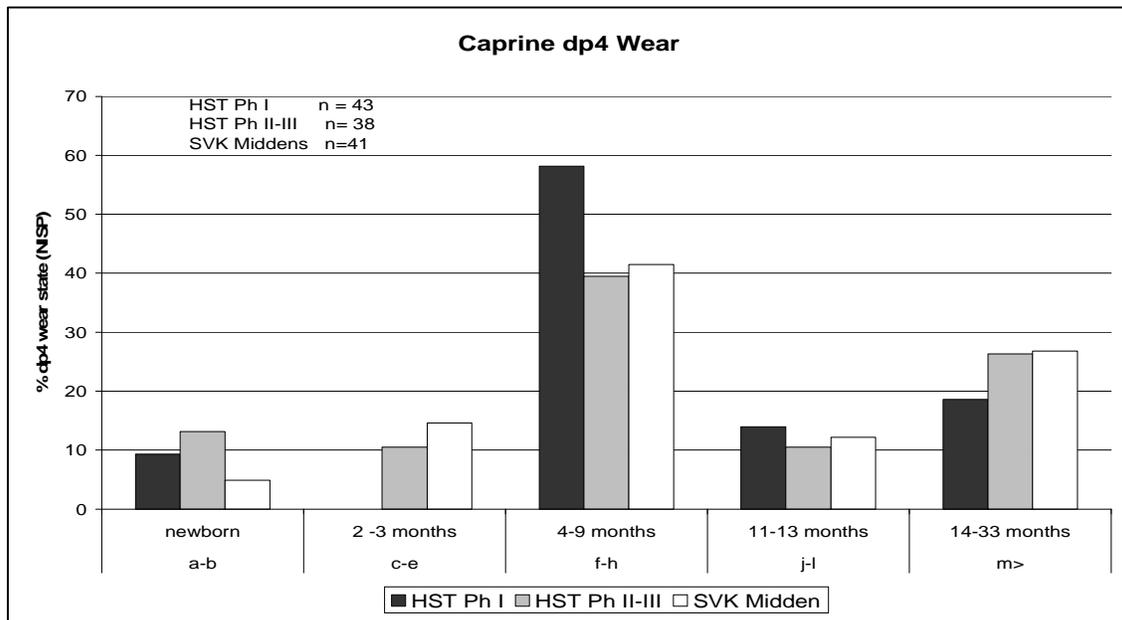


Figure 22

Figure 22 presents wear on the sheep deciduous premolars at Hofstaðir Phase I and Phases II-III and the Sveigakot total. All three collections show a peak in mortality in the 4-9 month range, which would correspond to a cull in late summer to early winter for lambs born that May. This probably reflects farmers adjusting their flock size and composition in autumn.

Mandibular Wear State (MWS) can be calculated for sheep (again following Grant 1982), and figure z23 presents the wear scores and inferred ages.

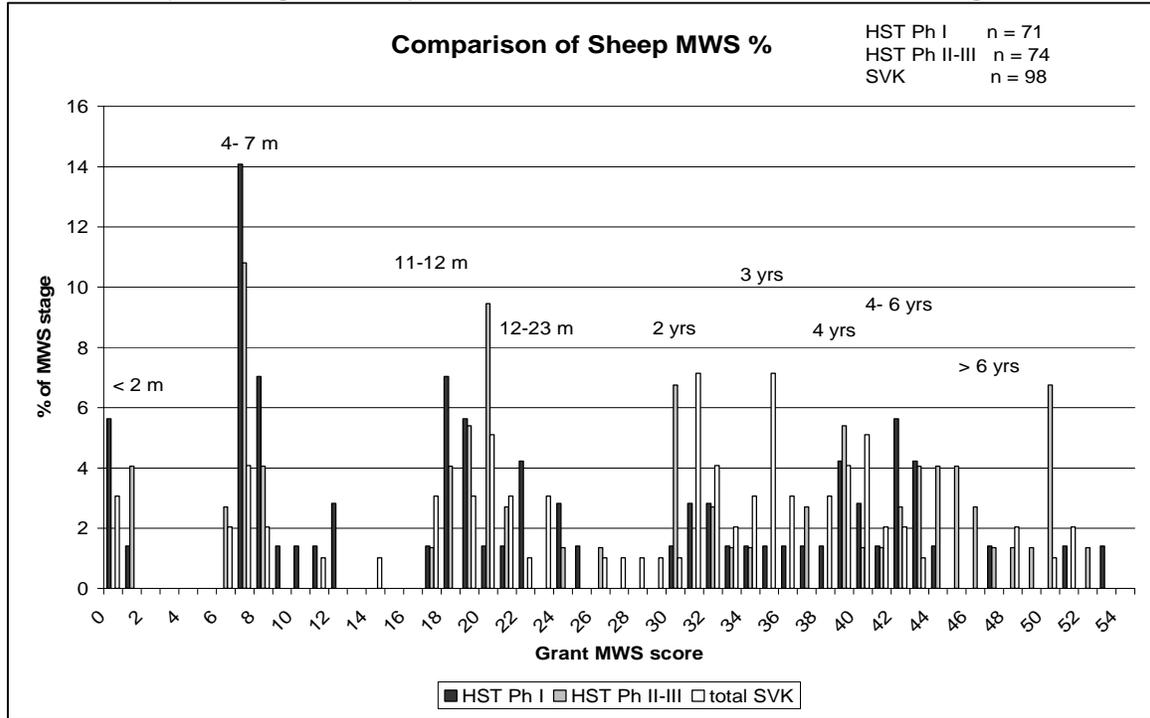


Figure 23

The Grant MWS analysis tends to support the general picture provided by the tooth eruption and dp4 wear evidence. Figure z24 presents an age aggregation of the sheep MWS stages for clarity (but note that this implicitly assumes close correlation of wear with age). The two phases at Hofstaðir and the Sveigakot sample show many similarities with a few animals dying very young, and more being culled at the end of their first summer. The next jump in mortality is in the second year of life, as “winter old” and “two winter old” sheep were culled for meat close to their full adult body size. Finally, a substantial proportion of the flocks seem to have lived well beyond four years, probably the upper age limit for milking ewes. As the later *Grágás* law code assumes, wethers or “completely barren” ewes might survive much longer as wool producers.

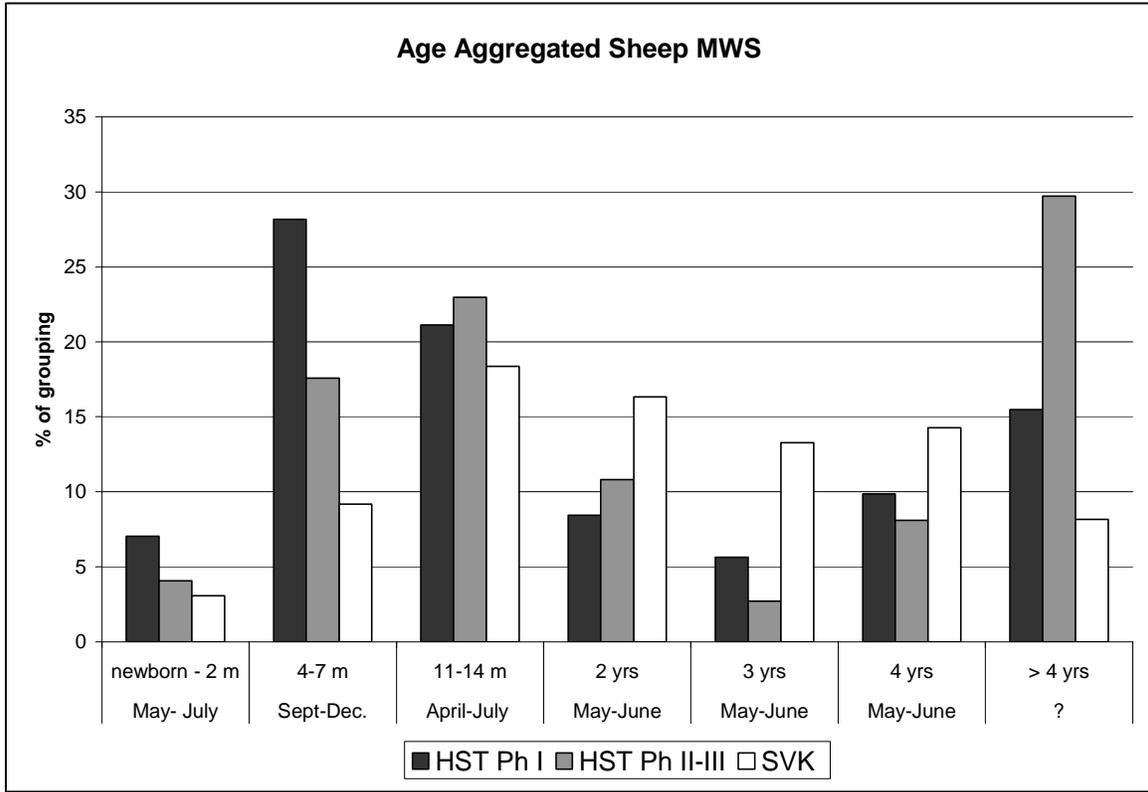


Figure 24

While there are overall similarities between these age profiles, there are also some apparent differences. Both phases at Hofstaðir seem to cull more heavily in the first year of life, and the Sveigakot profile suggests more regular culling of younger adults (2 to 4 year range). The apparently large proportion of older (wool producing?) individuals at Hofstaðir (especially in Phase II) suggests a more major commitment to wool production, but none of these mortality profiles is fully optimized for a clear wool production strategy.

Long Bone Fusion states in the sheep from Hofstaðir and Sveigakot may supplement the picture provided by neonatal bones and tooth eruption and wear. Figure z25 presents a comparison of the fused to unfused state of long bone ends selected for similar bone density and resistance to taphonomic forces. The patterning in these long bone elements broadly supports the other evidence; most animals are surviving their first six months, and a significant cull appears to have taken place by the second and third years. Some animals have survived past the four year mark, though again more at Hofstaðir than at Sveigakot.

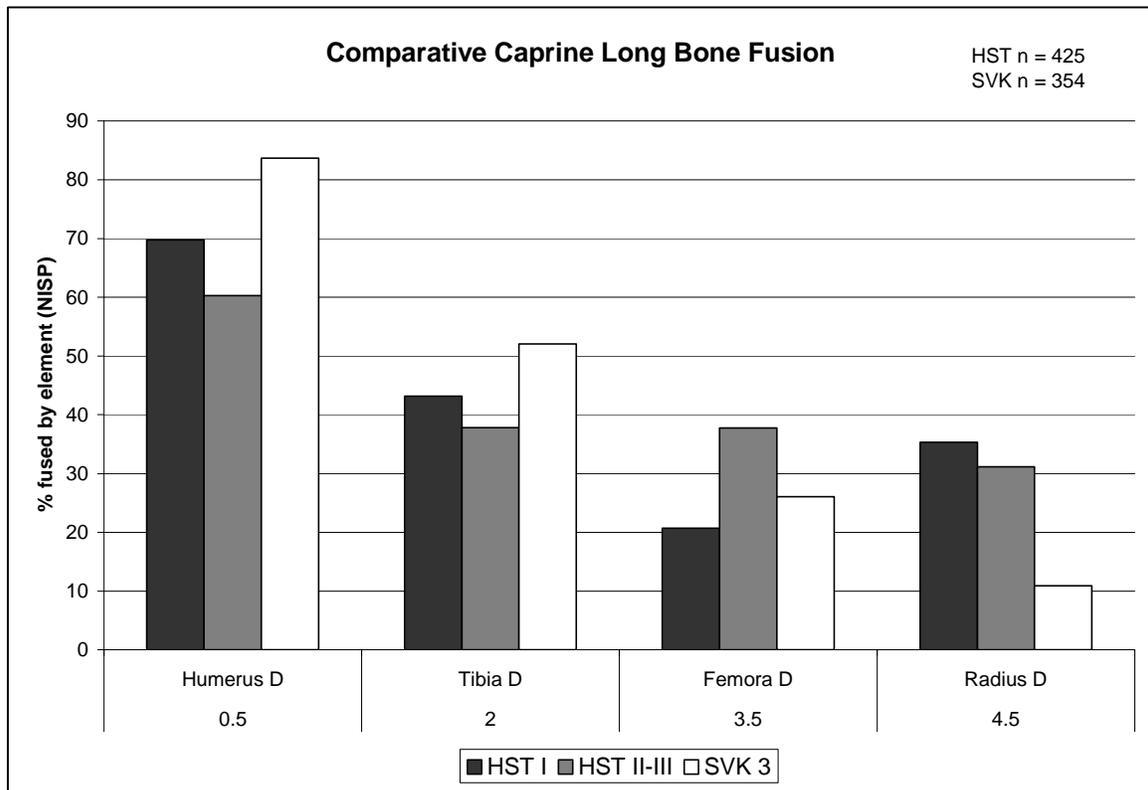


Figure 25

Sheep Stature Reconstruction

Several methods have been applied to the reconstruction of live weight and stature (withers height) from zooarchaeological specimens (see discussion in Wing & Reitz 2000, O'Connor 1989, Cussans, J. E., J. M. Bond & T. P. O'Connor 2007, Enghoff 2003). Following Teichart (1975) we can reconstruct withers height from a series of sheep radii and metapodials (table z6)

Table 6 Sheep Stature
Reconstruction Based on
Metapodials and Radius

Sheep withers ht (cm)	n	mean ht	range max	range min
SVK AU 3 (metatarsus)	28	63	70	57
SVK AU 3 (metacarpus)	24	60	70	56
SVK AU 3 (radius)	7	57	51	69
SVK AU 2 (metacarpus)	3	61	63	58
SVK AU 2 (radius)	1	55		
SVK AU 1 (metatarsus)	2	63	64	62
SVK AU 1 (metacarpus)	1	58		
HST Phase II-III (metatarsus)	21	60	69	54
HST Phase II-III (metacarpus)	12	61	68	57
HST Phase II-III (radius)	3	56	50	63
HST Phase I (metatarsus)	8	62	68	58
HST Phase I (metacarpus)	6	62	67	58
HST Phase I (radius)	6	60	46	71

Following O'Connor (1989) a reconstruction of live weight is possible based on the radius (table Z7).

Table 7 Radius
Reconstructions

sheep & caprine mean live wt (kg)	Mean Live wt (kg)	n	Mean Stature	n
Hofstaðir Phase II-III 11th c	35	9	56	3
Sveigakot AU 3 11th c	33	7	57	7
Hofstaðir Phase I c	38	7	60	6
Sveigakot AU 2 c	36	2	55	1

Both approaches produce reconstructed adult sheep standing from around 70 to 55 cm tall at the withers, and weighing between approximately 35-40 kg. Table z8 presents withers height and weight estimates for several modern N Atlantic sheep populations:

Table 8	<i>Icelandic</i>	<i>M</i>	<i>F</i>	<i>Faroese M</i>	<i>F</i>	<i>Greenl. M</i>	<i>F</i>
<i>Withers ht (cm)</i>	78	68	65	60	70	60	
<i>Weight in kg</i>	95	63	60	60	65	50	

(source: website of *European Assoc. for Animal Production and Breeding*, Dept of Animal Breeding & Genetics database, School of Vet. Med. Hannover Germany)

Our reconstructions thus seem a bit short and light by modern standards, though perhaps significantly the modern Greenlandic herds (derived almost entirely from Icelandic ancestors and occupying the least improved ranges) come closest to our reconstructed Viking age animals. It is likely that modern animals have had the benefits of enhanced feeding and modern management, and thus may represent “best of breed” characteristics. Data collected in 1913 from a flock of 60 ewes in S Iceland produced a mean live weight of 31.5 kg (minimum 27.5 kg) (Aðalsteinsson 1992, 2000). The Mývatnssveit sheep stature reconstructions also overlap with most of the range produced by Enghoff’s (2003) review of other N Atlantic medieval collections (ca 72-53 cm). Figure 26 graphs the distribution of the withers height reconstructions based upon both radius and metapodials for Hofstaðir and Sveigakot (as percentages grouped into 5 cm intervals). This analysis indicates that while the majority of the reconstructions fall into the range of modern Greenlandic and Icelandic ewes (ca 50-60 cm), a substantial proportion (around 12-15 %) are larger, falling into the size ranges of modern Greenlandic and Faroese males (65-75 cm). These animals are almost certainly mainly wethers, again suggesting the role of these animals in wool production on both farms.

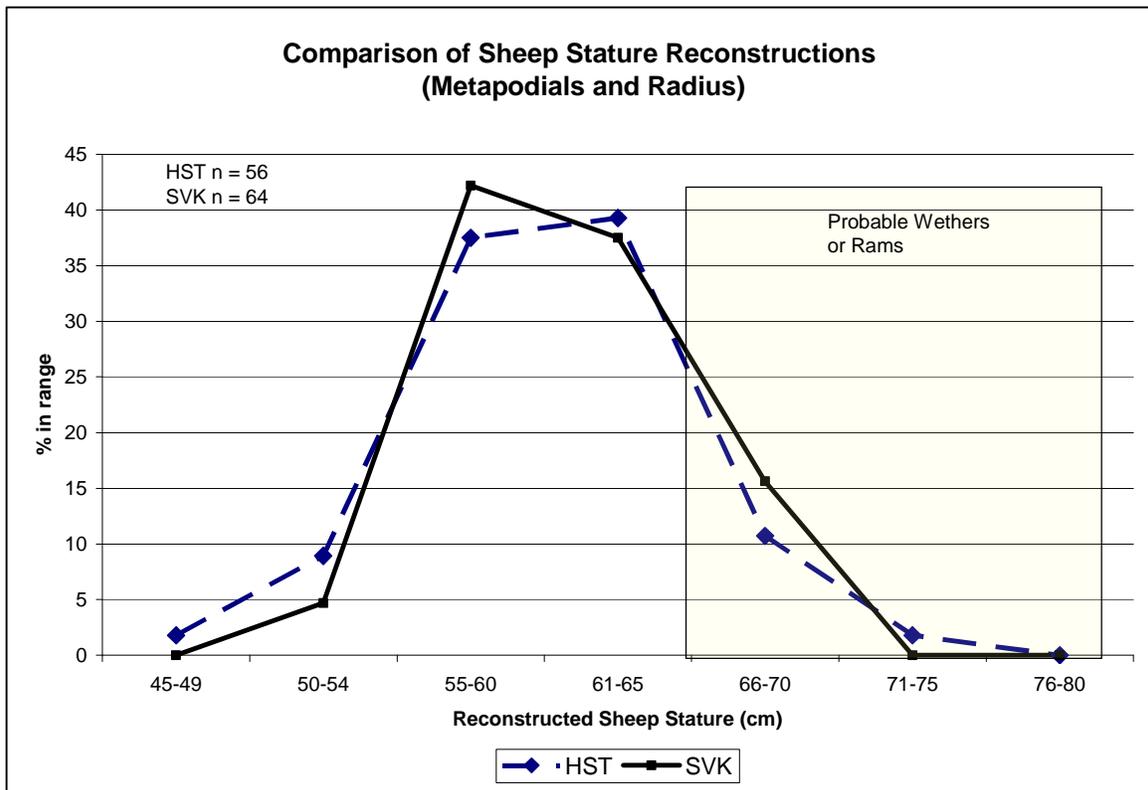


Figure 26

The reconstructions of age and size of the Hofstaðir and Sveigakot sheep population thus produce similar results. Both sites seem to have maintained a “dual flock” herding strategy, with some ewes being managed for milk, but with a

substantial portion of the flocks being managed for wool, and probably moved to highland grazing during the summer months

P4 Pathology and “Broken Mouth”

During analysis a marked pathology of the lower jaw was noted in sheep mandibles from Hofstaðir, Sveigakot, and Hrísheimar. This involved the loss of the permanent P4 premolar, often followed by serious abscessing, loss of additional teeth and very asymmetric wear. Figure z27 illustrates three typical examples from Hrísheimar. In every case, this pathology was seen only on sheep (not goats) and only on fully mature animals with extensive wear on the M3 adult third molar. On line consultation with Icelandic veterinary scientists at the Animal Production Inst. confirmed that this pathology (called “broken mouth” in English) is the result of soil and grit ingestion, and is associated with heavily eroded pastures today. Some (but not most) sheep in Viking Age Mývatnssveit were apparently ingesting enough grit to develop this marked pathology, but the individuals affected clearly often survived long enough to develop some extreme cases.



Figure z28 presents the frequency of the P4 Broken Mouth pathology in the

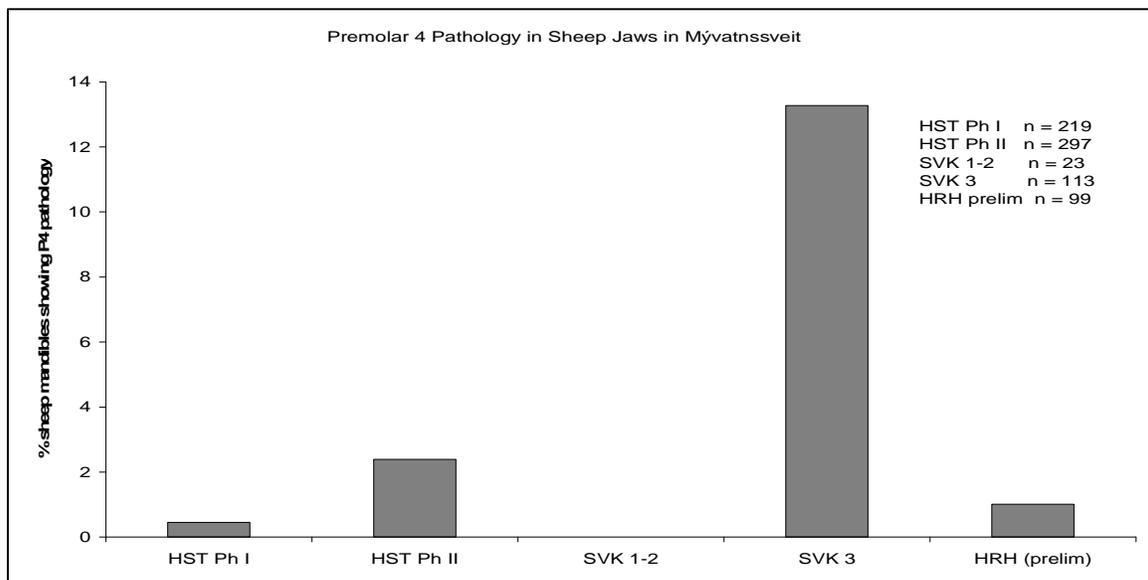


Figure 28 Sveigakot middens, Hofstaðir, and the currently processed collection from Hrísheimar. Note that the incidence of this pathology seems to increase

with time, especially dramatically at Sveigakot. Are the old sheep suffering from Broken Mouth more likely to be the senior weathers? If these animals were in fact experienced (and individually valued) leader sheep with multiple summer seasons in the (perhaps increasingly gritty) highlands this might explain the farmers' reluctance to slaughter them despite their advancing age and dental pathology.

Caprine Butchery Patterns As figure 10 illustrated, the element distribution pattern for caprines at Hofstaðir resembles the generalized Icelandic pattern of home butchery, with most parts of the body present in the midden deposits. Also typical of Nordic archaeofauna from Faroes, Iceland and Greenland is the distinctive longitudinally split sheep skull resulting from the preparation of a dish called *svíð* in Icelandic. The sheep head is split along the sagittal plane, and the skull halves roasted over an open fire. This preparation is clearly identifiable in all layers at Hofstaðir, and has also been identified in Viking-medieval deposits across the North Atlantic (in Greenland caribou heads were prepared the same way, McGovern 1985a, b; McGovern et al 1996). This traditional Icelandic dish thus can be shown to have definite Viking Age roots. As noted above the now-characteristic Icelandic method for extracting marrow from sheep and goat metapodials of the perforation of both ends of the long bone (bi-perforation) does not appear in the Viking Age Mývatnssveit collections. These bi-perforated metapodials have been identified in Late Norse Shetland and the Faroe Islands, and are common in Icelandic contexts dating after ca. 1100, but are unknown in Greenland (Bigelow 1984, Arge 1995). This practical and now widespread North Atlantic marrow extraction technique was thus not a part of the Viking Age butchery tradition, and was thus not spread to Greenland in the 11th century.

Goats

Domestic goats were a significant part of the original "Landnám mix" of domestic mammals spread across the North Atlantic during the settlement age. In both Iceland and Greenland, goats made up a variable but substantial portion of the caprine category at first settlement. In Greenland, goats remained a very important part of the domestic economy, nearly equaling sheep in some collections (Mainland and Halstead 2005). In Viking Age Mývatnssveit, sheep to goat ratios ranged from around three sheep per goat (Sveigakot 1) to 13 sheep per goat bone at Sveigakot 3 (Figure z 29). At Hofstaðir, goat bones actually increase slightly relative to sheep between Phase I and Phases II-III,

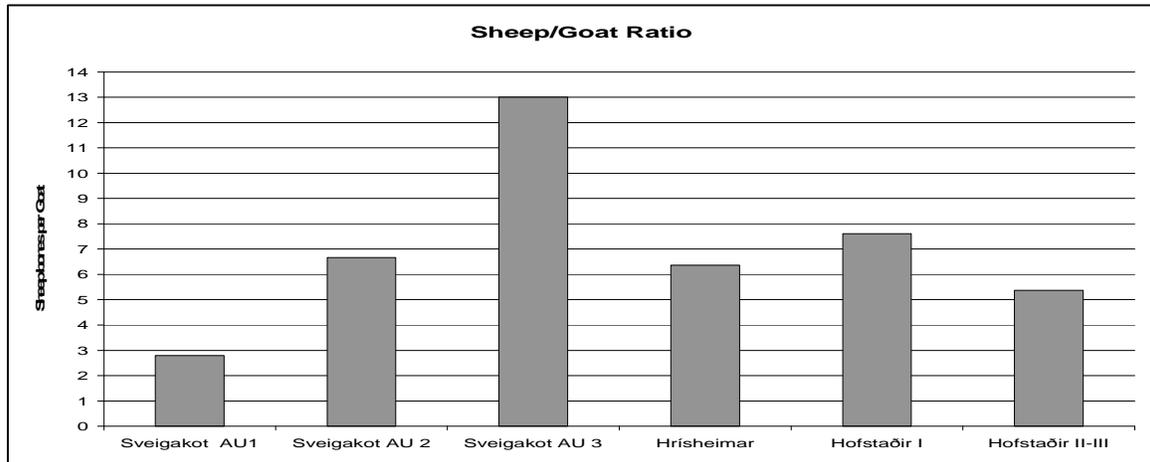


Figure 29 Taller bar indicates more sheep relative to goats

Again, Sveigakot and Hofstaðir seem to have been on somewhat different trajectories, with Hofstaðir maintaining and perhaps increasing its commitment to goat herding rather than increasingly concentrating upon sheep. The latter strategy would eventually win out in Mývatnssveit, with goats becoming very rare by the early 13th century. While goats did produce small amounts of high-quality mohair, they were normally managed in historic times entirely for meat and milk. Figure 30 presents the available tooth eruption for goat mandibles from Hofstaðir and Sveigakot. In both cases, there is a strong majority of jaws with fully adult dentition, but at Hofstaðir some animals were dying in their second or third year as well.

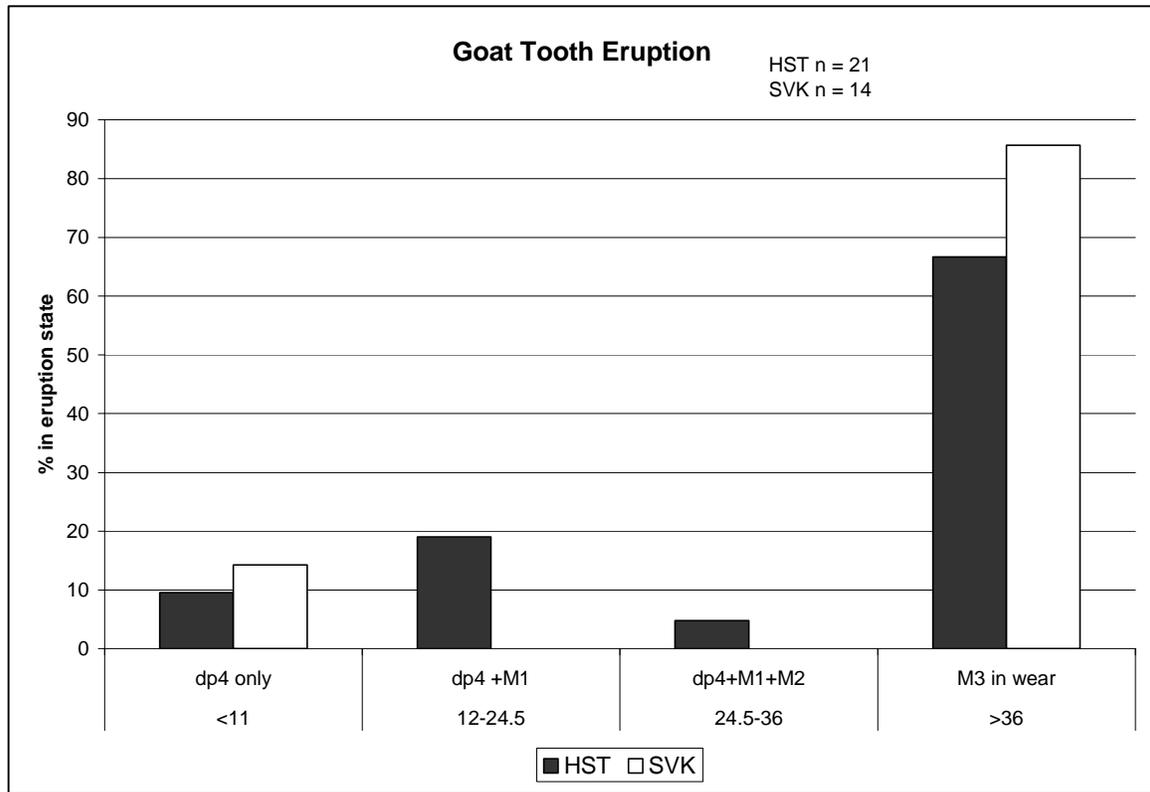


Figure 30

Figure 31 presents the Grant (1982) MWS distribution for the goat mandibles from Hofstaðir and Sveigakot. While sample size is modest, there are some patterns broadly consistent with the eruption data above. Again note that the Grant MWS analysis directly measures only tooth wear, and the age assignments are estimates. At both Hofstaðir and Sveigakot a few kids seem to die very young, and then the next peaks in mortality are at around two and around four years. Completely absent are the older animals with more advanced wear states seen among the sheep MWS. No goat jaws show the P4 'broken mouth' pathology. The major difference between the Hofstaðir and Sveigakot goat MWS profile is in the peak in 4-7 month mortality at Hofstaðir. This closely parallels the pattern in the sheep mandibles, and again indicates that the Hofstaðir flocks saw a regular and significant culling at the end of the first summer, a pattern not duplicated at Sveigakot.

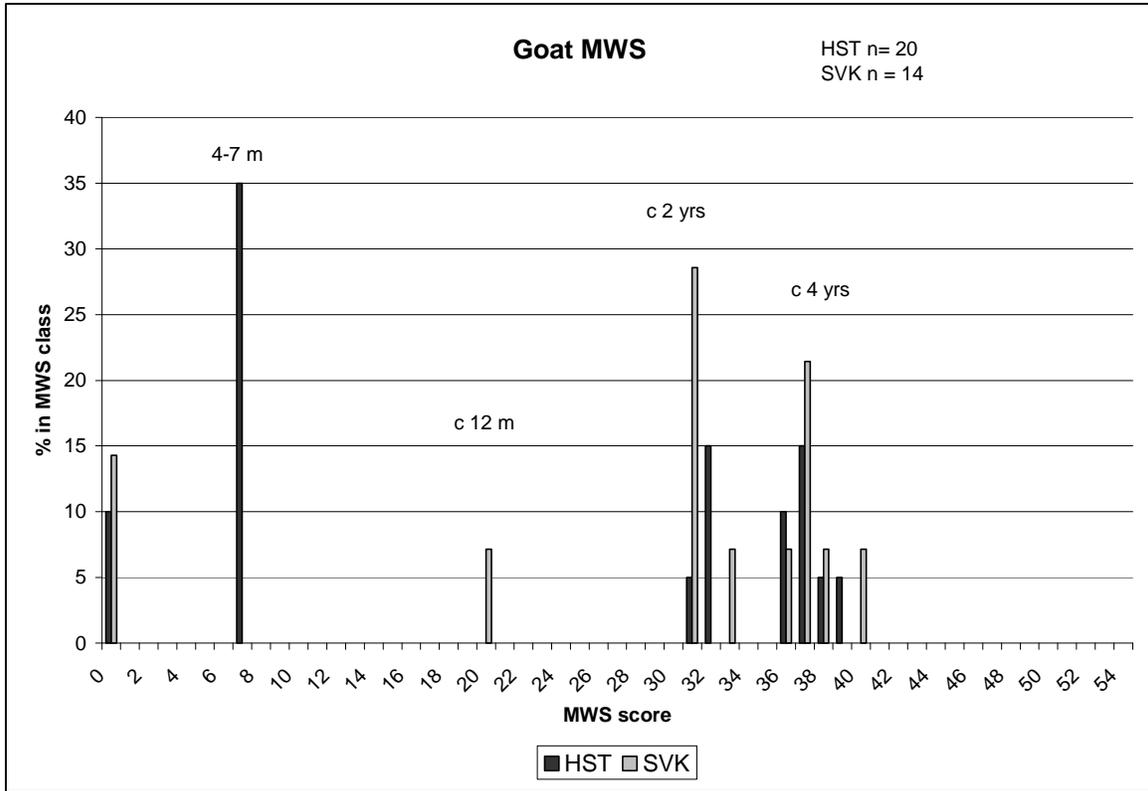


Figure 31

Goat live weight and stature reconstruction can be carried out based on radius and metapodial measurements (following O'Connor 1989; Teichart 1975), and the results of the small number of goat measurements for Hofstaðir, Hrísheimar, and Sveigakot are presented in table 9.

Table 9 Goat Stature and Live Weight Reconstruction

Site and Phase	element	Bd in mm	reconstructed		reconstructed withers ht (cm)
			Live wt (kg)	GL in mm	
Hofstaðir Phase I	radius	32.25	44	164.49	65
Hofstaðir Phase II	metatarsus	25.75		110.25	59
Hofstaðir Phase II	metacarpus	28.48		135.59	78
Sveigakot AU 2	radius	28.5	38	143.41	57
Sveigakot AU 2	radius	27.94	37		
Sveigakot AU 1	metatarsus	25.11		118.22	63
Hrísheimar (prelim)	metatarsus	24.45		112.07	60
Hrísheimar (prelim)	metacarpus	27.68		102.45	59
Hrísheimar (prelim)	metacarpus	27.61		104.89	60
Hrísheimar (prelim)	metacarpus	26.94		101.11	58

The reconstructed withers heights and live weights are again rather short and light by modern Icelandic breed standards, but are within the range of Greenlandic medieval specimens (Enghoff 2003).

The available evidence for goat husbandry in Viking Age Mývatnssveit is inevitably based upon a smaller sample size than for sheep. However, the existing data suggests that the goats were probably being managed largely for milk (many are adults, but few survive past peak milking years). As in the sheep culling profiles, there are some indications that the farmers at Hofstaðir were taking more young animals in late summer or early autumn of their first year, but overall the pattern seems to be aimed at dairy production as would be expected from modern practice.

Dental microwear in the Hofstaðir caprines

Ingrid Mainland, & Vicki Ewens

Introduction

Dental microwear analysis, the microscopic manifestation of tooth wear, is a well established palaeodietary technique within both palaeontology and archaeology (Teaford 1994, Rose and Ungar 1998, Mainland 2006, 2003, 2003a, 2003b). In the context of Norse North Atlantic studies, dental microwear analysis has recently been used to some effect in the elucidation of the management of grazing resources for sheep and goats in the Norse settlements of Greenland (Mainland 2006, 2001).

Analyses of diet-microwear patterning in modern caprines kept on diverse grazing ecosystems at differing stocking levels and in those fed various fodder types has enabled identification of microwear signatures associated with three broad dietary parameters: (1) 'high-abrasive grazing' (HAB) - grazing sheep/goats, kept at high stocking levels in which the level of soil ingestion (and hence non-dietary abrasives) is high; (2) 'low abrasive grazing' (LAB) - grazing sheep/goats, kept under low stocking densities in which soil ingestion is low; (3) 'soft diet' - a diet low in both indigenous and exogenous abrasives, typified in the modern populations examined by leafy-hay and milled cereals (Mainland 2006, 2003a, 2003b) (Fig. 1).

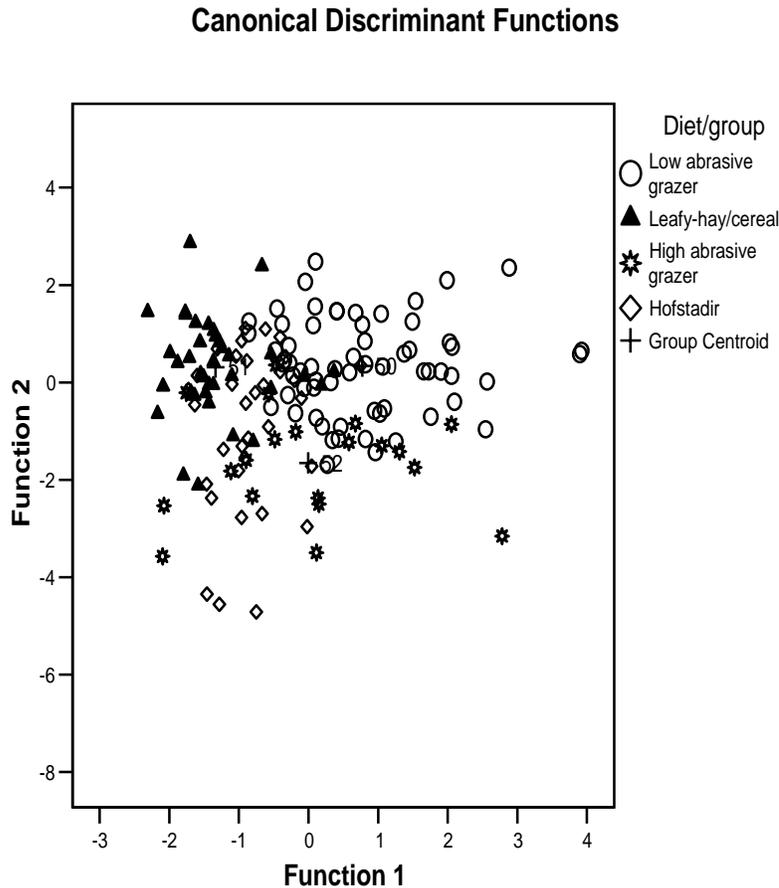


Figure 1. Stepwise discriminant analysis plot for known diet sheep/goat used in the classification of the juvenile archaeological mandibles from Hofstaðir. Function 1 separates fodder-fed ('soft-diet') from grazing individuals such that feature dimensions (length rounded pits, length narrow striations, breadth narrow striations) and pit length orientation decrease and the absolute frequency of defects increases towards the LHS of the diagram; function 2 separates the low abrasive grazers and the fodder-fed ('soft-diet') individuals from the high abrasive grazers, such that the relative frequency of pits and of rounded pits increases towards the top of the diagram.

Application of dental microwear analysis to archaeological caprine populations from Greenland has demonstrated patterns indicative of high stocking levels, namely heavily striated enamel surfaces, quite unlike microwear found in modern Greenlandic sheep kept under low stocking densities where pitted enamel surfaces predominate. These trends are apparent in both the Western and Eastern settlements and, where dating is possible, are found from the earliest occupation levels onwards. It has been argued that this could reflect maladaptive systems of grassland management in which the Norse farmers were keeping herds at levels detrimental to pasture resources in an ecosystem susceptible to pasture degradation and soil erosion (e.g. McGovern et al. 1998, Rose et al. 1998, Jakobsen 1997, Jakobsen 1991). The question of grazing

intensity and grassland management is as relevant to Iceland as Greenland (e.g. Simpson et al. 2001, 2004). One of the primary aims of the current study was thus to assess whether dental microwear analysis could help provide insight into grassland management systems for caprines in the Myvatn region. Research in progress is considering microwear in archaeological individuals from several farms in Myvansveit, including Sveigakot, Hrisheimar and Hofstadir as well as in modern sheep from the farms of Gardur and Gautlond; this report will only deal in detail with the evidence from Hofstadir.

Methods

All available dP4 and M1 from the Hofstadir assemblage were replicated and analysed for microwear patterning following the methodology outlined in Mainland (2006). A number of teeth had to be excluded from subsequent analysis due to poor resolution reflecting post-mortem damage to the enamel surface (n=14), adhering surface matter impossible to remove (n=11), or the presence of teeth which were either too worn (n=1) or had not yet come into wear (n=12). Mandibles exhibiting abnormal wear (e.g. those with broken mouth) were also excluded due to the possibility of confounding pathological wear with that caused by foraging behaviour. This left a total of 34 dP4 and 50 M1 for analysis. For the juveniles, Jones (2006) was used to estimate season-of-death.

For the dP4, identification of dietary signatures was achieved statistically using the discriminant analysis model for caprines outlined in Mainland (2006). This model uses a suite of microwear variables (e.g. relative pit frequency, ovoid pit breath, etc.) to distinguish between modern caprines grazing at high and low stocking levels and between grazing sheep and those housed and fed on soft-textured diets, including leafy-hay and milled cereals (Leafy-hay/cereal) (Fig 1). Assignment of archaeological mandibles to one of these three groups (high abrasive, low abrasive, soft) is achieved statistically using the predicted group procedure provided by DA (Norušis 1990).

The dP4 is a deciduous tooth which is replaced at c. 21-40 months in sheep and 17-30 months in goats (Silver 1969); any microwear trends identified in this tooth will thus only reflect management practices for juvenile caprines. To extend the analysis into adult animals, the M1 was also examined. This tooth erupts at approximately 3-6 months (Silver 1969) and is generally present until the death of the animal. Analysis of microwear trends in the M1 considered variability in the ratio of pits and striations, where pits are defined as features with a length to breadth ratio of less than 4:1 and striations, greater than 4:1 (Mainland 2006). Previous research has demonstrated that this variable is a useful index of level of soil ingestion, and hence grazing intensity, with a high percentage of striations evident where soil ingestion is high (Mainland 2006, 2003a).

Results

dP4

Nearly half the dP4 were classed with the with the 'soft' diet group (n=16, 47%); of the remaining, 44% (n=15) were classified with the high abrasive grazers (HAB) and 9% (n=3) with the low abrasive grazers (LAB) (Table 1, Fig. 2). The high frequency of individuals identified as having a 'soft' diet is quite unusual in comparison with archaeological dP4 analysed from elsewhere in the North Atlantic region. At Sveigakot, another Early Medieval farm in Mývatnssveit, 14% were classed to the soft diet group and 86% as HAB. In the Norse sites from Greenland, the HAB group was again dominant (62%), though a reasonably high percentage of individuals were identified as having had a soft diet (25%), with a further 13% classed as low abrasive grazers.

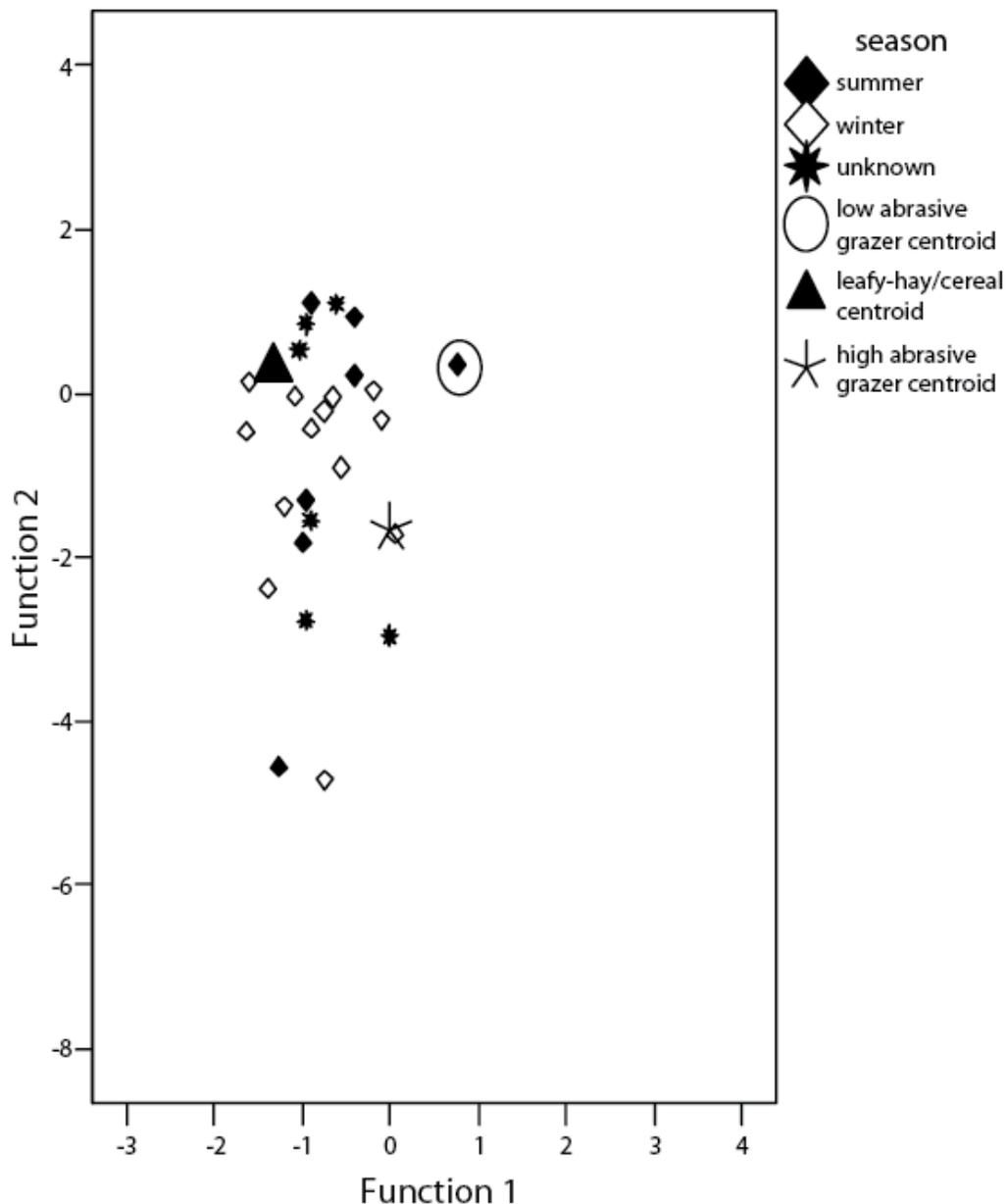


Figure 2. Classification of the juvenile sheep/goat mandibles from Hofstaðir using the discriminant analysis model detailed in Fig. 1: shows the position of group centroids (i.e. the mean scores for each group on functions 1 and 2) for the known diet groups and of each individual case (i.e. , animal) for the archaeological material coded by season-of-slaughter (after Jones 2006).

To assess what this variability in the Hofstaðir sample might reflect, the relationship between predicted group and a series of variables was considered: age-at-death, season-of-death, species, context of deposition and date (Table 1, Fig. 2). Too few goats were present (n=3) to identify whether microwear varied by species. There is a slight indication that microwear patterns vary across the site with a lack of individuals classed as high abrasive grazers deposited in area E, context 1144. Sample sizes are small (n=5), however, and this may merely reflect chance. For the remaining variables, no clear trends were identified. Of the teeth classified in each diet group (i.e. HAB, LAB, leafy-hay/cereal), individuals are represented from the entire age range, from animals killed in both summer and winter and from different dates (Table 1, Fig. 2).

Microwear reference code	Context	Area	Date	Sheep or goat	Season	Predicted Group for DA
160	1144	E	AD990	Sheep	2	LAB
142	6F	G	Late 10 th -early 11 th AD	Sheep	2	LAB
140	6N	G	Mid-Late 10thC AD	Sheep	1	LAB
147	1144	E	AD990	Sheep	1	leafy-hay/cereal
183	1144	E	AD990	Sheep	1	leafy-hay/cereal
201	1144	E	AD990	Goat	2	leafy-hay/cereal
291	1144	E	AD990	Sheep	4	leafy-hay/cereal
278	6D	G	Late 10 th -early 11 th AD	Sheep	4	leafy-hay/cereal
197	6HK	G	Mid-Late 10thC AD	Sheep	5	leafy-hay/cereal
290	6HK	G	Mid-Late 10thC AD	Sheep	2	leafy-hay/cereal
202	6M	G	Mid-Late 10thC AD	Sheep	4	leafy-hay/cereal
239	6N	G	Mid-Late 10thC AD	Sheep	2	leafy-hay/cereal
136	7B	G	Mid-Late 10thC AD	Sheep/goat	2	leafy-

						hay/cereal
146	7B	G	Mid-Late 10thC AD	Sheep	1	leafy-hay/cereal
153	7B	G	Mid-Late 10thC AD	Sheep/goat	2	leafy-hay/cereal
177	7B	G	Mid-Late 10thC AD	Sheep	2	leafy-hay/cereal
198	7B	G	Mid-Late 10thC AD	Sheep	5	leafy-hay/cereal
241	7B	G	Mid-Late 10thC AD	Sheep	5	leafy-hay/cereal
292	7B	G	Mid-Late 10thC AD	Sheep/goat	2	leafy-hay/cereal
163	5B	G	Late 10 th -early 11 th AD	Sheep	2	HAB
243	5B	G	Late 10 th -early 11 th AD	Sheep/goat		HAB
285	5B	G	Late 10 th -early 11 th AD	Sheep/goat	2	HAB
208	6D	G	Late 10 th -early 11 th AD	Sheep	3	HAB
143	6M	G	Mid-Late 10thC AD	Sheep	2	HAB
156	6N	G	Mid-Late 10thC AD	Sheep	4	HAB
164	6N	G	Mid-Late 10thC AD	Sheep	2	HAB
224	6N	G	Mid-Late 10thC AD	Sheep	1	HAB
176	7B	G	Mid-Late 10thC AD	Sheep	2	HAB
230	7B	G	Mid-Late 10thC AD	Sheep	1	HAB
231	7B	G	Mid-Late 10thC AD	Sheep	5	HAB
235	7B	G	Mid-Late 10thC AD	Goat	2	HAB
238	7B	G	Mid-Late 10thC AD	Goat	2	HAB
286	7B	G	Mid-Late 10thC AD	Sheep	5	HAB
172	4A	G	Late 10 th -early 11 th AD	Sheep	5	HAB

Table 1 Season/year of death and predicted group membership in DA for the juvenile mandibles from Hostadir. Abbreviations - Season/year of death (based on Jones 2006): (a) codes for sheep: 1 - summer year 1 (stages A-C1/2, i.e. 0-6 months); 2 - winter year 1 (C ¾-D1/2, i.e. 5-14 months); 3 - summer year 2 (D3-5, i.e. 12-21 months); 4 - winter year 2 (D6, i.e. 18-25 months); 5 - unknown; (b) codes for goats: 1 - summer year 1 (stages A-C1/2, i.e. 0-6 months); 2 - autumn/winter year 1 (C ¾-C5, i.e. 5-12 months); 3 - later winter/spring/early summer years 1-2 (C6, i.e. 8-15 months); 4 - spring/summer year 2 (D1/2, i.e. 10-18 months); 5 - spring/summer/winter year 2-3 (D3/4 - D6, i.e. 12-30m); 6 - unknown. Predicted group for DA (see text for explanation).

M1

Microwear in the Hofstaðir M1 is generally similar to that evident in the Norse mandibles from Greenland, and indeed at other Icelandic sites studied; specifically, the dominant microwear patterning is heavily striated enamel

surfaces (Fig. 3). This is verified by statistics for the ratio of pits to striations (Fig. 4). Hofstaðir is different, however, in having a rather wider range for this variable. Separation of the M1 into those derived from adults (defined as having a Payne (1973) wear stage from E-I) and juveniles (Payne (1973) wear stage A-D) indicates that this can be attributed to a more mixed microwear patterning in the juveniles, with some individuals having high pit frequencies and some high striation frequencies (Fig. 5). In contrast, the adults all demonstrated heavily striated enamel surfaces. This differences between adults and juveniles is statistically significant ($p < 0.05$, Student's t-test). Similar trends could not be detected at Sveigakot; here separation of juveniles and adults indicated very similar microwear patterns in both groups, namely an emphasis on striations ($p > 0.05$, Student's t-test) (Fig. 6). The variability identified in the M1 microwear of juveniles at Hofstadir agrees with observations made above for the dP4 where nearly half the sample were identified as having a 'soft' diet, in which pits will predominate.

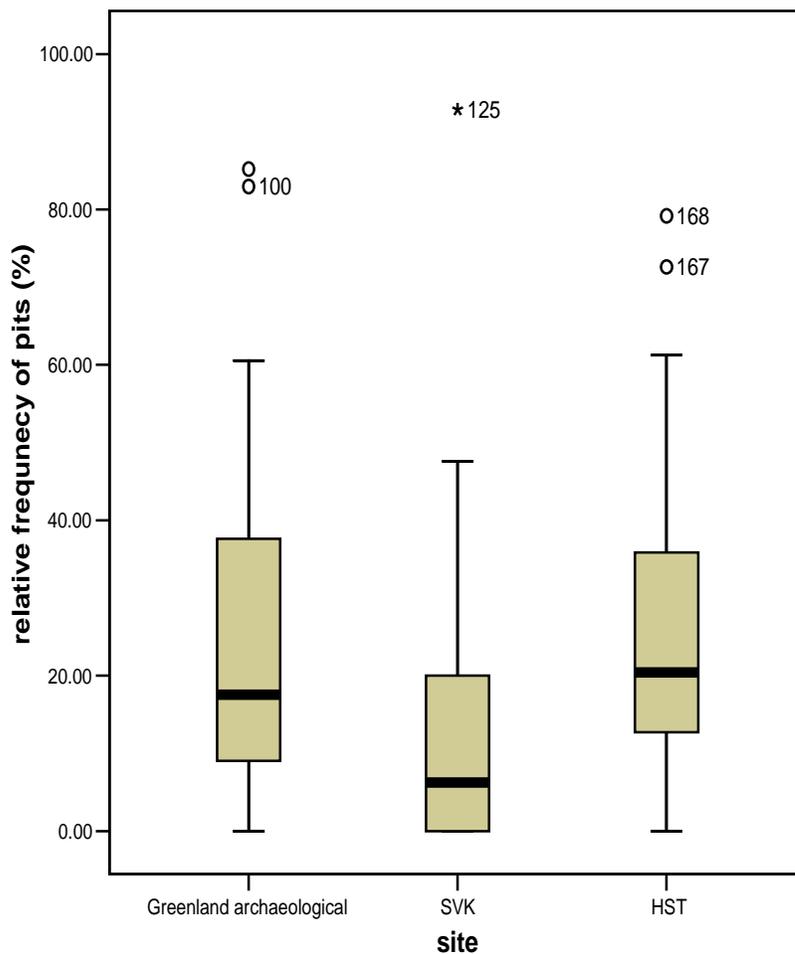


Figure 4 The ratio of pits to striations (expressed as a percentage) in the M1 of caprines from archaeological sites dating to the Norse period in Greenland ($n=76$) and at Sveigakot ($n=46$) and Hofstaðir ($n=50$) in Iceland. Mean, median,

Std. Deviation %pits: Greenland – 24.92, 17.57, 20.83; Sveigakot – 12.93, 6.27, 17.36; Hofstaðir – 26.45, 20.42, 19.18.

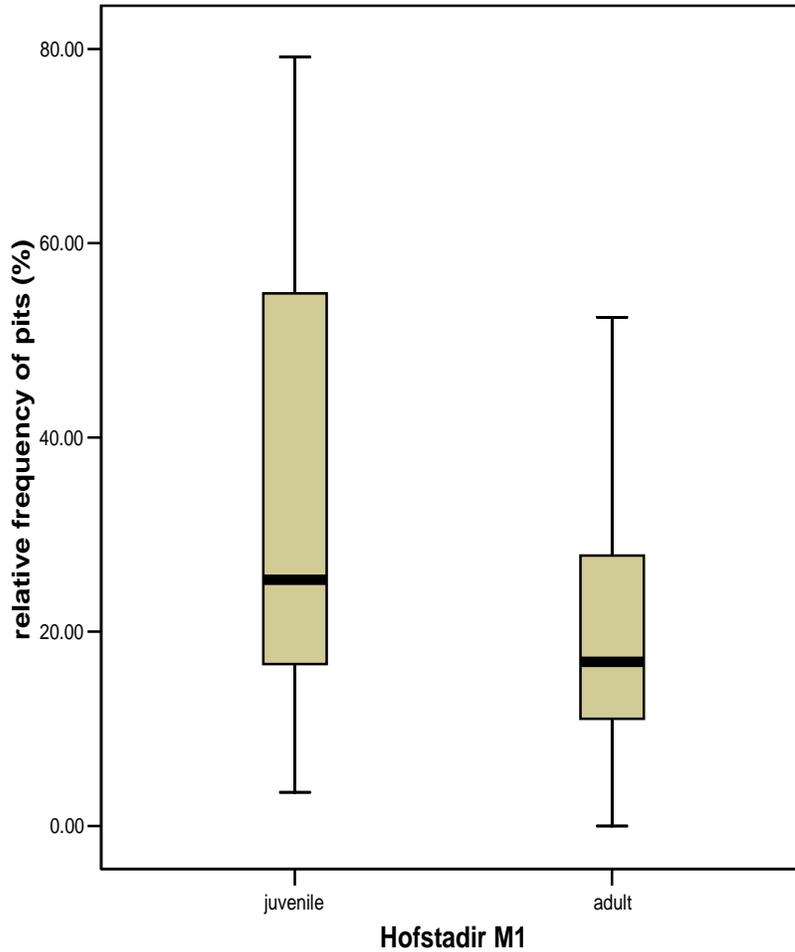


Figure 5 The ratio of pits to striations (expressed as a percentage) in the M1 of juvenile (n=22) and adult (n=27) caprines from Hofstaðir. Mean, median, Std. Deviation %pits: juveniles – 33.10, 25.34, 22.80; adults – 21.25, 16.9, 14.37.

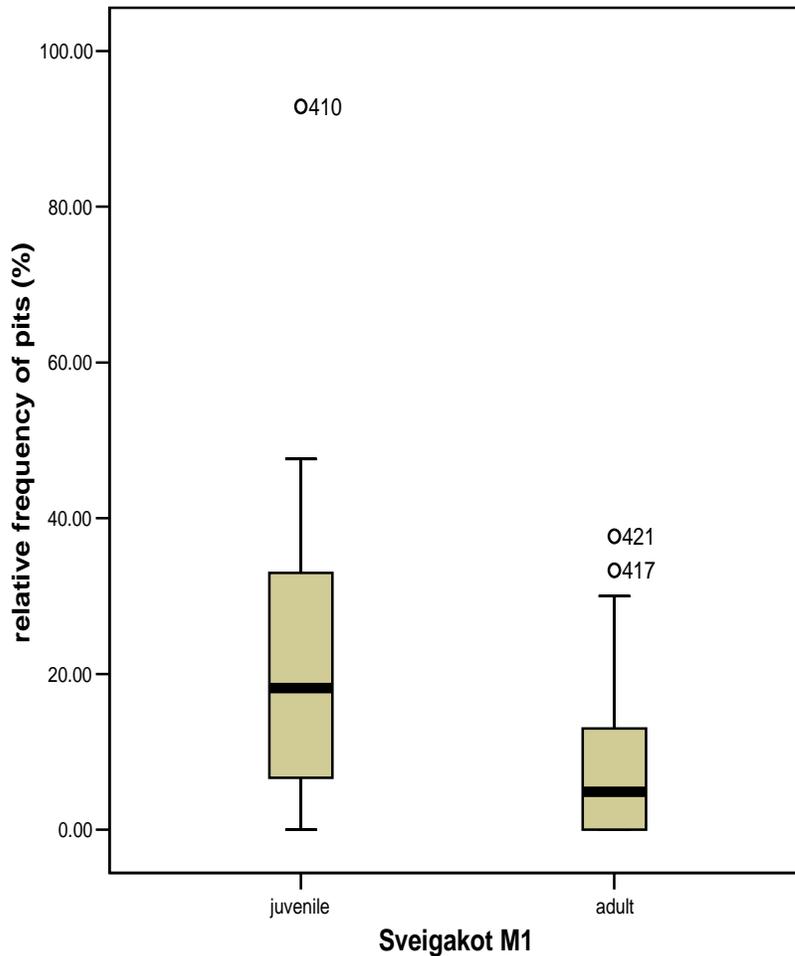


Figure 6 The ratio of pits to striations (expressed as a percentage) in the M1 of juvenile (n=11) and adult (n=35) caprines from Sveigakot. Mean, median, Std. Deviation %pits: juveniles – 24.76, 18.18, 27.20; adults – 9.22, 4.87, 11.04.

Sample sizes were insufficient to allow consideration of variation in M1 microwear by species, date or context: it was considered appropriate to treat juveniles and adults as separate groups due to the variability identified above, which reduced sample sizes for each species, context and phase group.

Discussion

Microwear patterning in the Hofstaðir teeth indicates grazing practices in which soil ingestion was high. Similar trends are found at Sveigakot, a further Settlement/Medieval farmstead in Mývatnssveit. Increased levels of soil ingestion will occur where stocking levels are high, and is a potential indicator of the mismanagement of pasture resources and overgrazing (Mainland 2006). This type of microwear is not found in modern Greenland (Fig. 7; LAB in Fig. 1) or

Iceland (Fig. 8) in locales where stocking levels under extensive grazing systems are kept within the carrying capacity of the landscape. It thus appears that rates of soil ingestion and hence by implication stocking densities, were routinely much higher in the Early Medieval period in the North Atlantic Islands. Furthermore, this is a practice that is evident from the earliest settlement onwards, i.e. it is not just associated with the deteriorating climate of the 'Little Ice Age'. Nevertheless, while the microwear pattern in the archaeological mandibles can unequivocally be associated with overgrazing, it is difficult to ascertain from microwear evidence alone whether this reflects extensive, and thus high impact, or localised, low impact, overgrazing. Animals kept in pens and corrals will create localised spots of soil erosion (e.g. Evans 1998, Mainland and Halstead 2005) which would be difficult to distinguish using microwear from animals grazing on extensive erosion fronts in the wider landscape.

The identification of contrasting microwear patterns in the juvenile and adult M1 and the high frequency of dP4 at Hofstaðir identified as deriving from individuals with a soft diet indicates that some, though not all, of the young sheep were fed/managed differently to the adults. Similar trends were not evident at Sveigakot which may imply that the differential treatment of young and old sheep was not a general feature of caprine husbandry in the region but was restricted to Hofstaðir, though further sites need to be examined to confirm this suggestion. In modern animals the 'soft' diet group represents stall-fed animals consuming very little abrasives, either exogenous or endogenous, and a diet which requires little comminution. The evidence from Hofstaðir may thus indicate a prevalence of stalled animals and/or those fed a diet lacking in texture or abrasives (e.g. leafy-hay, milled cereals) at this site. Moreover, these were not just winter-stalled animals; as Fig. 2 and Table 2 show many of the individual classed in the soft diet group were culled in summer. It is tempting to relate this to the apparent emphasis on the culling of young, 'meaty' animals at Hofstaðir, perhaps for feasting, and to suggest that what is reflected is the fattening up of animals prior to slaughter, a practice widely attested in feasting/ritual contexts (e.g., Mainland and Halstead 2005, Moens and Wetterstrom 1988, Maekawa 1983). A more prosaic possibility could, however, be the special housing and feeding of ewes and their offspring used for milking; the special treatment of economically important animals such as milking ewes is well attested both ethnographically and historically in the North Atlantic Isles and milking animals and their offspring, were often kept apart from other animals and stalled for at least part of the day (Fenton 1978).

Pig

Pigs were a significant part of the domestic stock of early North Atlantic settlers in Faroes and Iceland (McGovern et al 2000, Church et al. 2006, Arge 2007), and in the Northern and Western Isles of Britain Pictish/Celtic farmers had long incorporated pigs as an element of their island economies (Bond 2002, Albarella et al. 2007). By the end of the 11th century, pigs seem to have become increasingly rare in Iceland, and seem to have become extinct in both Iceland and the Faroes by the later Middle Ages (Church et al 2005, Arge et al in press). High status farmers in Greenland still imported substantial numbers of pigs in the 11th century (McGovern et al 1996), and some seem to have survived into the 13th century (Smiarowski et al 2007, Nyegaard pers. com.). Pigs can significantly supplement an economy based upon cattle and caprines, as they are omnivorous and can reproduce extremely rapidly in favorable conditions (up to sixteen offspring per year vs. two for sheep). Kept entirely for meat, pigs can help balance the needs of dairy and wool production in other components of the economy, allowing greater efficiency in the management of multi-product species like sheep and goats. In many NW European cultural contexts, pigs have also been favored menu items in communal and elite feasting (Adamson 2002, Albarella 2006, Dobney et al. 2007). However, pigs require special management efforts if they are to be successfully integrated into an intensively farmed landscape. Because of their rooting feeding pattern and their ability to penetrate even substantial fencing, pigs have the potential for significant destruction of cultivated crops and gardens, and an explicit reason for their extinction in early modern Shetland was the danger posed to newly important root crops and protected gardens (Fenton 1978). In the Faroes, place name evidence suggests that pigs were closely herded, and that their movements between outfield and village were carefully controlled (Arge 2007).

In Iceland, pigs may have been particularly useful in the earliest phases of colonization, when stocks of imported domesticates needed to expand rapidly and when the ability of pigs to find their own food (including unwary birds and nestlings) in an environment that was still heavily wooded and without the broad grassy meadows of the modern homefield. Their rooting impact on dense birch and willow woodlands may initially have been welcomed as an economical forest clearance tool, and it is easy to see the decline of pigs (as well as goats) after the age of settlement in relation to the changing natural and cultural landscape of a more heavily settled and less-wooded Iceland. The 13th century law code *Grágás* clearly sees pigs as “problem animals” and notes that “*Pigs are not to be kept in communal pasture. They have no immunity from injury on any man’s land except their owner’s unless it is a homefield boar with a ring or withy in its snout*” (preventing rooting) (p 139) but still provides a value conversion “*A sow of two winters or older with nine piglets equals a cow*” (p 209) which suggests the relative worth of a fertile sow and fertile cow (MS later 13th c, trans. Dennis, Foote, & Perkins vol 2 , 2000, pp 139, 209).

In the Hofstaðir archaeofauna, there is virtually no change in the relative abundance of pig bones between phases, with pigs making up between 3- 4 % of the domestic mammals in both Phase I and II. While this is a substantial amount of pig bones by North Atlantic standards, the lower sample size compared to the more common domestic mammals limits reconstruction of age and size of animal. As with other domestic mammals, the broadest measure of age structure of this taxon is a simple comparison of easily recognizable neonatal (newborn) or late foetal bone to the total pig bone count (NISP). Figure 32 presents these data from Phase I and II-III at Hofstaðir in comparison with the contemporary Mývatnssveit sites of Sveigakot (middens only) and Hrísheimar (midden, again making use of preliminary data). At Hrísheimar, there is an apparent increase in pig keeping after ca 940 which produced some of the highest relative percentages of pig bone in the area by mid-late 10th century. The changing (probably progressively poorer) households at Sveigakot seem to have kept progressively fewer pigs, and by the final phase in the 11th century Sveigakot had drastically reduced pigs, goats, and cattle in favor of sheep. The Hofstaðir archaeofauna shows a higher proportion of the bones of these very young piglets in both phases than any phase of the other sites (this is *not* the effect of counting semi-articulated piglets more than once at Hofstaðir).

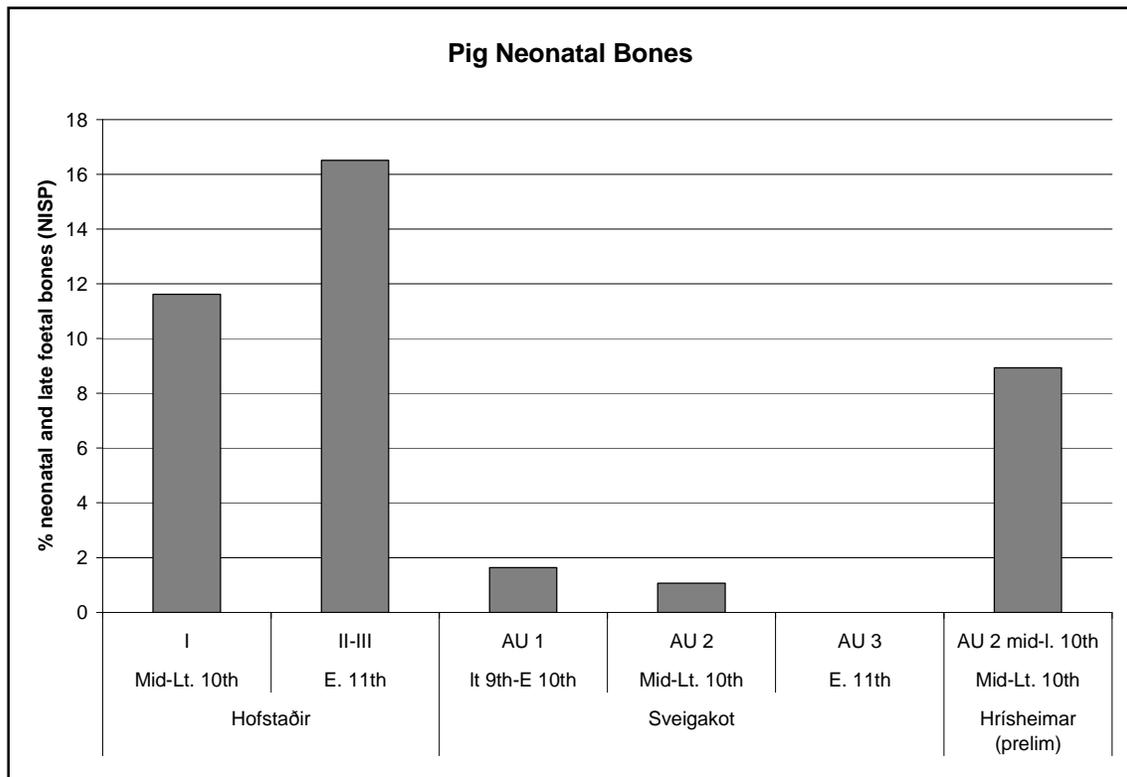


Figure 32

Something like 10 to 16 % of the Hofstaðir pigs were eaten very early in life, perhaps 7-10% at Hrísheimar were consumed in the same age group, but hardly any very young (suckling) piglets were consumed at Sveigakot. In later medieval times (cook books and feasting menus only become common after the mid-14th c Adamson 2002), suckling pigs were an expensive delicacy and a mark of status. Where fodder or rangeland is available, it is far more economic to raise the piglet to six months (end of first summer) or to a year (near the top of the growth curve for unimproved pigs). The Sveigakot farmers may well have followed this strategy, but Hrísheimar and especially Hofstaðir managers repeatedly chose to harvest piglets well before their “optimum” meat weight.

Sample size strongly limits what can be done with long bone fusion data, but figure z 33 presents a comparison of the existing pig fusion data with age estimates (in years) at bottom. This figure suggests the presence of some older individuals (three years and above), but suggests that the majority of pigs were slaughtered as they reached their growth peak.

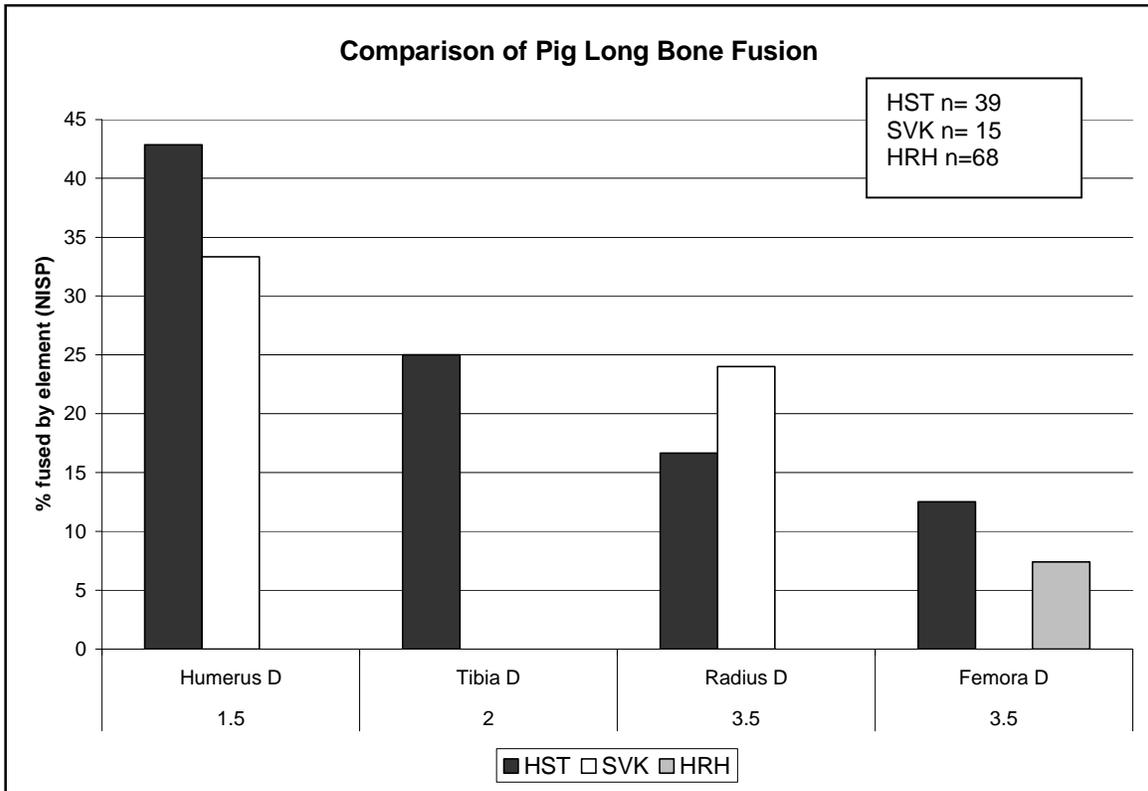


Figure 33

Pig tooth rows are also rare in the archaeofauna. Table zz 10 presents the available comparative eruption data, again suggesting the presence of some older individuals as well as the harvest of younger animals. Mandibular tooth rows are uncommon, and the only two from Hofstaðir that could be scored following Grant (1982) produced a score of one (very young) and 24 (mature adult).

Table 10 Pig tooth eruption (maxilla and mandible)

inferred age	eruption state	HST	SVK	HRH
< 5 m	dp4 only		2	1
5-6 m	dp4 +M1			2
12-14 m	dp4+M1+M2		3	2
23-26 m	M3 in wear		3	1
	total		8	4

Size reconstruction is again limited both by sample size and the shortage of mature adults with fused long bone ends, but table zz 11 presents two measurable distal pig humeri in comparison with pigs from contemporary Wessex (metrics follow Von Den Dreisch 1976). These few measurements support the impression given by the many un-measurable fragments: these were small animals even by the standards of early medieval Europe. They were long-snouted, long limbed relative to body size, and may have resembled the early modern Orkney breed (long limbed, black, bristly, and aggressive Bond 2002). These pigs would have been much closer to the size of a modern Icelandic sheep than a modern rounded, pink-skinned commercial hog, and were probably fully capable of fending for themselves with little supervision.

Table 11 Pig

Distal Humerus (Bd)

	HST	9th-11th c Winchester & Southampton (ABMAP)
n	2	22
mean	32.21	36.61
max	35.52	41.80
min	28.9	32.00
sd	4.68	2.66

Stable Isotopes and Pig Diets in Mývatnssveit

Philippa Ascough

Differences in the diet of pigs and other domestic animals in Mývatnssveit may be elucidated by measurement of the stable isotope abundances of carbon and nitrogen (expressed as $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) in bone collagen samples, using isotope-ratio mass spectrometry (IRMS). The stable isotopic composition of an animal's tissues reflects that of its environment, including dietary carbon sources, with an enrichment in $\delta^{13}\text{C}$ of around 0-2‰ per trophic level (Fantle and Dittel, 1999). Distinct differences exist between the $\delta^{13}\text{C}$ of primary producers in the marine, terrestrial and aquatic environments, allowing the identification of differences in dietary carbon between individual organisms. Nitrogen isotopic composition is enriched with respect to $\delta^{15}\text{N}$ with increasing trophic level by around 3-4‰ (Peterson and Fry, 1987), and the complementary use of these isotopes therefore allows a detailed analysis of ecosystem dynamics. Preliminary work with $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements of animal bone collagen

from Mývatnssveit has highlighted the utility of this approach. For example, assessment of domestic mammal bones from Hofstaðir and Hrísheimar show isotopic values of $\delta^{13}\text{C} = \text{c. } -22.0\text{‰}$ and $\delta^{15}\text{N} = \text{c. } +1.0\text{‰}$ for cattle, typical of primary consumers existing solely within the terrestrial (C3) food web. However measurement of some pig bone from Hofstaðir (GU-13510 from context [254]) gives much higher values, e.g. $\delta^{13}\text{C} = -16.9\text{‰}$ and $\delta^{15}\text{N} = 7.4\text{‰}$ (Ascough *et al.*, 2007). These are consistent with a more mixed diet for at least some pigs in Mývatnssveit, which appears to have incorporated a significant proportion of carbon originating from aquatic sources, possibly including waterfowl eggs, and waste from human consumption of fish and birds from Lake Mývatn. These values are more comparable to the isotopic values produced by Viking age human burials in Mývatnssveit and at least some of dogs buried with them, suggesting a mixed diet. Such an interpretation is supported by the high apparent ^{14}C age of the pig bone incorporating an aquatic isotopic signal. This is much older than the cattle bone from the same context, and suggests that the freshwater carbon reservoir in Mývatnssveit is strongly depleted in ^{14}C , as a result of the low ^{14}C content of the groundwater flow to the lake, which is transferred throughout lake trophic levels. This was confirmed by ^{14}C measurements of Arctic char bone collagen, which revealed an offset between the aquatic environment and the contemporaneous atmosphere of c.1300-1700 ^{14}C yr (Ascough *et al.*, 2007). It would appear that while many pigs in Viking age Mývatnssveit had diets producing fully terrestrial isotopic signatures (similar to cattle and sheep), at least some pigs at Hofstaðir appear to have regularly fed partially in the freshwater ecosystem. Does this difference in isotopic ratio indicate the difference between pigs allowed free-ranging feeding vs. stalled pigs fed human food scraps or fish offal? Currently, a collaborative research effort is underway, drawing upon initial data to more fully investigate ecosystem dynamics in Mývatnssveit, the results of which will be interpreted within a wider framework of current ecological and archaeological research.

Table 12 Viking Age Pig Bone Stable Isotopes

			13C/12C ratio (%)	d15N(cf)
Hofstaðir				
GU-12076	HST 7a pig	lower pit house fill	-21.00	n.a.
GU-12078	HST 6d pig	upper pit house fill	-21.50	n.a.
GU-12080	HST 6g pig	upper pit house fill	-20.00	3.7
GU-13510	HST C.254 BS.B	HST barrel pit	-16.9	7.4
Hrísheimar				
GU-12082	HRH 003 pig H	Fill of pit house	-21.40	0.1
GU-12084	HRH 002 pig H	Midden deposit	-20.20	1.3
GU-14806	HRH 429 SUS	Midden deposit	-20.6	3.9

Horses

Horses have long been important farm animals in Iceland, and the hardy traditional breed has transported many loads over the rough landscape since first settlement. Horses were regularly included in pre-christian graves, and like dogs seem to have had a special status in mortuary ritual (Friðriksson 2000, 2004). Unlike dogs, horses were regularly butchered and eaten in pre-christian times, and their bones regularly appear among what appears to be food waste in Viking

Age Mývatnssveit. Table 12 presents the percentage of horse bones showing butchery marks at Hofstaðir, Sveigakot, and Hrísheimar (preliminary), suggesting the regularity of this widespread pattern.

	HST I	HST II-III	SVK	HRH
% Butchered	33.33	21.95	11.76	33.33

Age structure of the Hofstaðir horse cannot be effectively reconstructed because of fragmentation and sample size, but most horse bone fragments definitely came from adult animals and no neonatal fragments were recovered. Table 13 presents a count of the fused long bones with approximate age of fusion, indicating that most animals survived to full adulthood, although one horse seems to have died in its second year.

Age of fusion (yrs)	Element	fused	unfused
c 3.5	Humerus P	2	0
c 1.5	Humerus D	1	0
c 3.5	Femora P	1	0
c 3.5	Femora D	1	0
c. 2	Tibia D	4	1

Nearly all horse bones were too fragmented for measurement, but in general size and conformation the Hofstaðir horses greatly resemble the modern Icelandic breed.

Dogs

While dog tooth marks on other species bones are widespread at Hofstaðir, the bones of dogs themselves are very rare (a pattern common to all other Icelandic sites), suggesting that Viking Age Icelanders did not eat dogs regularly. The three dog bones recovered from the Hofstaðir deposits are all from Unit A, the A4 Phase III (two fragments) and from the A6 phase VII-VIII comprising post-medieval materials and some possible Bruun excavation spoil (one fragment). One of the fragments from A4 Phase III is a jaw of a young puppy, with only the first adult molar erupted. While no measurements were possible, all three dog bones were from a small-medium sized breed similar to the modern Icelandic dog.

Cats

Cat bones are rare on Icelandic sites of all periods, and only Hofstaðir thus far has produced any cat remains in Viking Age Mývatnssveit. Several concentrations of cat bones were encountered during excavation and some clearly articulated limb and vertebral groups were documented, but no fully complete skeletons suggestive of deliberate burial were encountered in excavation. Cut marks on two bones (pelvis and femoral shaft) may relate to

skinning, and the deposit of partially articulated individuals is certainly consistent with skinning not followed by human meat consumption (and very similar to the pattern of fox bones found at Sveigakot). Cat skin gloves feature as part of pre-Christian ritual paraphernalia in the widely quoted (but probably wholly fictional) account of a pagan sorceress in Eirik the Red's Saga (Blaine 2002). More prosaically, cat skinning seems to have been a minor industry in Anglo-Scandinavian York (O'Connor 2003) and cat skins were certainly regularly used outside of ritual contexts in the Viking Age.

Mice

Mouse bones have been recovered from several Mývatnssveit sites, and where enough cranial elements have survived these have all been identifiable as the house mouse (*Mus musculus*). It is entirely possible that some of the post-cranial remains and smaller fragments may come from the field mouse *Apodemus sylvaticus* (now widespread in Mývatnssveit) and it seems probable that both species were accidentally introduced to Iceland by the Viking Age settlers. Both species have been recovered from both Iron Age and Norse contexts in Shetland (Nicholson, Barber, & Bond 2005), and a group of over 100 house mice were recovered from the same tub in a site in medieval Greenland (Veboek 1993). As rats do not seem to have been introduced to Iceland during this time period, one or both of these species of mice are responsible for the distinctive rodent tooth marks noted on other species' bones.

Wild Mammals

The only wild mammal native to Iceland is the Arctic fox (*Alopex lagopus*) and a very small number of fox bones have been recovered from Hofstaðir (table 2). Fox bones have been recovered in larger numbers from the site of Sveigakot, some showing slice marks indicating skinning.

Whale bone fragments include both small pieces that may be craft waste or fragments of finished artifacts, one great whale vertebra (species indeterminate) used as a chopping block in area E 3 Phase III context [1097], and a single rib from a porpoise or small toothed whale from Area G Phase I [7a]. This rib could also have been brought to the site as fleshless tool material, but the find of an articulated set of porpoise tail vertebra (chopped off) at Sveigakot suggests the possibility that porpoise or whale meat was reaching Mývatnssveit from the sea 50 to 70 km to the north.

Seal bone fragments do suggest transport of meat, as they include ribs and flippers as well as one tooth that could be identified as the harbor or common seal *Phoca vitulina*. In the post-medieval deposits (A6, context 100, Phase VII-VIII) a single femora was recovered which could be identified as a Harp seal (*Phoca groenlandica*). Harp seals were taken in substantial numbers and some elements transported inland after later medieval to early modern sea ice brought

large numbers of this migratory seal species into Icelandic waters (Amorosi 1992).

Birds

The Mývatn basin area today supports a large and diverse migratory bird fauna, and the lakeside provides one of the few areas where birds from both sides of the Atlantic nest and raise young. When the project began, it was anticipated that a very large proportion of the Mývatnssveit archaeofauna would be migratory waterfowl, and an excellent comparative skeletal collection made by Dr. Arni Einarsson (Mývatn Research Station, <http://www.hi.is/HI/Stofn/Myvatn/>) from net-drowned and road killed birds was kindly donated to the CUNY Zooarchaeology laboratories, greatly aiding all subsequent identification efforts. Despite such zooarchaeological anticipation, bird bone in fact makes up a very minor portion of the Mývatn archaeofauna overall, and the great majority of the bones identified come from the non-migratory Ptarmigan (*Lagopus mutus*) rather than the migratory waterfowl (table 3). Instead, large concentrations of bird egg shell were encountered in virtually all Mývatnssveit excavations, and egg shell has been observed in soil corer samples from additional unexcavated midden deposits in the area.

Table zz14 presents the breakdown of bird bones from the Mývatn archaeofauna, this time including a small collection from the site of Selhagi in the Mývatn lakeshore area as well as bird bone and egg shell from Sveigakot, Hofstaðir, and the preliminary counts from Hrísheimar. While a diverse range of species are represented, virtually all the bird archaeofauna are dominated by bones of ptarmigan (grouse, *Lagopus mutus*), commonly found in the upland heaths and often taken in snares (especially in winter). Nearly all the unidentifiable bird bones (mainly long bone shaft fragments) are in the ptarmigan size range and could also come from this species. The absence of substantial numbers of migratory waterfowl bones from any of the site collections is surprising, as is the presence of both bone and egg shell from sea birds on these deep inland sites. While the current archaeofauna from Selhagi on the lakeshore is too small to fully quantify, it is clearly *not* dominated by migratory waterfowl and in fact includes as many sea bird and ptarmigan bones as waterfowl, despite its location in the midst of one of the largest modern waterfowl nesting areas in the North Atlantic. Since the lake shore has been fully settled by humans for over 1,200 years, the continued survival and abundance of these vulnerable nesting birds would appear to be the result of deliberate management.

Historic and ethnographic records provide some indications of the management strategy. Harvesting duck eggs rather than killing adults has been a traditional way of exploiting the waterfowl populations at Mývatn (Gudmundsson 1979). Duck egg harvesting was first mentioned in the 1712 *Jarðabók* land register, taking place at 11 farms bordering the lake (JÁM 1990). Interestingly, in the *Jarðabók* register the Kráká valley sites closest to the egg-rich abandoned Hrísheimar site (Baldursheimar and Gautlönd) were not recorded as having egg

collection access- perhaps reflecting environmental or social changes since the 10th century. The annual harvest of about 4000 eggs in the Jarðabók register is probably understated because of fear for taxation. A number ten times higher (about 41,000) was obtained in Gudmundsson's (1979) inquiry in 1941. The present rule to leave at least 4-5 eggs in the nest for the female to incubate is first mentioned by a traveler in the area in 1862 (Shepherd 1867), but self-imposed restrictions to harvesting are mentioned some 40 years earlier (Thienemann 1827). The 4-5 egg rule ensures a sustainable yield, as the ducks produce only 0.3-2.8 young per female a year on the average and the overall production of young is regulated by the availability of food in the lake, mainly midges and their larvae and small crustaceans (Gardarsson and Einarsson 1997; 2002; 2004). Although duck hunting seems to have been the exception during the last 180 years or so (Gudmundsson 1979), numerous diving water birds get drowned in gill nets used for char and trout fishing (Gardarsson 1961). The zooarchaeological evidence for intensive egg collection coupled with a shortage of waterfowl bone in the collections provides persuasive evidence for millennial-scale local level sustainable resource management. The current abundance of migratory birds at this RAMSAR- recognized site of international biological importance is a product of sustained human effort extending back to the first settlement in the early Viking Age (McGovern et al 2006).

The presence of sea bird bone and egg was also a surprise. While a few gulls occasionally wander inland to Mývatn, the other sea birds were certainly purposively imported by humans from the seacoast. The eider duck (*Somateria mollissima*.) identified from Hofstaðir rarely ascends the Laxá as far as the site and is more likely to have been taken along the coast or in the lower reaches of the river. One eider bone contained medullary bone present in females during the spring egg laying season. Raven (*Corvus corax*) bones from Sveigakot include a nearly complete articulated leg with claws (counted as a single NISP) and need not indicate human consumption.

Table 14 Bird Bone and Egg Shells

Scientific Name	English	SVK 1	SVK 2	SVK 3	HST I	HST II-III	HRH	SLH 1	SLH 2
<i>Anatidae</i> sp.	Duck sp.			3	egg	1 + egg	2 + egg	1 + egg	egg
<i>Anas platyrhynchos</i>	Mallard		1	3		5			
<i>Aythya</i> sp.	Scaup or Tufted duck		3	1	1	2	2		
<i>Clangula hyemalis</i>	Long tailed duck						1		
<i>Somateria</i> sp.	Eider duck					2			
<i>Bucephala clangula</i>	Goldeneye					1	1		
<i>Gavia</i> sp.	Diver sp.			4			1		
<i>Gavia immer</i>	Great N Diver			1			2		
<i>Gavia stellata</i>	Red throated diver			1					

<i>Podiceps auritus</i>	Slavonian grebe	1	1						
<i>Melanitta nigra</i>	Common scoter						1		
Anserinidae sp.	Goose sp.	2					2		
Cygnus sp.	Swan sp.	1			1		2	4	
<i>Lagopus mutus</i>	Ptarmigan	13	346	338	20 + egg	137	324 + egg	3 + egg	egg
<i>Corvus corax</i>	Raven	4				6			
<i>Larus</i> sp.	Gull sp	2					1		
<i>Alcidae</i> sp.	Auk sp								
<i>Alca torda</i>	Razorbill				1				1
<i>Uria</i> sp.	Murre or Guillemot				6 + egg	5 + egg			1
<i>Fratercula arctica</i>	Puffin				1				
<i>Alle alle</i>	Little auk					3			
Phalacrocoracidae sp.	Shag or cormorant	2							
Procellariidae sp.	Shearwater sp.								egg egg
<i>Aves</i> sp.	Bird species indet	11	274	177	52	125	324	13	
	total bird bone	24	636	529	82	288	566	21	2

Figure zz34 illustrates the relative percentage of migratory waterfowl, ptarmigan, and sea bird bones in the larger archaeofauna. While all archaeofauna are dominated by ptarmigan, the largest concentrations of sea bird remains (both bone and identified egg shell) are consistently at Hofstaðir.

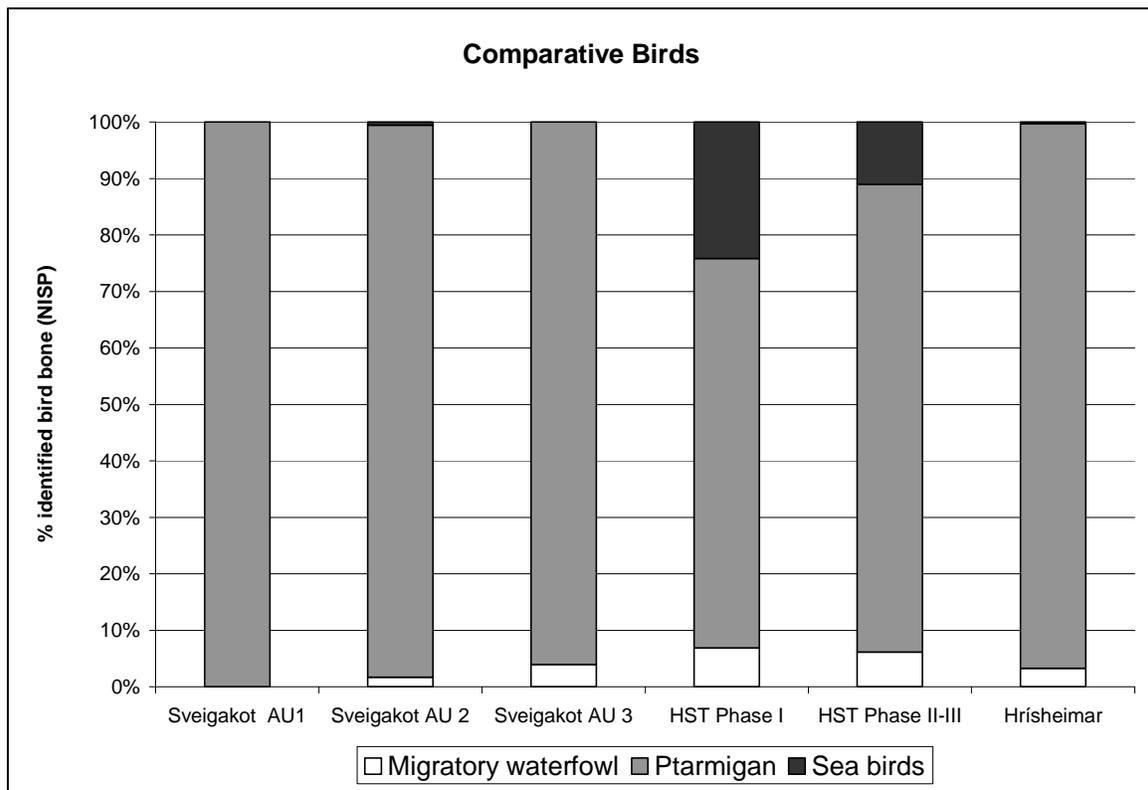


Figure 34

Apart from ducks a few other species need to be mentioned. Horned (Slavonian) grebes (*Podiceps auritus*) are common but nest and moult mainly in the northern part of the Mývatn area (Einarsson 2000). The total number of nests is between 250 and 325. There is a large colony at Sandvatn (ytra), within reach from Hofstaðir (4 km). A few pairs nest in the neighborhood of Selhagi and Hrísheimar but Sveigakot is quite far away (5 km or more) from any present grebe habitat. Only few pairs of each of the diver species (great northern diver *Gavia immer* and red-throated diver *G. stellata*.) breed in the Mývatn area. Whooper swans (*Cygnus cygnus*) nest sparsely in the Myvatn area, but flocks of molting swans occur on Lake Myvatn and Lake Sandvatn (sydra) in mid summer (Gardarsson and Einarsson 2002). Open water in the winter sustains 150-260 swans (Gardarsson and Skarphédinsson 1985), some of these ice-free areas are at Grænavatn, close to Sveigakot, at Laxá close to Selhagi and also by Hofstaðir. Two species of geese nest in the region. The graylag goose (*Anser anser*) is common around Lake Myvatn and the pink-footed goose (*Anser brachyrhynchus*) being a highland species nests at the southern border of the Mývatn area. Both species are increasing in numbers and the pink-footed goose is expanding its range northwards within the study area. The upland heaths of northeastern Iceland (including the Mývatn area) are the present day key habitat for the Icelandic population of ptarmigan. It occurs at spring densities ranging from 1.8 to 11.8 males/km² at Hofstaðir, with higher densities in the lower lying region towards the sea (Nielsen 1995). The nearest seabird cliffs are found in the island of Grímsey, some 100 km from Mývatn and about 60 km from the mouth of the river Laxá; and Raudinúpur at the tip of the Melrakkaslétta peninsula, 100 km from Mývatn. These cliffs have mixed colonies of thick-billed and common murrelets (guillemots) (*Uria lomvia* and *U. aalge*) and razorbills (*Alca torda*). The Mánáreyjar islands, 8 km off the tip of the Tjörnes peninsula and 70 km from Mývatn have a small colony of razorbills (Gardarsson 1995). Puffins (*Fratercula arctica*) nest in large numbers in the islands of Grímsey, Mánáreyjar and Lundey (Skjálfandi bay) and in smaller numbers on the Tjörnes peninsula. In winter, both *Uria* species and the razorbill are common on the Skjálfandi bay, that part of the Arctic Ocean closest (50 km) to Mývatn, and the little auk (*Alle alle*) is not uncommon. The numbers of little auk seem to be temperature related, only few birds are observed in mild winters whereas in cold winters they occur by the thousand (Gunnarsson and Pálsson 1998). A sizeable eider colony is at the mouth of the river Laxá, but a small number of eiders nest along the river some 20 km upstream.

Bird Eggshells

Smooth textured pale blue-green bird eggshells have been found on most of the Mývatnssveit sites (excluding only Sveigakot), both as individual flecks and in concentrations suggesting a discarded entire egg shell. It is impossible to effectively quantify this material (which is hard to recognize *in situ*, preserves poorly, and is nearly impossible to recover effectively in the field), but wherever possible shell was recovered in whole soil samples and running logs of numbers

of egg concentrations were maintained during excavation. In 1998 one layer of midden fill of feature G at Hofstaðir (6j) produced 37 egg concentrations within a 2 x 2 m unit, illustrating the density encountered. At Hrísheimar in 2006 a dense carpet of egg shell averaging 1-2 cm in thickness covered a context approximately 1 x 2 meters in extent which rested directly upon the AD 871+/-2 Landnám tephra, indicating the long history of intensive egg collection.

Identification of the recovered egg shell fragments was carried out by Dr. Jane Sidell, making use of the SEM and reference collections of the Institute of Archaeology, University College, London. The samples were sieved through a 1mm mesh and then all egg shell was picked out. These then required additional cleaning prior to microscopy. To this end, each sample was placed in a water-filled beaker within a water filled ultrasonic tank. This process gently lifts dirt adhering to the individual pieces of shell without damaging them. The shells were then air-dried. Each sample was then scanned using a stereo microscope at magnifications of between 10 and 40 times. This was done in order to pick out superficial differences and ascribe types, based on gross morphology such as thickness and relative size of mammillae. Unusually, from these sites, some colour remained – generally colour is lost entirely as the colour of eggs is held within and organic cuticle that decays over time. In this case it would seem that some ground color (blue/grey) is present within the crystal structure. This cannot be relied upon as an identification criterion because color from the cuticle may have been lost, including characteristic speckling, although this has been retained in one sample, possibly through water logging. Some brown/yellow staining was also noted, and is assumed to derive from organic material present in the surrounding deposits rather than being natural shell color. Shell thickness was measured under the microscope, with a range from 0.225-0.55mm for the assemblage. Sub-samples were then selected for scanning electron microscopy (SEM) using a Hitachi SEM at an accelerating voltage of 10kv and using magnification of between 25 and 1500 times. Descriptions were made of the internal surface, counts made of the mammillae/mm² and photomicrographs taken, generally at 300 times with several taken at 800 times.

Species identification of archaeological eggshell is generally undertaken by collecting a series of measurements and using these in conjunction with superficial external description and detailed description of the internal surface. The resulting data are then compared with modern reference material. This procedure obviously relies on reasonable preservation of the archaeological material, and relies on the inherent assumption that shell characteristics of a species have not changed through antiquity. Some of the egg shell from Iceland has proved to be too damaged to identify, however, preservation of other fragments is remarkably good.

After processing over 1000 fragments from Hrísheimar, Hofstaðir, and Selhagi, it became clear that most of the archaeologically recovered eggs derived from waterfowl, with Ptarmigan egg shell the next most common. Also present were egg shell fragments from sea birds including murre or guillemot (middle sized

alcidae also represented by identified bone fragments) and a shearwater species (Table 14). Curiously, both waterfowl and marine bird eggs show evidence of interior surface changes associated with full term development or actual hatching. It seems likely that this pattern reflects the Viking Age origins of the ethnographically known early modern Icelandic practice of collecting near-term bird eggs and consuming the fully developed chick, bones and all. This is still a preferred bird egg consumption pattern in many parts of SE Asia and represents a nutritionally superior option to current Western practice of eating only “fresh” bird eggs. While quantification issues are hard to resolve, it may be worth noting that the ratio of the number of waterfowl egg concentrations identified in the field logs to recovered waterfowl bones identified in these collections is on the order of 100 to 1. Eggs (and probably preferentially full term embryos) were extensively consumed but adult waterfowl were rarely taken.

Fish

The Laxá river is one of the richest trout streams in all of Iceland, and today attracts fishermen from around the globe (providing a major source of income for modern residents). Arctic charr are found in most lakes, and are abundant in Mývatnssveit, historically providing a major subsistence resource. It is thus not surprising to find large quantities of trout (*Salmo trutta*) and charr (*Salvelinus alpinus*) bone in the Mývatn archaeofauna. More surprising was the presence of substantial amounts of marine fish bone on sites up to 70 km from the coast. As Table 15 indicates most of these marine fish were of the cod family (gadidae), but some flatfish and wolf fish have also been identified. Note that the presence

Table 15	Fish species identified						
	Site	SVK 1	SVK 2	SVK 3	HST G3	HST G4	HRH
<i>Gadus morhua</i>	Atlantic cod	9	47	137	475	861	193
<i>Melanogrammus aeglefinus</i> .	Haddock		41	28	202	248	20
<i>Pollachius virens</i> .	Saithe		1	63	21	35	12
<i>Molva molva</i>	Ling			15			
<i>Brosme brosme</i>	Cusk					2	
Gadidae, species indet.	Gadid family	18	89	211	1,071	1,485	167
<i>Hippoglossus sp.</i>	Halibut				2	3	
<i>Anarhichas lupus</i>	Wolf fish				2	1	
<i>Salvelinus alpinus</i>	Arctic charr	15	227	341	693	1,409	809
<i>Salmo trutta</i>	Brown trout	8	94	111	3,413	4,058	684
<i>Salmo salar</i>	Atlantic salmon			1		4	
Salmonidae, species indet.	Salmonid family	114	967	893	2,082	3,329	585
Fish, species and family indet.	Fish species	105	641	899	1,720	4,113	405

of a few definite Atlantic salmon bones (*Salmo salar*) also indicate connections outside Mývatnssveit, as these fish do not ascend the Laxá beyond its lower reaches. Due to the taphonomic differences between the area G middens and

the high traffic, high dog activity E [1144] midden and the floor layers at Hofstaðir only the area G fish data is used here for comparative purposes. Figure 35 presents the relative proportions of marine and freshwater fish present in the archaeofauna from Sveigakot, Hrísheimar, and area G middens at Hofstaðir. While there is some variation between phases and sites, marine fish bones make up a substantial portion of the identified fish bones (ca. 15-25%). This graph understates the importance of marine fish, as the marine species are all represented by very partial skeletons, while the freshwater fish are represented by bones from the whole skeleton (Amundsen et al 2005, McGovern, Perdikaris, Einarsson & Sidell 2006).

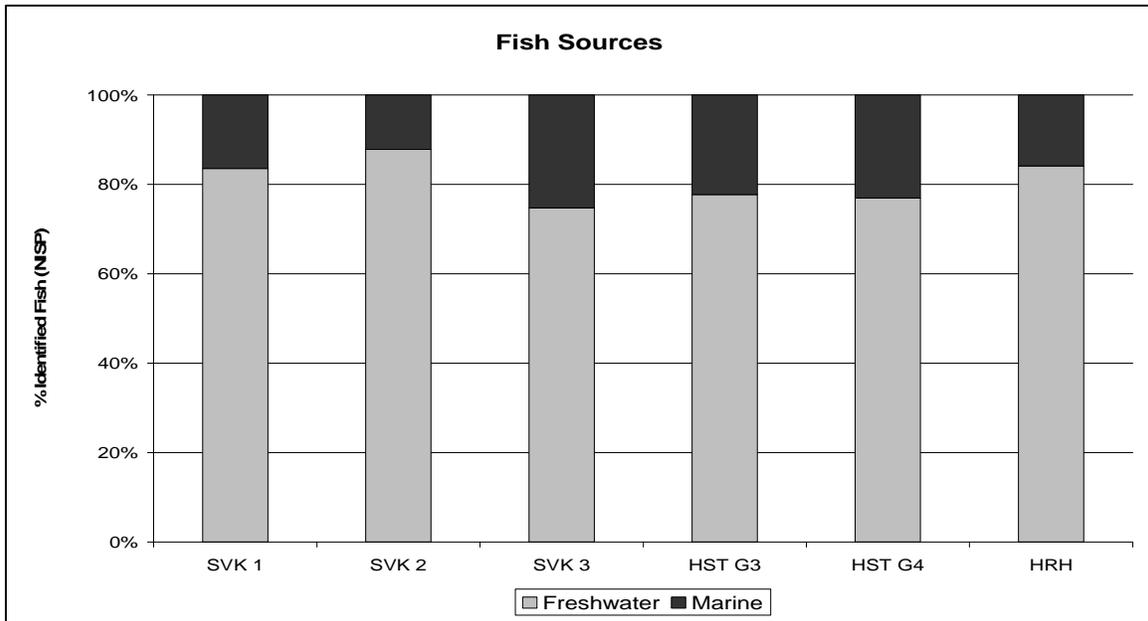


Figure 35

Freshwater fish species distribution is illustrated in figure zz 36. Hofstaðir has some of the best access to the Laxá trout stream in Mývatnssveit, so it is not surprising that it has a higher ratio of trout to charr than the Kráká drainage sites.

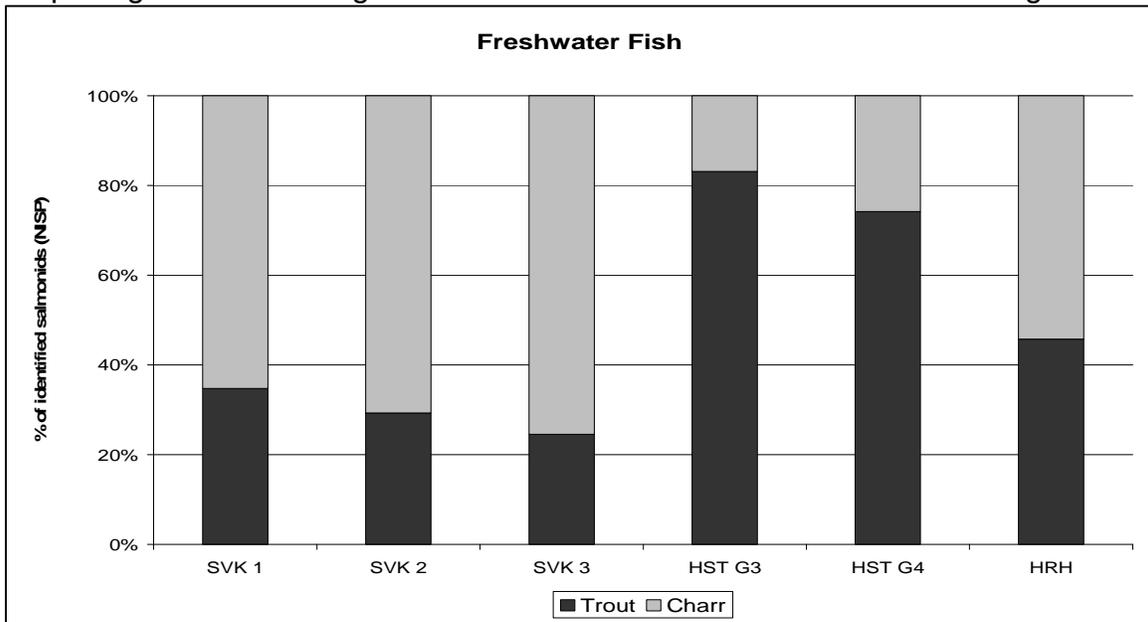


Figure 36

Drainage patterns have changed dramatically in the Kráká area since the Viking Age (McGovern, Perdikaris, Einarsson & Sidell 2006, Lawson et al. 2006) and it is likely that the Kráká and some smaller streams near Hrísheimar may have had larger quantities of trout than at present.

Figure 37 presents the relative proportions of the identified marine fish from the larger Mývatnssveit archaeofauna. While cod make up the majority of the identified elements, haddock, saithe, and (at Sveigakot 3) ling also contribute significantly to the total. Note the apparent difference in marine fish consumption at the roughly contemporary Sveigakot 3 and Hofstaðir G4 phases, with more ling and saithe and less haddock being consumed at Sveigakot.

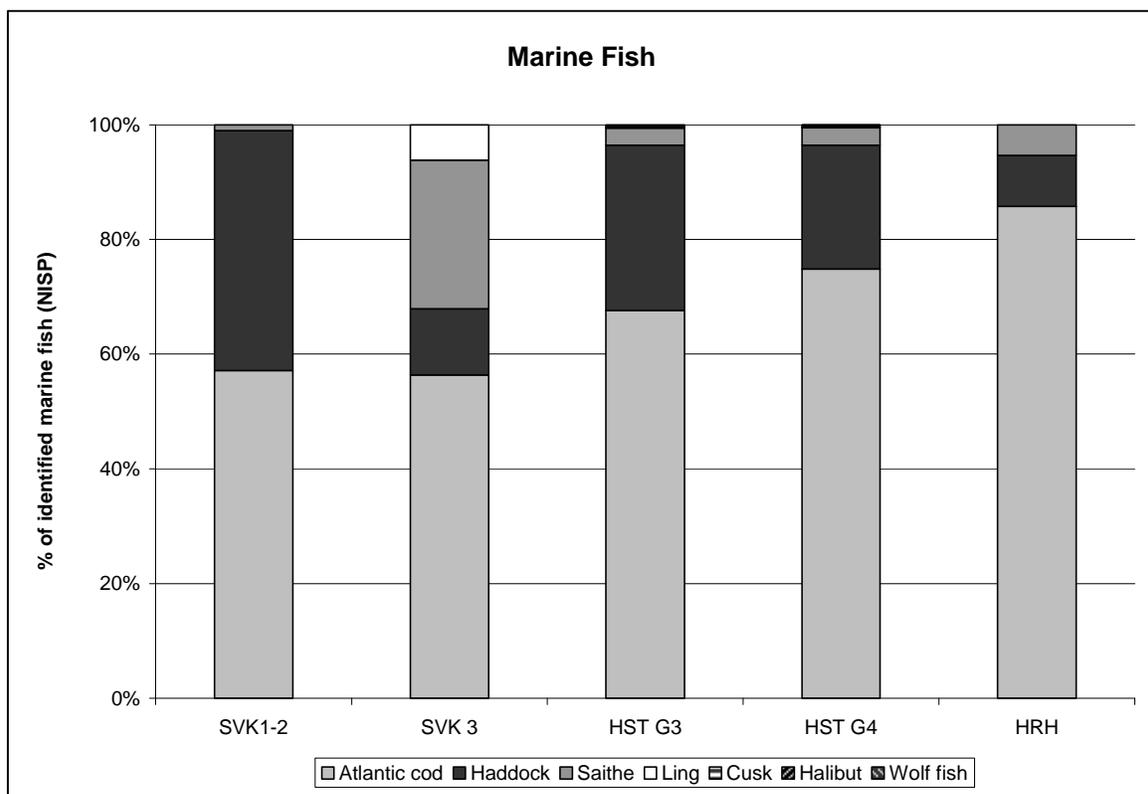


Figure 37

Fish element distribution suggests a strong contrast between marine and freshwater species. Table 16 presents the freshwater fish skeletal elements in the Mývatn archaeofauna. The salmonids are effectively represented by the whole skeleton; head, full vertebral column, and fin rays.

Table 16 All Salmonids

<i>site</i>	<i>SVK 1</i>	<i>SVK2</i>	<i>SVK 3</i>	<i>HST 3</i>	<i>HST 4</i>	<i>HRH</i>
<i>Element</i>						
Ethmoid						
Prefrontal			1			
Vomer		2			1	
Mesethmoid		1			1	
Alisphenoid						
Parasphenoid		15	21	40	43	96
Orbitosphenoid						
Supraoccipital				3	1	
Exoccipital			3	16	11	4
Basioccipital			7	7	24	4
Sphenotic				2	1	2
Pterotic		1	4	6	11	10
Epiotic		6	8		20	8
Opisthotic						
Prootic				10	5	8
Otolith						
Nasal						
Frontal		2	2	9	4	6
Parietal						
Supratemporal						
Premaxilla		2	2		4	58
Maxilla		9	6	10	21	11
Supraorbital						
Lachrymal						
Suborbital				3	6	
Dentary		27	26	66	68	57
Angular		40	63	74	97	46
Retroarticular						
Suprapreopercle						
Preopercle		3	3	24	7	
Supramaxilla						
Opercle		4	17	24	9	6
Subopercle				2		13
Interopercle		2		4	24	12
Branchiostegal Ray		1	4		17	9

Palatine		3	6	6	6	11
Ectopterygoid						
Quadrate		19	31	14	62	25
Mesopterygoid		1		19	11	17
Metapterygoid		1	7	17	16	21
Hyomandibular		30	44	97		17
Symplectic		1				
Interhyal						
Epihyal		12	9	15	30	34
Ceratohyal	1	37	53	66	93	17
Hypohyal				1		
Basihyal						
Pharyngeal Plate				5	8	2
Epibranchial		1		1	6	16
Ceratobranchial		2	4	7	76	
Hypobranchial		2	4	1		
Basibranchial						
Basibranchial Plate						
Urohyal		2	5	29		11
Pharyngobranchial			1	1	1	8
Posttemporal			4	4	1	6
Supracleithrum			4	5	3	
Scapula		2	2	5	13	2
Cleithrum				3	14	7
Postcleithrum					44	
Coracoid		11	10	23	49	17
Mesocoracoid			1		2	
Radials						
Basipterygium	1	19	11	45	73	18
Interrhaemal Spine			2	9		1
Vertebral Frags	8	9	51	62	675	20
Atlas	1	9		10	38	102
Thoracic		239	33	1044	1540	85
Precaudal	13	158	301	909	969	158
Caudal	40	533	559	3432	4644	944
Penultimate			4		3	
Ultimate			2	1	2	7
Hypural		2	1	11	37	10

Uroneural					50	
Epural						
Caudal Bony Plate				7		
Expanded Neural Spine						
Expanded Haemal Spine						

Table 17 presents the combined Gadidae marine fish element distribution data, showing a concentration of bones from the lower vertebrae and the cliethrum and associated bones. Mouth and upper skull bones are very rare, and the dense and easily identified premaxilla is completely absent.

Table 17	All Gadidae						
	site	SVK 1	SVK 2	SVK 3	HST G3	HST G4	HRH
<i>Element</i>							
Ethmoid							
Prefrontal					1		
Vomer							
Mesethmoid						1	
Alisphenoid							
Parasphenoid					6	3	
Orbitosphenoid							
Supraoccipital					10	13	
Exoccipital							
Basioccipital					2	10	
Sphenotic							
Pterotic						4	
Epiotic						3	
Opisthotic							
Prootic						1	
Otolith							
Nasal					1		
Frontal							
Parietal							
Supratemporal							
Premaxilla							
Maxilla					3	7	
Supraorbital							

Lachrymal						
Suborbital						
Dentary						
Angular			1	1		
Retroarticular						
Suprapreopercle						
Preopercle				1	1	
Supramaxilla						
Opercle					2	
Subopercle						
Interopercle						
Branchiostegal Ray		1	3	4	21	
Palatine						
Ectopterygoid				1		
Quadrate			1			
Mesopterygoid					8	
Metapterygoid						
Hyomandibular				4		
Symplectic						
Interhyal						
Epihyal						
Ceratohyal		1		4		2
Hypohyal						1
Basihyal						
Pharyngeal Plate						
Epibranchial						
Ceratobranchial				2		
Hyporanchial				1	1	
Basibranchial						
Basibranchial Plate						
Urohyal				2		
Pharyngobranchial						
Posttemporal				1	3	1
Supracleithrum		1		3	20	
Scapula	3	20	44	79	154	17
Cleithrum		18	114	831	1117	87
Postcleithrum	1	16	30	224	391	20
Coracoid				29	40	5

Mesocoracoid						
Radials						
Basipterygium		2	1	16	24	
Interrhaemal Spine						
Vertebral Frags	12	17	7	43	45	4
Atlas		1				
Thoracic		5	10	2	9	2
Precaudal		3	50	2		1
Caudal	11	77	193	470	824	251
Penultimate						
Ultimate						
Hypural				4	11	1
Uroneural						
Epural						
Caudal Bony Plate						
Expanded Neural Spine						
Expanded Haemal Spine						

This pattern is very consistent between phases and between sites, irrespective of sample size variability. It is not likely to be a product of differential bone survival, as the gadid mouthparts and upper vertebrae are dense bones commonly recovered from other sites in Iceland and the North Atlantic, and are substantially larger, more robust, and easier to recover than the smaller and more fragile salmonid elements or the smaller gadid caudal vertebrae. The usual method of preparing dried fish for consumption in Iceland in later time periods involved pounding with a stone hammer to tenderize the hard cured flesh, which also tends to disproportionately damage or totally destroy the smaller caudal vertebrae. Taphonomic attrition would thus tend to work against the patterning we see in the marine fish element distribution.

The head and variable amounts of the upper vertebral column have apparently been filleted away and discarded at the distant fishing station supplying the processed fish. The common upper body parts found inland are the cliethra and associated bones, all traditionally left in cured fish products to help hold the beheaded body together and aid in spreading and drying the opened upper body cavity (Perdikaris 1999; Amundsen *et al.* 2005; Barrett 2005, Barrett *et al.* 1997, 2000; Krivogorskaya *et al.* 2005).

In later historic times, several different air dried fish products were being made without the use of salt in the North Atlantic. This air dried product could last without further treatment for up to seven years, and provided the basis for the

major economic engine of the later medieval fish trade. The most famous product was the round-dried “stockfish” or *skreið*, which was produced from a gutted and beheaded fish hung up to freeze-dry in winter on racks. This round-dried stockfish required a consistent and narrow temperature window within a few degrees of freezing, and good exposure to wind to ensure complete drying. These requirements have historically tended to limit intensive stock fish production to the Lofoten and Vesteraalen islands of arctic Norway, and stockfish was not regularly produced in southern Norway (Perdikaris 1999). Stockfish can be made successfully in many localities in Iceland, but drying racks often have had to be carefully located, often on hilltops some distance from convenient landing places. A flat dried product in which the body cavity is opened up entirely and the upper (thoracic and many pre-caudal) vertebrae are filleted away) can be successfully prepared under a wider range of environmental conditions, and was the typical product of much of the Northern and Western British Isles as well as southern Norway (Perdikaris & McGovern 2007). This flat dried product was called *rotscher* in medieval Norway, but it may be most useful simply to use the more neutral terms “round dried” and “flat dried” to distinguish the zooarchaeological signatures for the two product types.

Figure 38 presents the vertebral element distribution for the marine Gadidae from Sveigakot, Hofstaðir G, and Hrísheimar (preliminary data) as percent of MAU (a complete fish vertebral column would thus have precisely equal amounts of each element). This patterning suggest that Sveigakot was being regularly provisioned with some round-dried marine fish as well as flat dried products, as substantial (but not naturally proportionate) numbers of upper vertebrae are present. At Hofstaðir and in the completed contexts at Hrísheimar, the pattern suggests that most or all of the marine fish reaching these sites arrived as a flat dried product.

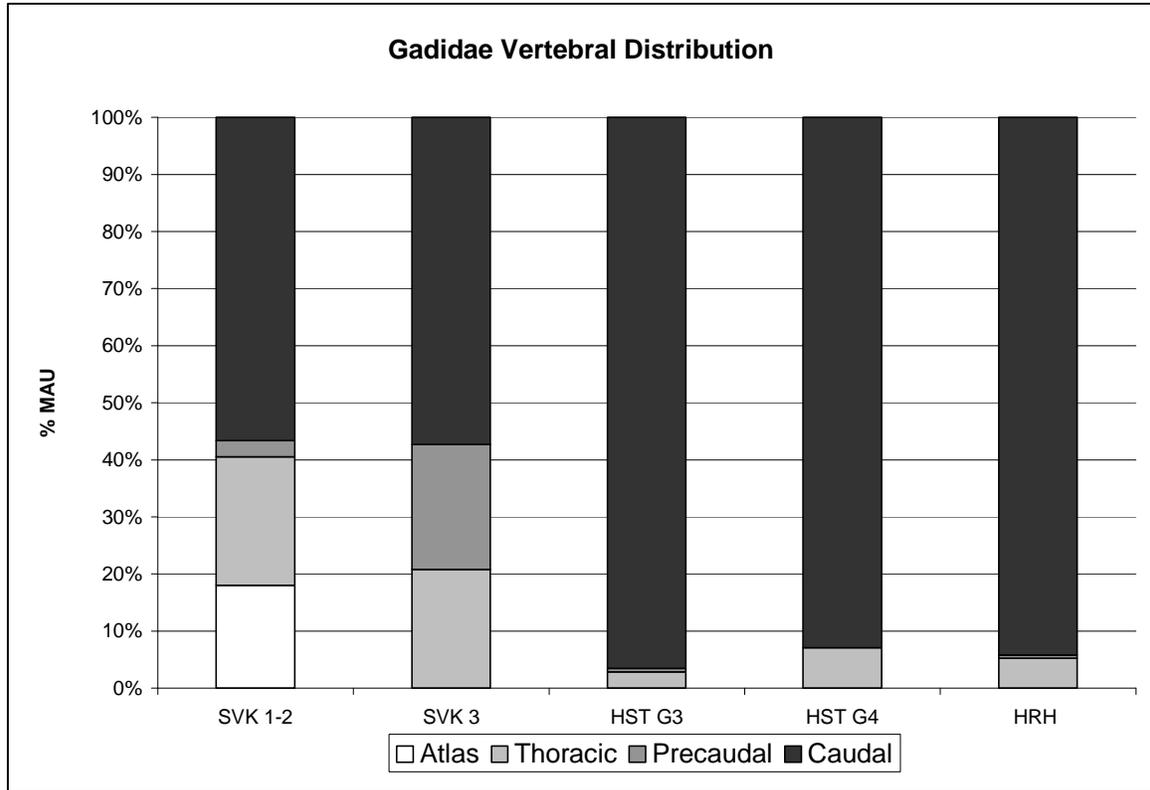


Figure 39

This pattern of element distribution on the Mývatn settlement period sites indicates that early settlers made extensive use of freshwater fish in both lakes and streams but also felt the need to regularly acquire cured marine fish from some coastal location, probably Skjalfandi bay to the north. The dense Haddock cliethrum was regularly available in sufficient numbers to provide a favored raw material for the carving of gaming pieces in Mývatnssveit (including most of the famous set of “fox and hounds” recovered from a Viking Age burial at Baldursheimar in the late 19th century and a later medieval post-crusades Muslim-style chess piece from the small site of Steinbogi). The contrast between these nearby sites in the type of marine fish product being consumed raises some questions about patterns of acquisition and distribution of marine products to these inland Viking Age farms.

Invertebrates

Some fragments of marine shellfish have also been recovered from the Mývatn sites, including very worn and battered clam shells (*Mya sp.*) which could have served as spoons or another artefactual use (clam shells have also been recovered from the 10th century inland site of Granastaðir in Eyjafjörð district, Einarsson 1994). Especially at Hofstaðir and Hrísheimar, numbers of tiny (2 cm long and smaller) mussel shells (*Mytilus edulis* L.) were found in concentrations in the midden layers, often partially burnt and in ash-rich contexts (table zz18). These are unlikely to be part of direct human diet (some were recovered still closed) but the concentrations resemble those found in the root ball of sea weed

(*Laminaria* sp.) collected after storms in several locations along the shores of Skjálfandi Bay to the north. These may well be associated with sea weed collection for fodder, bedding or for salt extraction (involving burning) documented at other Norse sites throughout the North Atlantic (Buckland 2000). The concentration of these tiny mussels at Hofstaðir and their association with ash layers may reflect particularly intense salt production efforts at this site.

Table 18 SVK 1- 2 SVK 3 HST G3 HSTG 4 HRH

Common mussel <i>Mytilus edulis</i> L.	6		116	22	13
Clam species indet.	2	1	21	7	14
Shellfish species indet.	6		81	376	11
total Mollusca	14	1	218	405	38

Figure zz_40 illustrates the concentration of these small mussel shells in a few (ash -rich) contexts in the G midden fill area. These fragments are not distributed evenly over the site, and their concentration suggests their association with some discrete activity; perhaps periodic salt extraction events.

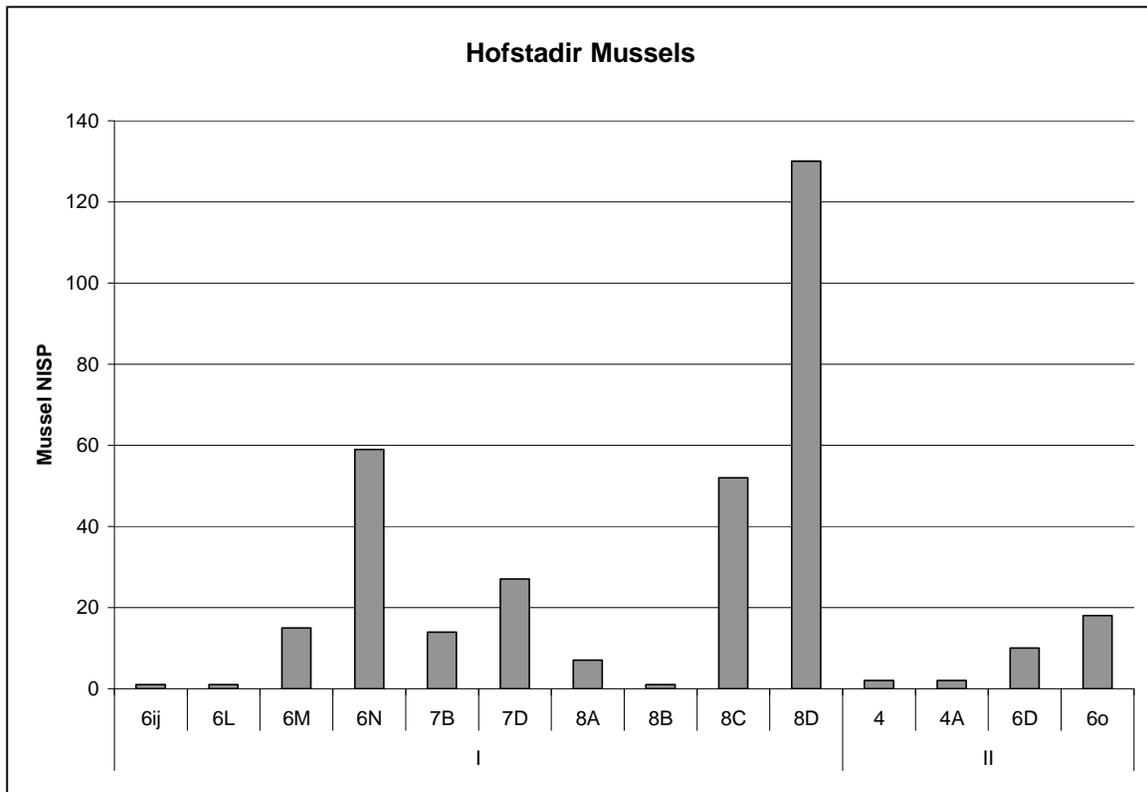


Figure 40

Cattle Skulls and Ritual Activity

While the great majority of the bone fragments recovered from the excavations at Hofstaðir in 1996-2001 appear to represent the normal refuse generated by a Viking age working farm, some cattle skull fragments discovered in and around the great hall appear very different from those found elsewhere on site or in other Icelandic archaeofauna. A minimum of twenty three individual cattle skulls recovered outside the great hall (A/B) show evidence of specialized butchery and prolonged display on the outside of a structure. Butchery marks include depressed fracture of the frontals caused by a heavy and immediately fatal crushing blow between the eyes, and (where the base of the skull is preserved) a powerful shearing blow which would have beheaded the animal. Horn cores were left attached, and not removed for horn craft working (an otherwise universal use of horn and horn cores). Marked surface weathering is present on the upper (external) surfaces of skull bones, with lower, interior surfaces remaining un-weathered, suggesting differential exposure to wind and weather. At least two different styles of presentation are represented by these specimens; one comprising the “full face” of a skull with only the lower jaw removed, the other comprising a “horn rack” with only the frontal bones and attached horn cores present, and the lower face cut away prior to mounting. Differential weathering indicates that the specimens were displayed face outwards, and that they remained exposed to weathering for months or years after the soft tissue had decayed.

Two skulls were found in the wall demolition deposits along the exterior walls of the great hall (context [15]). These two specimens were discovered lying face down (with their weathered surfaces downward), approximately 75 -80 cm apart. A third specimen was recovered from wall demolition deposits in area E (context [1056]). The rest of the skulls were concentrated in a pit (context [159]) in the out-shot room A2 of the great hall (14 specimens) or in the demolition fill of room D (context [62], 5 specimens). The two skull dumps appear to represent the deposit of skulls collected during the demolition of the great hall and probably do not provide direct evidence for their original placement.

Where tooth rows are attached, the age of death ranges from just fully grown to middle aged adult; a pattern very different from the “dairy economy” profile of many newborn and a few very old animals normally observed on Icelandic farm sites. The skulls include both two naturally polled (hornless) cattle and seven individuals with measurable horn core bases. The measurable horn cores produce basal minimal diameters indicating that the majority of the cattle (five of seven) were definitely bulls.

AMS radiocarbon age determinations on five skulls (three from context A2 [159] and two from context D [62] have been kindly provided by Dr. Gordon Cook of SUERC. These indicate that the skulls came from animals who died up to 50 - 100 radiocarbon years apart from each other, and that the latest deaths occurred

near the year 1000 AD. Both the area D and A2 skull dumps contained a spread of AMS age determinations.

At approximately the same time the cattle skulls were deposited in the pit in room A2, a naturally polled female sheep was killed by a blow between the eyes (unlike normal caprine butchery but identical to the damage to the cattle skulls) and its un-butchered, still articulated body was left beside the pit filled with cattle skulls. This unusual deposit is probably best understood in a ritual rather than strictly agricultural context, and seems to be associated with the act of demolition of the skali and burial of the skulls. Two phases of potential ritual activity are thus represented by these deposits; the initial killing of the cattle and the mounting of their heads in the 10th-early 11th c, and a perhaps apotropaic slaughter of a sheep at the close of demolition work on the skali (Lucas & McGovern 2008).

Summary Skull Data

Table 19 presents the twenty three cattle skull specimens which exhibit most or all of the key characteristics (differential weathering, frontal depressed fracture, un-cut horn cores), with context number (1-24, replacing alphabetic designations in interim reports), horn core basal minimum diameter (cranial metric number 45 following Von Den Dreisch 1976), notes, and the available AMS dates as uncalibrated radiocarbon years BP. All of the fragments were tested for inter-connection, and all refits have been combined under a single specimen number. At least 23 different individual cattle are represented in this collection, and other fragments not included in this table may in fact represent pieces of additional skulls too fragmented to positively identify. Table 1 thus probably presents a minimum rather than a maximum listing of prepared skulls present at Hofstaðir.

<i>Species</i>	<i>ID #</i>	<i>Context</i>	<i>HC (45) Diameter</i>	<i>Notes</i>	<i>C14 Uncalib.</i>
Cattle	1	15		naturally polled, beheading cut	
Cattle	2	15	R 6.16, L 6.14	Bull	
Cattle	3	A2 159		naturally polled	
Cattle	4	A2 159	R 6.14, L 6.10	Bull	
Cattle	5	A2 159			
Cattle	6	A2 159			BP 1110+/-35
Cattle	7	A2 159			BP 1035+/-35
Cattle	8	A2 159			BP 1015+/-35
Cattle	9	A2 159			
Cattle	10	D 62			BP 1065+/-35
Cattle	11	D 62			BP 1120+/-35
Cattle	12	D 62	5.84	Bull	
Cattle	13	E 1056			
Cattle	14	A2 159			
Cattle	15	D 16			
Cattle	16	A2 159		paired halves of maxilla	

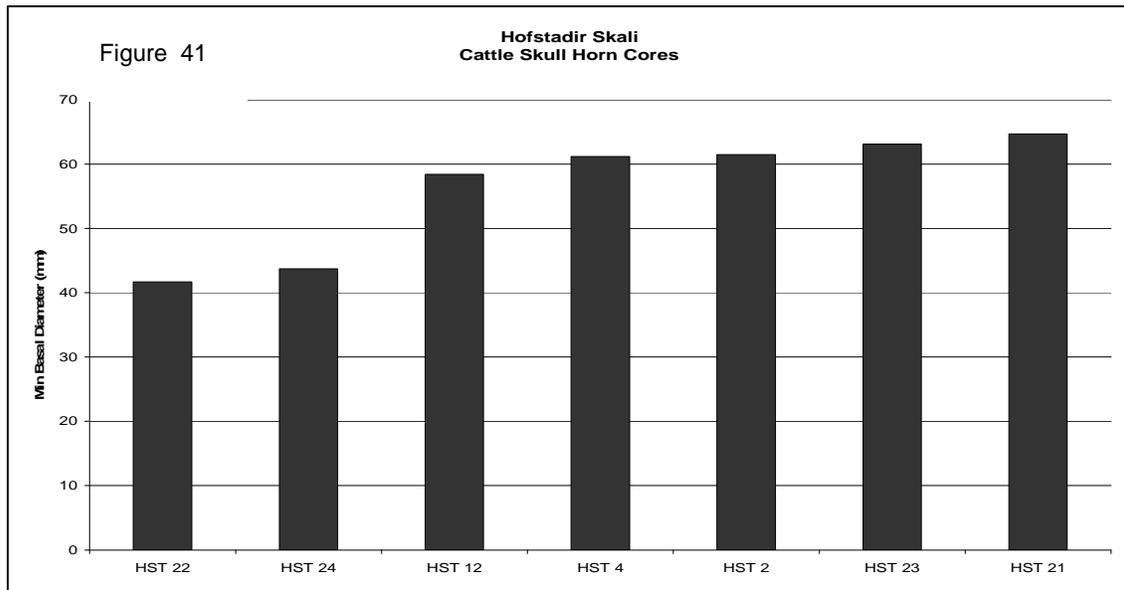
Sheep	17	A2 159		naturally polled sheep
Cattle	18	D 62		beheading cut
Cattle	19	D 62		
Cattle	20	A2 159		
Cattle	21	A2 159	6.47	Bull, beheading cut
Cattle	22	A2 159	4.17	cow?
Cattle	23	A2 159	6.31	Bull
Cattle	24	A2 155	4.37	cow?

Table 20 presents the tooth eruption and wear for the seven skulls with maxillary bones and upper tooth rows present. The maxillary tooth wear stages have not been so heavily studied by zooarchaeologists as the mandibular tooth rows (Grant 1982), but they can be broadly grouped into light wear (lw; approximately Grant stages A-E), medium wear (mw; approximately Grant stages F-H) and heavy wear (hw; approximately Grant stages >H).

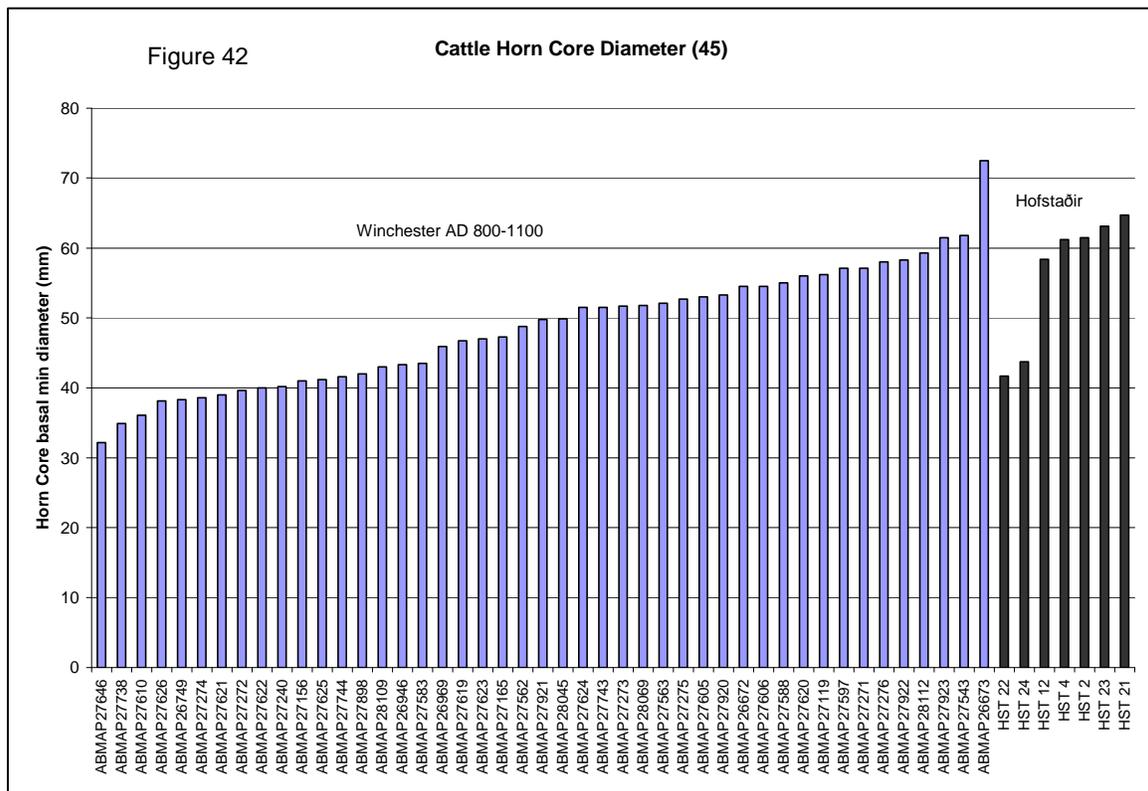
Specimen	dp4	P3	P4	M1	M2	M3
1	mw			lw	crypt	
3		mw	mw	mw	mw	lw
6			mw	mw	lw	lw
8					mw	
9		missing	missing	lw	lw	missing
11				mw	mw	lw
13			erupting	mw	mw	lw
15			missing	missing	mw	lw
16			mw	hw	mw	mw
20			Crypt	mw	lw	erupting

These eruption and wear patterns indicate that two of the eight cattle (specimens 1 and 20) were not yet fully mature, with some adult dentition still erupting. These heifers would have been near their full adult size, and would have provided approximately the same dressed meat weight as a full adult. The other cattle show only lightly worn second and third adult molars (M2 & M3), indicating that these were adult but still fairly young animals. These cattle are thus not simply elderly dairy cows at the end of their productive lifespan (the off-take of the normal dairy economy) but animals in their prime, with many potentially productive years ahead of them. In conventional zooarchaeological terms, these animals would better fit a 'meat production' rather than a 'dairy production' harvest profile.

Still more unusual is the ratio of male to female cattle in this sub-group. Sexing animal bones in zooarchaeology depends largely on morphology of pelvis and horns (where available) combined with overall stature reconstruction. As many workers have noted, modern animals often provide a poor analog to ancient breeds, and size and morphology differences between both modern and ancient cattle populations can be extreme (Crabtree 1990, Cussans et al. 2002). Norse North Atlantic cattle from Iceland, Hebrides, and Greenland known from zooarchaeology tend to be small (usually reconstructed stature below 125 cm at the shoulder), with sexual dimorphism much reduced from their wild ancestors (see review in Enghoff 2003). Overall, the Hofstaðir cattle resemble other Icelandic and North Atlantic cattle in reconstructed size and overall skeletal conformation (short, stocky, large headed, with small slightly curved horns). Five



of the seven skulls carrying measurable horn cores are relatively robust, with broad frontals and comparatively wide horn core bases. Figure 41 presents the minimum diameter of the measurable horn core bases, indicating the contrast between the horn cores around 60 mm and those between 40 and 50 mm in diameter (Von Den Dreisch 1976, cranial metric 45). A broader perspective may be provided by a comparison with Viking Age-Early Medieval Anglo-Saxon cattle from Winchester (Animal Bone Metrical Archive 2003 [www:ads.ahds.ac.uk](http://www.ads.ahds.ac.uk)). These Anglo-Saxon cattle are also a comparatively small bodied early medieval type, but come from a far richer farming environment, so the placement of the larger Hofstaðir horn cores near the upper end of the Winchester distribution may be particularly telling (figure 42). These Hofstaðir skulls are almost certainly mature bulls, and appear to be large bulls by the standards of both the Norse North Atlantic and contemporary Wessex.



This concentration of bull skulls is particularly surprising in light of the dairy economy profile of the other Viking Age Icelandic sites and in most other Norse N Atlantic archaeofauna, as dairy bulls were expensive and rare animals in most pre-modern agricultural settings. The land survey of the *Jarðabók* lists cattle by age group and sex, and the 1712 entry for Mývatn and Reykjadalur indicates a ratio of “young bulls” to milking cows as 1 : 33 for Mývatn and about 1:10 for the larger and then much more prosperous Reykjadalur (JAM 1990) . By the 18th c., Icelandic dairy farmers were economizing right up to the biological limits of their stock, and “young bulls” listed in *Jarðabók* were not adults like the 10th c Hofstaðir animals but late adolescents raised just to puberty, bread widely and then slaughtered before they reached their full growth weight (and maximum fodder consumption level). The Viking Age bulls represented by the Hofstaðir skulls were thus far more expensive than their 18th c younger counterparts. It appears that more mature bull skulls decorated the great hall at Hofstaðir by AD 1000 than live bulls existed in any part of Mývatn in AD 1712 (table 5).

Description of Specimens

Specimen 1: The first individual is roughly a right half-cranium divided down the mid line including the occipital, frontal, parietal, and maxilla, but lacking the premaxilla. The only fragment of the left half of the skull is the left occipital condyle. One tooth (M1) is in the maxilla, and a second (P3) is loose but clearly associated. The dentition indicates an old juvenile/young adult with the adult M1

just coming into wear and the M2 and M2 still in crypt (unerupted). In developmental terms this would be a young animal but close to full adult size. The fragments here represent the side of the face of the animal, but without the jaw present. Note that this animal was naturally polled (hornless), which is a genetic trait found skeletally in other specimens from late medieval and early modern Iceland and from Norse deposits in Greenland (Amorosi 1996, McGovern 1985). This would have been a low frequency trait in Viking age-early medieval times; with the great majority of cattle of both sexes carrying horns (note that the later Grágás code anticipates that “legal cattle” will be horned). There is a marked depressed fracture in the frontal, just behind the eye socket. Running across this depression is a straight cut mark made by a metal instrument with a blade at least 5 cm long (and probably double this). The bone around the cut mark shows slight but not marked crushing, suggesting a blow (rather than a slice), but one that was probably somewhat cushioned at the point of impact by skin and tissue. The blow was thus probably delivered to the face of an animal rather than to a bare skull. The cranial fracture along the mid line is certainly partly the result of the impact fracture, and does not show and clear signs of further cutting. The skull of most cattle and caprines tends to come apart along the mid line, especially if a strong blow has been delivered to the mid line of the cranium as in this case. Note that the specimen is in good condition overall with little weathering apparent on interior surfaces and only minor exfoliation on the exterior surfaces. This skull was found in the wall collapse (context [15]) along the south west corner of the skali, lying on its side next to specimen 2.

Specimen 2: The second animal from context [15] is represented by a paired left and right frontal and horn core set, the two halves were found close together in excavation, lying face down in the wall collapse about 75 cm from specimen 1). The frontal extends down to the orbit, but the occipital and maxilla have been broken away prior to deposition. The halves match perfectly along the mid line and were probably attached together before being broken apart at burial- the fracture edges are not abraded and match closely. While teeth area absent the fusion state and the surface character of the frontals indicate a fully mature individual of a conformation similar to modern Icelandic cattle, with horns moderate in length and carried straight and only slightly curved forward and upwards. From the size of the horn cores this animal is most likely to have been male (bull). This animal also shows a clear depressed fracture on the midline of the frontal just above the eyes. No cut marks are visible, but the depressed fracture was clearly caused by a strong blow. This specimen is far more heavily weathered than specimen “A” and the weathering is not evenly distributed. The bones of the interior of the cranium have smooth surfaces showing little weathering, while the exterior (front) surface shows extensive checking, cracking, and localized exfoliation. This weathering is consistent with the bare bone being exposed for some time (months or years) to direct contact with sun, wind, and rain. Note that when excavated this specimen was lying face down, not face up, and the differential weathering must have occurred at some point before the specimen was broken and deposited where it was found. The clean nature of the

break along the sagittal midline indicates that the specimen was only broken at or shortly before burial and it would have been a single piece prior to the demolition of the wall. The lower face was removed prior to mounting, so that (unlike skull 1) skull 2 would have been presented as a rack of horns connected by frontal bone rather than a nearly complete skull.

Specimen 3: The skull 3 is represented by left maxilla and most of the frontals, temporals, and occipital bones. Like specimen 1 this individual is naturally polled (hornless). Specimen 3 also has a large depressed fracture between the eyes. No healing was observed in the margins of this massive wound, and it certainly caused the animal's death. This specimen was found along with 14 other cattle skulls in the pit (context [159] in the outshot room A2). The entire skull was probably originally present, and was broken (and the right maxilla lost) prior to final deposition in context [159]. Skull 3 showed substantial weathering on the external surface of the frontals, extending to the penetration of the compact bone surface around the right orbit. This degree of weathering again suggests exposure in a fleshless or partly de-fleshed condition for some time (months or years). The interior surface of skull 3 was un-weathered and in essentially fresh condition, suggesting that it had not been exposed in the same way. The right occipital condyle has been sheared off by a powerful blow from above by an axe or heavy cleaver, probably detaching the head with one stroke.

Specimen 4: Skull 4 is also from the pit deposit of context [159], and also shows evidence of massive trauma. A depressed fracture between the eyes extends into the brain case below, certainly a fatal wound (figure 43). This individual was the largest in the group, and the conformation of the frontals as well as the minimum basal horn core diameter (R 61.4 mm, L 61.0 mm) suggests that it is a bull (though of the small Viking-medieval type). This skull lacks maxilla or lower



face, and these seem to have been removed during the initial preparation of the cranium rather than being broken away when the skull was disposed of in the pit context [159]. Note that while the ends of the horn cores have subsequently broken away, they were not cut from the frontals during initial butchery for horn extraction, as was the normal practice. In its original condition, this specimen would have had a full rack of horns. The external surface of the skull is heavily weathered, showing flaking and exfoliation of the compact surface, while the interior surface is again comparatively smooth and un-weathered. Again this pattern suggests prolonged exposure of a fleshless skull for a period of months or years. This specimen seems to have been additionally modified by having nearly the whole occipital (base) of the skull removed, possibly to make the frontal rest flat against a surface. Thus skull 4 resembles skull 2 in its preparation and presentation as a rack of connected horns rather than a full – faced skull.

Specimen 5 : Skull 5 appears to have shattered into five major fragments when deposited in the pit [159], and is represented by parts of the occipital, parietal, and frontals. The skull originally had horn cores but these have been broken off and were not associated with the smashed cranial elements. The five fragments refit with each other but not with any other cattle skull fragments from context [159]. It is possible that it was originally a full-faced preparation like skull 1, but this cannot be proven given the damage suffered when it was thrown in the pit.

Specimen 6: Skull 6, context [159] comprises most of the frontals and the right zygomatic and maxilla of a cattle skull with a depressed fracture between the eyes. The horn cores are now missing, but seem to have been lost to decay or damage when the skull was placed in the pit, as there are no cut marks around the base of the horn cores. The three fragments fit together, and represent the remains of a “full face” preparation like that of skull 1, but with a horned individual. Measurements of basal diameter were not possible, but the animal seems more similar to the smaller specimens than the larger bulls. This specimen produced an AMS radiocarbon date of BP 1110+/-35.

Specimen 7: Skull 7, context [159] comprises a set of cattle frontals with attached horn cores, partial parietals and part of the occipital. The skull again shows effects of a massive crushing blow between the eyes, which produced a depressed fracture extending into the brain case and which would have been immediately fatal. This skull is very similar in preparation to skull B, comprising the same set of elements and also exhibiting considerable weathering on its upper surface but little or none on its lower surface. This skull is much smaller than skull B and probably does not derive from a bull. This specimen produced an AMS radiocarbon date of BP 1035+/-35.

Specimen 8: Skull 8, context [159] is represented by a cattle maxilla and premaxilla, with a single surviving second molar (M2, Grant wear state g). Differential weathering is again present, with the exterior surface showing flaking and exfoliation, and the interior surface showing nearly undamaged compact bone surface. This specimen produced an AMS radiocarbon date of BP 1015+/-35.

Specimen 9: Skull 9, context [159] is an isolated left cattle maxilla that cannot match any of the other cranial fragments. It is a juvenile with nearly unworn first and second molars, and like specimen 9 shows differential weathering on surface and interior.

Specimen 10: Skull 10 is a nearly complete left cattle maxilla with part of the zygomatic bone. It has fully adult dentition, but the wear on premolar 4 and molar 3 indicates that this was not an aged individual. Again, differential weathering is very evident. This specimen did not come from the pit context in room A2, but from context [62] in room D2, phase III. Four other skulls came from the same

context in D2, and it appears that a second dump of skulls (perhaps removed from the West side of the skali?) was created in this area during demolition of the great hall. This skull provided an AMS radiocarbon date of BP 1065+/-35

Specimen 11: Skull 11 is also from room D2, context [62], and comprises a cattle right maxilla and premaxilla with part of the left premaxilla attached. Heavy weathering is present on exterior surfaces but not on interior surfaces. Adult dentition is present, with the third molar (M3) showing only light wear, again suggesting a fully grown but not aged animal.

Specimen 12: Skull 12 is also from context [62] and comprises a cattle frontal with attached right horn core. This specimen shows a strongly depressed fracture in the frontals between the eyes and heavy weathering on the exterior (but not interior) surface. The broad horn core and conformation of the surviving frontals suggest a bull. This specimen, like skulls 2 and 4, was prepared as a rack of horns rather than a full-face preparation.

Specimen 13: Skull 13 is from context [1056] area E (3) phase III. This fragment is a cattle right maxilla with tooth row intact, showing differential weathering. The eruption and wear pattern suggest that this is an animal just reaching its full growth, with adult dentition just coming into wear.

Specimen 14: Skull 14 is from context [159] area A2, and comprises a cattle occipital bone with a shearing cut across the base of the skull which has removed both condyles in a beheading stroke.

Specimen 15: Skull 15 is from context [16] in room D (D5 phase IV-VII) and is probably ultimately associated with the skull dump of context [62]. It comprises a fragment of left maxilla with two adult molars (M2, M3) showing moderate to light wear (again indicating an adult but not elderly animal). Strongly differential weathering on interior and exterior surfaces indicate external display, but this element does not articulate with any of the other skull fragments.

Specimen 16: This cattle skull is represented by paired halves of maxilla recovered from the pit fill [159] in room A2. Both halves of the maxilla are preserved, and they match down the line of the palate. The right zygomatic is also preserved, and this seems to have originally been a "full face" presentation. Heavy weathering is present on the external surfaces. The surviving maxillary teeth indicate a fully mature but not aged animal.

Specimen 17: Skull 17, context [159] area A2 is a naturally polled sheep skull with depressed fracture between the eyes. It articulates with the rest of the sheep skeleton found nearby and is described below.

Specimen 18: Skull 18 is from context [62] in room D (2) like specimens 10,11,12, and 19 probably part of a dump of skulls created during the demolition

process. This specimen is a fragmented cattle skull with the occipital, right zygomatic, and left lachrymal surviving, all showing differential weathering. The occipital condyles (which articulate with the neck vertebrae) show a heavy cutting blow from the right side which probably decapitated this animal.

Specimen 19: Skull 19 is also from context [62], and is very fragmentary, with portions of the right frontal, lachrymal, and zygomatic preserved. These do not match with any of the other cattle skull fragments, and show very heavy exterior weathering.

Specimen 20: Skull 20 is from context [159], the pit filled with skull fragments from room A2. This specimen is most of a right cattle maxilla, with a nearly complete tooth row intact. This animal still had its permanent fourth premolar (P4) “in crypt” below the gum line, and its third permanent molar (M3) had only just erupted and was only beginning to wear. This animal was thus just reaching adult size at the time of death at the end of its second year, and was somewhat younger than specimens 3., 6, and 11. If this animal were born in late May (as was usual for all Icelandic domestic stock), then it probably died in late May to late June of its second year.

Specimen 21: Skull 21, context [159] comprises a set of frontals, occipital, and a surviving right horn core. This specimen is probably a bull given the horn core diameter and conformation, and shows both the massive depressed fracture and differential weathering exhibited by the other specimens. The occipital condyles (articulating with the neck vertebrae) show the mark of a massive beheading blow which sheared across the base of this skull, completely removing the right condyle and certainly beheading the animal.

Specimen 22: Skull 22, context [159] comprises a left frontal with partial occipital attached and a nearly intact right horn core. The specimen shows a large depressed fracture to the center of the frontals, and heavy bone erosion on the exterior. The basal diameter of the horn core and general conformation suggest that this was a female.

Specimen 23: Skull 23, context [159] is a very weathered right frontal and occipital with a very large but heavily eroded right horn core attached. The erosion of the horn core and frontal is extreme, laying open the interior of the horn core. If this occurred prior to the skull’s removal and discard in the pit [159], then this may have been one of the older or more exposed mountings. Diameter of the horn core base indicates that this was a bull.

Specimen 24: Skull 24 context [155] (Room A (4) Phase III) is a right frontal with occipital and right horn core attached. There is the usual depressed fracture of the frontal between the eyes, but relatively light weathering. The basal horn core diameter suggests that this was a cow.

The Articulated Sheep Carcass

Specimen 17 from context 159 is the only sheep (*Ovis aries*) skull in the group, and is represented by most of the skull including both halves of the maxilla (figure 44). This individual is unusual as it is naturally polled (hornless) like the cattle skulls 1 and 3. This trait was very rare in medieval Icelandic stock, and modern Icelandic sheep are almost all horned (both sexes). This would have been an unusual animal in the farmyard of the 10th-11th c. AD. The skull shows a powerful impact between the eyes, causing a fatal depressed fracture just as in the cattle skulls. This mode of butchery is a bit unusual, as most sheep and goat skulls recovered in large enough fragments from midden and other refuse deposits do not show such depressed fractures. A more common specialized sheep skull processing method was to split the skull lengthwise along the sagittal plane to produce a dish very similar to the modern *svið* still enjoyed in Iceland. The mid-frontal smashing would preclude *svið* production, and this is the only clear example of this form of butchery applied to caprines that have been seen in the Mývatn collections. Initially it was believed that this specimen had been prepared for mounting like the cattle skulls, but in the laboratory it became clear that this skull in fact belongs to the partially articulated sheep skeleton recovered nearby within room A2 in context [154] Phase III. This sheep apparently had been killed and its body deposited in the ruins of room A2 at the same time as the demolition of the skali and the deposition of the cattle skulls in pit [159]. The sheep skeleton was not butchered for consumption, and most of the vertebral column and hindquarters survived in articulation. However, the skeleton was scattered slightly within the ruins of room A2 and was subject to some weathering before being finally covered over. The skeleton thus is not quite intact, and the head, forequarters, and hindquarters were separated and originally collected as two separate individuals. Matching of elements (jaw with maxilla etc.) demonstrate that these bone concentrations in fact came from the same individual. Table 22 lists the elements present and table 23 provides metrical data on this individual late Viking Age sheep.



Table 22 Articulated Sheep from A2 floor

Bone	End	Count
Skull (complete)	Whole	1
Mandible	Left	1
Atlas	Whole	1
Axis	Whole	1
Cervical Vertebrae (3-7)	Whole	5
Thoracic Vertebrae	Whole	5

Thoracic Vertebrae	fragments	7
Lumbar Vertebrae	Whole	7
Caudal Vertebrae	Whole	5
Innominate (complete)	Whole	1
Astragalus	Left	1
Astragalus	Right	1
Calcaneus	Left	1
Calcaneus	Right	1
Naviculocuboid	Left	1
Naviculocuboid	Whole	1
Tarsals other	Left and Right	7
Carples	Left and Right	3
Rib fragments	fragments	30
Humerus	Right	1
Scapula	Left	1
Femora	Left	1
Femora	Right	1
Patella	Right	1
Radius	Left	1
Radius	Right	1
Metacarpus	Left	1
Metacarpus	Right	1
Metatarsus	Left	1
Metatarsus	Right	1
Phalanx 1	Whole	8
Phalanx 2	Whole	8
Phalanx 3	Whole	5
Sacrum	Whole	1
Sesamoids	Whole	4
Sternum (articulated)	Whole	6

Table 23 Measurements (Von Den Dreisch 1976)

End	Bone	Bd	SD	GL	Bp	GB
left	Calcaneus			56.96		18.89
right	Calcaneus			57.33		18.79
left	Femora	36.16	16.61	177.85	42.31	
right	Femora	36.16	16.71	177.85	43.25	
right	Humerus	29.24	15.82	141.68	36.90	
left	Metacarpus	24.59	12.17	129.84	22.13	
right	Metacarpus	24.97	13.51	128.41	22.50	
left	Metatarsus	23.81	11.77	142.93	18.96	
right	Metatarsus	23.47	12.14	142.00	19.93	
left	Radius	30.29	15.21	153.00	27.76	

right	Radius	28.44	14.08	154.10	28.67
left	Tibia	26.15	13.60	210.56	39.19
right	Tibia	24.94	13.45	210.59	40.57

Table 24 presents a comparison of estimates of reconstructed live weight and stature for the A2 sheep. Note that while there is some variability between element-based stature reconstructions, the paired elements produce closely similar results, and the overall reconstruction of a medium-sized adult sheep near the mean of the Viking Age Mývatn reconstructed size/weight range seems plausible given the overall dimensions of the partial skeleton. Table 25 presents the eruption and wear state of the matching mandible and maxilla, again suggesting a fully adult animal with well worn but not pathological dentition.

Table 24
Articulated Sheep from A2 floor
Reconstructed Stature and Weight

Element	Bd in mm	Live wt (kg)	GL in mm	withers ht (cm)
Radius L	30.29	41	153.00	61
Radius R	28.44	38	154.10	61
Metatarsus L			142.93	65
Metatarsus R			142.00	64
Metacarpus R			128.41	63
Metacarpus L			129.84	63
Mean Reconstruction		39		63

Table 25
Articulated Sheep from A2 floor
Tooth eruption and wear (Mandible follows Grant 1982)

	P4	M1	M2	M3
Mandible	l	M	h	g
Maxilla	hw	Hw	hw	hw

Radiocarbon Dating

Table 26 presents the laboratory data for the AMS radiocarbon assays carried out on the cattle skulls from the skali area at Hofstaðir. The delta C13 % all indicates completely terrestrial diet for these cattle, and thus no marine reservoir effect.

Laboratory numbers	Context	C-14 Age (BP)	Error (+/-)	Delta C-13 %
GU-12953 SUERC-6392	HST D.62 Skull 10	1065	35	-20.7

GU-12954	SUERC-6393	HST D.62 Skull 11	1120	35	-21.1
GU-12955	SUERC-6397	HST C.159 Skull 6	1110	35	-21.0
GU-12956	SUERC-6398	HST C.159 Skull 7	1035	35	-21.2
GU-12957	SUERC-6399	HST C.159 Skull 8	1015	35	-21.2

Figure 45 presents the calibration results for these dates (OxCal 3.9, Bronk-Ramsey 2003), indicating that three cattle probably died in the late 10th-early 11th century (ca. AD 1000), but that two others are probably older, dying during the mid-late 10th century “calibration plateau”. These dates are fully compatible with the other radiocarbon and tephra dating evidence for Hofstaðir.

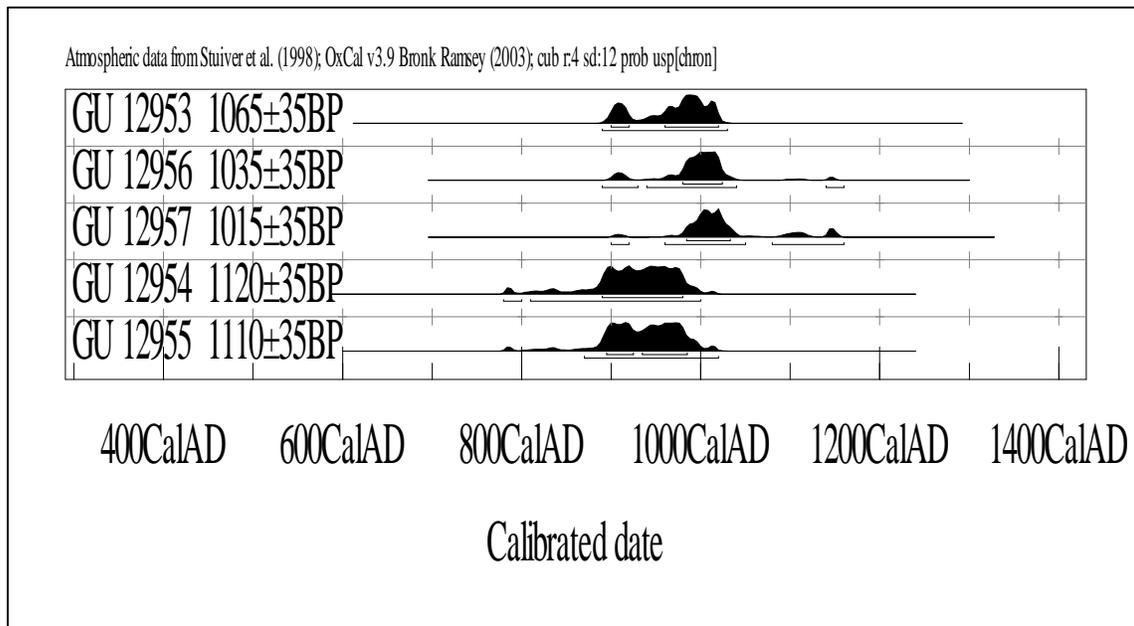


Figure 45

The radiocarbon dates do strongly suggest that not all of the cattle represented by the skull preparations were close contemporaries, and that they in fact probably have died several decades apart from each other. This radiocarbon evidence is supported by the condition of the specimens themselves; some showing extreme weathering on the external surface, others showing less heavy or prolonged exposure. The current evidence would thus better support a model of recurring ritual activity resulting in an accumulating cattle head display over a period of years rather than a single mass killing event.

Interpretation

The “beheading cuts” noted in both the Hofstaðir skull fragments deposited around the skali and in the neck vertebrae recovered from the midden fill of area G make sense only if there was an intent to cut through the neck of an intact animal still in a standing position. The most likely reconstruction from the forensics of the skulls is at least a two-person team, one of whom strikes the animal between the eyes (effectively killing it and certainly stunning it into

momentary immobility), while the second swings a broad bladed axe at the neck/base of the skull for a beheading stroke. Note the concentration of beheading blows from the right side towards the left of the animal's skulls. If the axe wielder was right handed, he was probably standing to the right of the sacrificial animal and probably using a two-handed stroke with full force. If the slaughtering team gets their timing right, the beheading will produce a blood fountain as the animal's heart will still be beating. This is of course un-necessarily dramatic butchery, as freeing the head from the neck during normal disarticulation of a carcass can be carried out with a few knife cuts once the neck muscles have been filleted away, and this is in fact the sort of marking found on most cattle bones recovered from other sites in Iceland. This sort of controlled disarticulation is also less likely to damage the cutting instruments used or to embed bone splinters in the meat, and it is easier to remove the tongue if the skull is still partially supported by the neck. However, drama was clearly more important than optimal butchery strategy in the creation of these detached heads.

Summary and Discussion

The Hofstaðir archaeofauna represents a rare opportunity in the zooarchaeology of the North Atlantic to fully exploit a large collection made from a virtually total site excavation, closely dated to a fairly short time period, with consistent, high standards of bone recovery and uniformly excellent conditions of bone preservation. As noted above, the close cooperation of specialists and excavators in the field and during the post-excavation work has been stimulating and productive, and certainly has made it possible to answer many questions which would have been left unasked without such prolonged collaboration. It is likewise certain that many of the particular characteristics of the Hofstaðir archaeofauna would have gone un-noticed without the comparative examples of the other comparably excavated and exactly contemporary Mývatnssveit archaeofauna. Many have urged full integration of environmental and field archaeology and the replacement of narrow site-focused investigations with the adoption of a broad landscape perspective (e.g. Arge 2005, Bigelow 1985, Crumley 1994, 1998, 2001, O'Day et. Al. 2004, Smith 1995, Van Neer & Ervynck 2004, Smith & Mulville 2003, Dockrill et al. 2007) and it is gratifying to see these scholars proved correct in this case.

The Hofstaðir archaeofauna is important not as a methodological exercise, but as an important element in the description and explanation of one of the most famous and controversial Viking Age "temple" sites in the North Atlantic and an important source of evidence for early human settlement and landscape change in the inland lake basin of Mývatnssveit. Hofstaðir is at once both special and typical, and sorting out the specialized features of the reconstructed farm economy from the elements common to most Mývatnssveit farms in the Viking Age is challenging. In many different zooarchaeological patterns, Hofstaðir appears slightly but not always profoundly exceptional. It may be helpful to bring

together the zooarchaeological evidence to provide a sort of summary “balance sheet” of the typical and unusual features of the Hofstaðir archaeofauna.

- **Birds and Eggs:** Hofstaðir seems to have participated in a community wide pattern of intensive egg collection combined with only minor predation upon adult waterfowl. This pattern seems to have been established prior to the founding of Hofstaðir, as evidence dating to the first generation of settlement at Hrísheimar suggests, but the farm certainly participated in the remarkable long term sustainable use of the immense but potentially fragile migratory waterfowl resources of Mývatn.
- **Inland Marine Fish Before the Fish Event Horizon:** Making use of extensive multi-site data resources for Britain, James Barrett and his colleagues (Barrett et al 2004a, 2004b) have convincingly documented a “Fish Event Horizon” (FEH) dating to ca AD 950-1050 (Late/terminal Viking Age). Prior to this horizon, marine fish bones are rare or absent in any site further than 10 km from the sea. These findings make the discovery of processed marine fish in inland Mývatnssveit in the early Viking age well before the FEH particularly significant. These well dated inland Icelandic collections have sparked the realization that an earlier Nordic chiefly exchange network in Iceland (and subsequently identified in the Faroes) pre-dated the FEH and the historically documented rise of commercial cod fisheries after 1100 (Perdikaris & McGovern 2007, 2008, Church et al 2005). It has now become clear that the ultimate origins of the FEH and of modern commercial North Atlantic fisheries are to be found in the small scale, chiefly, artisanal fisheries of the Nordic Iron Age. While these general findings are having revolutionary impact upon modern scientific understanding of North Atlantic history, Hofstaðir’s place among the other early inland farms of Mývatn is unexceptional- like its contemporaries, Hofstaðir provisioned its household with a range of dried marine fish, showing a clear preference for flat dried cod and haddock over round dried products
- **The Marine Connection:** While the pattern of marine fish use at Hofstaðir is unexceptional in the quantity or type of fish consumed, the overall patterning in fish, birds, sea mammals, and shellfish/seaweed consumption point to a very strong marine connection- perhaps stronger or more regularly maintained than that of the other Mývatnssveit farms. The concentrations of sea bird bones and eggs, the presence of occasional lower- Laxá products like Atlantic Salmon and Eider Ducks, and the very occasional arrival of a whole (fresh) codfish (note that the *only* gadid head or mouth parts recovered from the Mývatn archaeofauna are from Hofstaðir; Table 17) all seem to point to a special marine connection for the farm. Prior to deforestation of the mid-valley areas (like Reykjadalur), the easiest route from Mývatnssveit to the sea probably was along the line of the boundary dyke running along the ridge line of the

eastern side of the Laxá, a dyke ending in the Hofstaðir holding. Was Hofstaðir acting (or seeking to act) as a gateway settlement to the marine resources already supplementing farm economies throughout Mývatn?

- **Stock Keeping:** Cattle, Sheep, Pigs, and Goats appear in all the known Mývatn archaeofauna, and there are certainly broad similarities evident in general stock keeping practices: cattle and goats were managed mainly for dairy production, pigs for meat, and sheep for a mix of meat, milk, and wool. However, in each case Hofstaðir stands as an exception in some aspect of animal husbandry.
 - **Cattle** remains at Hofstaðir certainly show an overall dairy profile, with many neonatal calves and old adults. However, a second management strategy aimed at producing and culling 'prime beef age' young adults is also evident in the neonatal percentages, the tooth eruption and wear patterns and in long bone fusion. In each case there are traces of young adult mortality not evident at Sveigakot, but reminiscent of the clear provisioning pattern documented for the medieval trading center at Gásir. It cannot be accidental that the detached cattle skulls from around the *skali* which can be aged also fall into this category of young to just mature, and are not aged worn out dairy cattle. Hofstaðir was primarily a dairy farm, but the demands of beef production also seem to have regularly caused the expensive slaughter of animals at the top of their growth curve.
 - **Sheep** culling likewise follows general Mývatn patterns, and certainly reflects some wool production probably based upon old wethers as well as milk production from younger ewes. However, Hofstaðir again shows a culling spike of younger lambs, apparently maintaining a significant meat off take not evident at other farms.
 - **Goats** show a clear dairy profile, despite a culling spike at the same age group as the young sheep. The ratio of goats to sheep at Hofstaðir appears anomalous- increasing when the other Mývatnssveit sites thus far known seem to have been reducing goats in favor of sheep. The higher goat ratio at Hofstaðir certainly reflects a greater commitment to food production over secondary products, and again seems to reflect the need to provide provisions.
 - **Pigs** show a higher proportion of animals culled as neonatal sucking piglets than at Sveigakot, a pattern that persists through both sites occupational phases. Suckling pig is an inefficient and expensive delicacy, but one apparently provided regularly at Hofstaðir. Isotopic evidence suggests stall-feeding of at least some pigs at Hofstaðir, perhaps again reflecting special efforts to produce high quality provisions.

- **Feasting and Ritual** : Hofstaðir is most anomalous in the size of its great hall and in its concentration of beheaded cattle (including a disproportionate number of bulls), and even without its name and associated modern controversies there would be reason to suspect something out of the normal range of Viking Age subsistence farming. The household economy was apparently geared to produce piglets, goat milk products, and young sheep in preference to wool or older swine. All of these partial specializations seem aimed at producing desirable food, even when this entailed reduced efficiency in reaching other farming goals. However, maximizing farming efficiency is only one potential goal for a past household economy. Feasting certainly was a key aspect of Germanic (and other) chieftainship and ensuring the availability sufficient high-quality (and energetically expensive) food to secure a memorable event would have been a critical economic goal for any aspiring chiefly household (Dobney et al 2007, Ervynck et al 20003, Ervynck 2004). Ritual activity could well be associated with seasonal feasts or feasts be held to celebrate ritual occasions- in either case generating the need for drama and conspicuous consumption seen at Hofstaðir. If Icelandic Viking Age stock were born in early spring as in historic times, then cattle heads were cut off and beef -aged young adults were consumed at approximately the same time, placing at least one round of feasting in early summer- probably June. The zooarchaeological evidence is clear that Hofstaðir was not simply a specialized temple, but it also suggests strongly that this was also not simply another working farm.

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