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An early Christian cemetery at Björned in northern Sweden

Stable isotope analyses of skeletal material

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The cemetery of Björned in the parish of Torsåker, Ångermanland in northern Sweden has caught the attention of several researchers. It is a unique site for several reasons and its well-preserved bones has enabled a number of scientific investigations. The people buried at the site seem to belong to an early Christian congregation not mentioned in extant written records. They seem to have lived longer than people buried at contemporary sites in Scandinavia and to have been as tall as the tallest contemporary populations. So who were these people and where did they come from? In order to address these issues we analysed the stable isotopes of carbon ($\partial^{13}C$), nitrogen ($\partial^{15}N$) and sulphur ($\partial^{34}S$) in remains derived from 42 individuals. The results indicate that the population had a fairly homogeneous diet but that its members were of varied origin in terms of geological background.

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We report here on analyses of skeletal material from the Late Viking Period – Early Medieval cemetery of Björned in the parish of Torsåker, province of Ångermanland, northern Sweden. The site is in one of the region's central settlement areas, at the mouth of River Ångermanälven, in a Late Iron Age landscape characterised by pagan cult, as seen in the surrounding place names: Hov, Torsåker etc. (Grundberg 2005b). The province of Ångermanland was at the time on the northern border of farming settlement and a transit centre for goods. The site had direct means of contact both to the west, up the river and over the mountains, and to the east across the Baltic. Far contacts have also been confirmed by finds in the area: such as numerous silver hoards and richly furnished Viking Period burials in mound cemeteries at Björkå and Holm. The area's wealth was obviously based on its control over trade in furs and other goods from the hinterland hunting grounds to the north (Grundberg & Hårding 2003; Grundberg 2005a).

The cemetery was excavated in 1988–1994, as part of the Styresholm Project conducted by Väs-

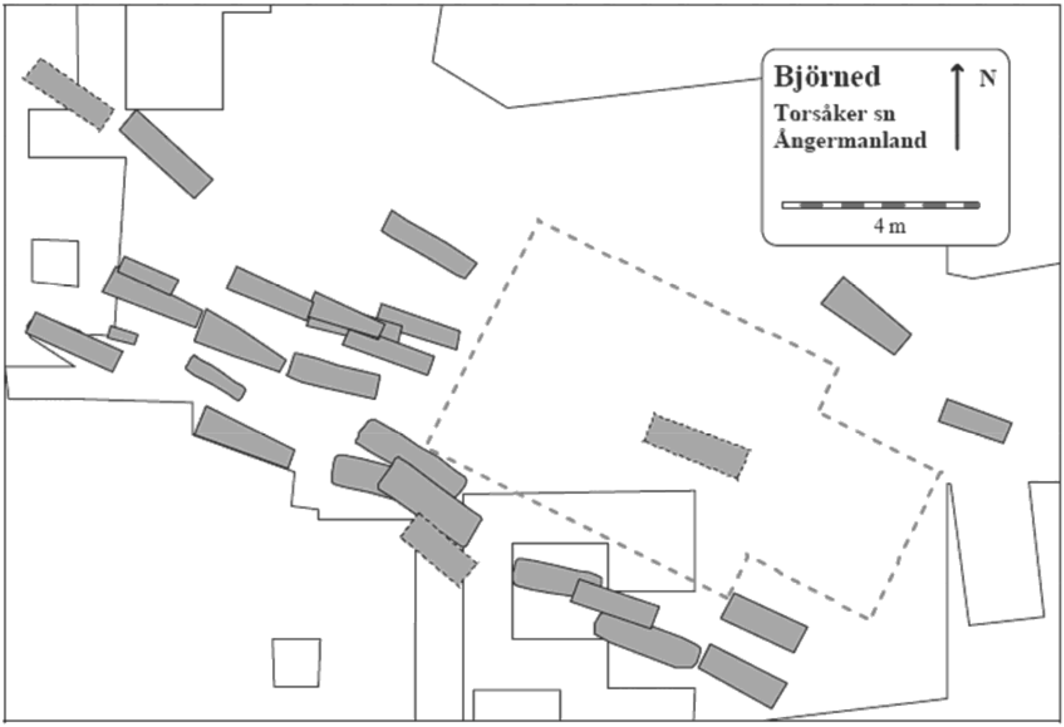

Fig. 1. The cemetery at Björned, with graves shown in grey and a possible location for a wooden church marked with a hatched line. Burial 50 was situated within the possible church (Grundberg & Hårding 2003, p. 13).

ternorrland County Museum and Hola folk high school in cooperation with the University of Umeå and others (Grundberg 2005b). The investigators concluded that the site had been in use from the 4th through the 13th century AD. Eleven previously published radiocarbon dates for the cemetery cover 250–300 years and span the 10th through the 13th centuries (Grundberg 2006). So far, over fifty individuals have been identified in the cemetery, of which thirty had a proper burial context. All were burials orientated west–east with the heads to the west, under flat ground, and sometimes in coffins, indicating Christian burial customs. By the end of the 13th century, when the parish church in Torsåker had already been built, the cemetery was no longer in use. No physical traces of any church have been found at Björned (Grundberg 2006), though it has been speculated whether burial number 50 might have been located within a wooden church, as a founder's grave (Grundberg 2005b; fig. 1).

The change in burial customs from cremation to inhumation probably took place during the 10th century at Björned, making these some of the earliest Christian burials in northern Sweden. So who were these people buried at Björned who lived in an area with abundant trading contacts, and where did they come from?

The issue of the origins of artefacts and human remains has interested archaeologists since the beginning of the discipline, whereas the focus of questions concerning what and/or who moved has oscillated. For obvious reasons it has been easier to study moving artefacts than moving humans, but with the development of new techniques within the field of biomolecular archaeology, the study of individual people on the move has attracted renewed attention.

Diet has strong cultural and regional connotations and is generally regarded as being something of a persistent structure that is resistant to change. Diet can thus be used to provide information on mobility and cultural coherence. One way to infer prehistoric diet is through stable isotope analysis, a set of methods that has long been applied to archaeological problems (Vogel & van der Merwe 1977; Schwarcz & Schoeninger 1991; Schoeninger & Moore 1992; Katzenberg 2000; Richards et al. 2003b; Kellner & Schoeninger 2007). The information to be inferred from such analyses concerns whether the digested protein originated from terrestrial or marine resources ($\partial^{13}C$), from which trophic level in the food chain it originated ($\partial^{15}N$) and site-specific information given by the sulphur signal for a specific regional environment ($\partial^{34}S$). By using local animals as reference material to infer human diet and determine the local sulphur signal, it is possible to compare the diets of individuals buried in a cemetery and trace differences in diet and mobility. It is also possible to use bone elements and teeth to study changes in diet over an individual's life span (Eriksson 2003).

In the present case we analysed the stable isotopes of carbon, nitrogen and sulphur in various skeletal elements and teeth and in animal remains found at the cemetery at Björned to infer diet and mobility. For comparison purposes we also included some human samples from nearby Viking Period cemeteries at Björkå (four samples) and Holm (one sample), excavated in the 1940s and 50s (Hårding 1997; Grundberg 2005a).

Material

Most of the skeletal material was very well preserved, and around 30 of the more than 50 individuals excavated had at least one skeletal part still in the original position, so that the position of the burial could be determined (Grundberg 2005b). Approximately fifteen individuals had an almost intact skeleton, and of the total of 27 individuals that could be osteologically determined as to sex, 23 were males and 4 females (Grundberg & Hårding 2003). Some of these individuals were also subjected to sex determination by aDNA, whereupon the results of the two analyses turned out to be in complete agreement. It was also possible to identify five additional individuals as males by aDNA analysis, making a total of 28 males (Grundberg et al. 2000). The low proportion of females at Björned has led to the conclusion that the cemetery may have been spatially gender-segregated, as seen at certain other Medieval cemeteries, e.g. Västerhus in the nearby province of Jämtland (Gejvall 1960). It seems that only the southern part of the Björned cemetery has been excavated, and that the women were buried in the northern part. This part of the area has been badly damaged, however, and cannot be excavated, partly because of a 20th century barn (Grundberg 2005b).

The average heights of the males (174 cm) and females (164 cm) at Björned are comparable with those of the tallest populations in Medieval Scandinavia, whereas average life span at Björned, 32.7 years for males, is higher (Grundberg & Hårding 2003). The population's overall health seems, on the basis of skeletal features, to have been good, especially in comparison to the Västerhus cemetery (Grundberg 2005b).

Of the 50 individuals identified at Björned, 37 were included in the analyses of stable isotopes (table 1; fig. 2). In six individuals both teeth and bone were analysed, to detect any changes in diet from childhood to adulthood. Several animals were included as reference material for the dietary reconstruction and to identify the site's local sulphur signal. The animal samples included were bones of cattle, horse, pig, sheep/goat, hare, fish and a seal that were available from the excavation, probably derived from Late Iron Age settlement at the site. We also included a salmon specimen from the nearby Late Medieval fortress site of "Pukeborg" (Wallander 2005; table 2). Although this salmon bone is from a different period, we deemed it important to include it in the material since the salmon is a migrant fish with intermediate $\partial^{13}C$ values, and was an important food item in the region over a very long stretch of time (Nordlander 1934; Stattin 2005).

Two of the individuals from the Viking Period cemetery at Björkå were identified morphologically as females and two as males, all adults (Hårding 1997; table 1). No sex or age determination was available for the single individual from Holm.

Some of the present material has been included previously in biomolecular studies, giving evidence of the very good preservation conditions at the site for bones and teeth. The biomolecular analyses performed on those occasions had included both bacterial and human DNA as well as stable isotope analysis (Nuorala 2004; Götherström et al. 2001; Andersson 2006).

Method

Analysis of the stable isotopes ^{13}C and ^{15}N has become a standard method in archaeology (Ambrose 1993; Sealy 2001; Eriksson 2003). The information it provides concerns the origin of an individual's dietary protein, i.e. whether the diet was based on marine or terrestrial resources. The third stable isotope studied here, the sulphur isotope ratio $^{34}S/^{32}S$ (expressed in the usual notation as $\partial^{34}S$, by analogy with $\partial^{13}C$ and $\partial^{15}N$), has been introduced into archaeological studies relatively recently and is held to provide information on the geological background from which the ingested protein originated (Richards & Hedges 1999; Richards et al. 2001; Richards et al. 2003a; Privat et al. 2007).

The protein collagen, which is used in dietary reconstruction, is made up of 18 amino acids all containing carbon and nitrogen, whereas only one, methionine, contains sulphur (Brady & Weil 1999). Although the sulphur itself is only 0.16% of total collagen by weight, it constitutes 0.5% of mammalian collagen by volume (Ambrose 1993), which is more than enough for measurements. The variation in sulphur isotope values is based on the fact that plants obtain their sulphur from three natural sources: organic matter, soil minerals and atmospheric sulphur gases. It then enters the food web predominantly in the form of sulphide ions (from sulphate assimilation) and plays an important role in several animal proteins (Brady & Weil 1999). The range of sulphur isotope values varies between ecosystems, from -10‰ to +20‰ in marine systems and terrestrial ecosystems and from -22‰ and +20‰ in freshwater systems (Soloman et al. 1971; Peterson & Fry 1987). Trust & Fry (1992) showed that the fractionation of sulphur within plant ecosystems is small. As the combination of the three sulphur sources mentioned above may vary from one geographical location to another, the $\partial^{34}S$ value in local plants and in animals feeding on those plants will vary accordingly (O'Connell & Hedges 1999; Macko et al. 1999; Bol & Pflieger 2002; Sharp et al. 2003; Buchardt et al. 2007). Hence, if people move between ecosystems with different sulphur "finger prints" it will be possible to detect this in an analysis of their bone and teeth. Bone collagen has different turnover times in different skeletal elements, while the collagen in teeth undergoes no turnover at all. This makes it possible to study life-history changes in an individual's diet (Lidén & Angerbjörn 1999; Eriksson 2003).

Collagen was extracted from various skeletal elements following Brown et al. (1988) in a designated bone laboratory at the Archaeological Research laboratory in Stockholm. The samples were demineralised in a 0.25M HCl solution for 48 hours at room temperature, then filtered and washed twice with deionised water through a glass filter. After addition of 0.01M HCl, the samples were incubated at 58°C overnight in order to dissolve the organic material. The dissolved organic residue was then filtered and washed with deionised water through an ultrafilter (30,000 MWCO Amicon Ultra-15 Centrifugal filter device, Millipore), removing particles of less than 30kDaltons. Particles larger than 30kDaltons are likely to be undamaged collagen. The residual solvent was then transferred to a 2 ml Eppendorf tube and frozen at -80°C, after which the sample was freeze-dried and weighed. The stable isotope analyses were performed on a Carlo Erba NC2500 elemental analyser connected to a Finnigan MAT Delta+ isotope ratio mass spectrometer (IRMS) at the Department of Geology and Geochemistry, University of Stockholm. The precision of the measurements was ±0.15‰ for both $\partial^{13}C$ and $\partial^{15}N$, and ±0.2‰ for $\partial^{34}S$.

Post mortem degradation in bone occurs in at least three ways: chemical deterioration of the organic phase, chemical deterioration of the mineral phase and microbiological attack on the overall composition. In addition, several parameters are involved in the loss of collagen from bone, the main ones being time, temperature and pH (Collins et al. 2002; Hedges 2002). In

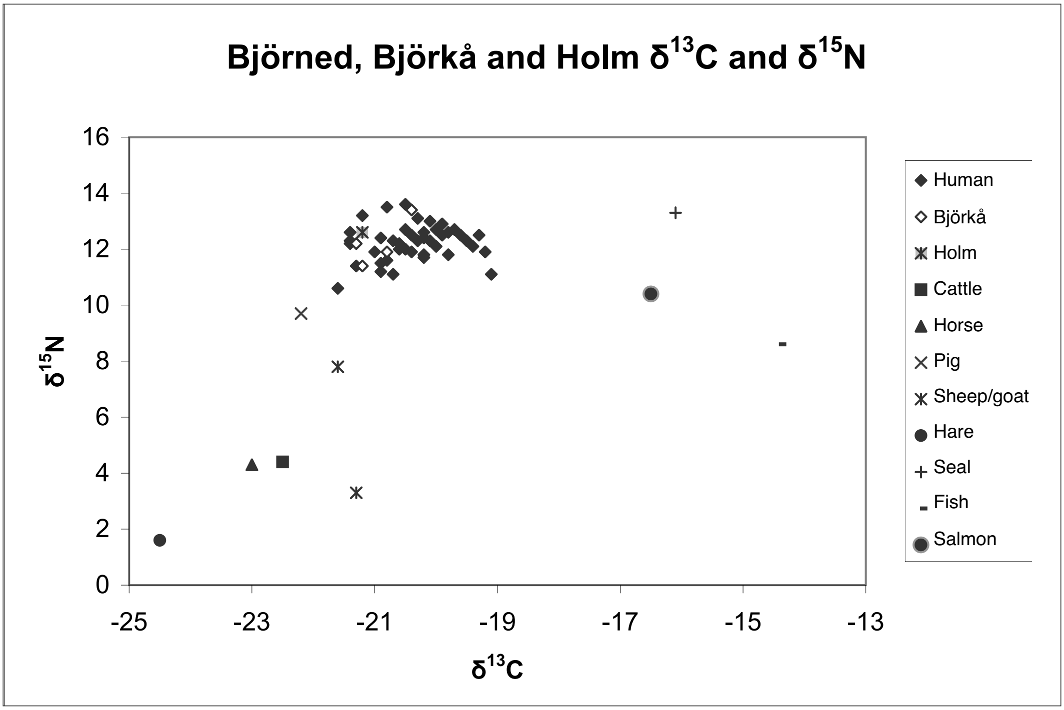

Fig. 2. Plot of carbon and nitrogen values for Björned, Björkå and Holm.

order to control for diagenetically altered bone, we used the parameters put forward by De Niro (1985), Ambrose (1990) and Van Klinken (1999). The ratio C/N should fall into the range 2.9–3.6, the collagen should fall in the stipulated interval of 15.3–47% for carbon and 5.5–17.3% for nitrogen and the collagen yield should be larger than 1%.

Results

Only one sample had to be rejected due to poor preservation (Table 1). Carbon and nitrogen values were obtained for all 42 individuals under study (37 from Björned and 5 from Björkå and Holm), and for the nine animals, including the samples from Björkå, Holm and "Pukeborg" (fig. 2; tables 1, 2). The ∂^{13}C values ranged from -21.6‰ to -19.1‰ in the human samples, with a mean of -20.4‰ (s.d.= 0.6). In the animals, ∂^{13}C ranged from -24.5‰ (hare) to -16.5‰ (salmon). The ∂^{15}N values ranged from 10.6‰ to 13.6‰ in the human samples, with a mean of 12.3‰ (s.d.=0.6). In the animals, ∂^{15}N ranged from 1.6‰ (hare) to 13.3‰ (seal).

Five individuals were also successfully analysed for intra-individual differences, comparing teeth (one of the pre-molars or one of the first, second or third molars) with bones (table 1). Since collagen has a turnover time of 10–15 years in bone, the information obtained from the isotope values represents the diet over the last 10–15 years of an individual's life, whereas collagen in the teeth is metabolically inert and represents diet at the time of tooth formation (Balasse et al. 1999). A shift in diet during an individual's lifetime is shown in fig. 3, where ∂^{13}C values as a child lie between -20.9‰ and -19.1‰ and ∂^{13}C values for the adults between -21.6‰ and -20.4‰. The trend here seems to be for a shift towards a more terrestrial diet in adulthood, though it is not statistically significant ($p=0.056$ with ANOVA). ∂^{15}N values rang-

Grave	Sex	Age	Fragment	^{14}C BP	∂^{13}C ‰)	% C	∂^{15}N(‰)	% N	C/N	∂^{34}S (‰)	% S
A1a	-	adult	radius dx	910+/-100	-20,2	46	11.8	16,1	3,3	6,9	
A1b	M	7–8	-	395+/-195	-20,9	43,3	11,5	16,3	3,1	-1,7	
A2	M	20	fibula		-20,1	38,3	13	12,8	3,5		
A3	M	adult	scapula		-20,2	35,4	12,4	11,5	3,6		
A4	M	50	scapula	1009+/-66	-20,7	40,4	12,3	12,3	3,3		
A5	M	25–35	fibula	885+/-60	-20,3	45	12,3	16,2	3,3	2,8	0,2
A6	M	14–18	cranium	805+/-60	-21,4	39,4	12,6	13,8	3,3		
A6	M		M2		-20,2	40,4	12,6	14,4	3,3		
A7	-	6 m	cranium	1165+/-75	-20,5	40	13,6	14,3	3,3	15,5	0,4
A8	M	40–64	costa		-20,2	40.9	11,7	14,8	3,2		
A9	F	20–25	fibula		-21,6	38,8	10,6	14,3	3,2	8,5	0,2
A9	F		M3		-20,9	39,7	11,2	14	3,3		
A11	M	53-63	cranium		-20,9	40,6	12,4	14,9	3.2		
A12	-	10–24	vertebra		-20,7	41,5	11,1	15,5	3,1		
A15	-	adult	-		-20,8	43,7	11,6	16,2	3,2		
A16	M	56–65	scapula	775+/-65	-21	40,7	11,9	15,2	3,1	4,5	0,1
A16	M		M3		-19,5	42	12,3	14,7	3,3		
A17	M	adult	fibula		-20,1	43,7	12,3	16,3	3,1	3,3	0,2
A18	M	10–14	long bone		-20,6	36,8	12,2	12,3	3,5		
A19	M	adult	tibia		-20.8	40,3	13,5	14,9	3,2	5,1	0.2
A24	M	66–75	scapula		-20,3	43,9	13,1	16,5	3,2	2	0,2
~~A25~~	~~F~~	~~40~~	~~radius/ fibula~~	~~865+/-86~~	~~-21,4~~	~~45.4~~	~~12,3~~	~~14,4~~	~~3,7~~	~~4,5~~	~~0,2~~
A25	F		M3		-20,5	40,8	12,7	14,4	3,3		
A27	-	8	cranium	1010+/-70	-20	42,1	12,1	15,6	3,2		
A28	M?	15–20	fibula		-20,4	43,2	12,5	16,3	3,1		
A30	M	25	cranium		-21,2	40,6	13,2	15,2	3,1	1,6	0,2
A31	-	18 m	cranium		-19,6	41,9	12,5	15,8	3,1	3,3	0,2
A32	M	40–50	cranium		-20,4	39,9	11,9	15,2	3,1	6	0,2
A32	M		M1		-20,6	38,8	12	13,3	3,4		
A35	M	adult	cranium		-21.3	28,1	11,4	9,6	3,4		
A36	M	37–46	scapula		-20,5	41,7	12	15,7	3,1	12,4	0,2
A36	M		PM		-19,1	42,9	11,1	14,8	3,4		
A38	M	adult	long bone		-19,3	41,9	12,5	15,4	3,2	6,1	0,2
A39	M	adult	cranium		-19,4	40,1	12,1	15,4	3	6,3	0,2
A40	-	adult	cranium		-19,8	36	11,8	13,7	3,1	5,8	0.2
A41	M	adult	costa		-19,2	40,1	11,9	14,3	3,3	6,7	0.2
A42	-	6 m	cranium		-21,4	32,4	12,2	12,4	3,1	3	0,2
A46	M	15	costa	775+/-55	-19,7	42,7	12,7	14,7	3,4	5,9	0.2
A47	-	adult	cranium		-19,8	37,6	12,6	13,2	3,3	5	0,2
A48	M	25	long bone		-19,9	40,1	12,5	14,4	3,3	8,2	0,2
A49	F	25	fibula dx		-20	42,5	12,7	15,2	3,3	6,1	0.2
A50	-	adult	long bone	805+/-55	-19,9	32,3	12,9	11,5	3,6		
A300	M	20–24	cranium		-19,9	42,3	12,9	14,8	3,3	4	0,2
Björkå Ab	F	17–25	long bone		-21,3	42,7	12,2	15,2	3,3		
Björkå At	F	15	cranium	800–950	-20,8	39,8	11,9	14,2	3,3	2,8	0,2
Björkå 32B	M	40–50	cranium	10th c.	-20,4	43,9	13,4	13,4	3,1		
Björkå 34F	M	25–35	cranium	vendeltid	-21,2	40,1	11,4	13	3,2		
Holm					-21,2	40,1	12,6	13,8	3.4		
		Mean			-20,4		12,3			5,4	
		S.d.			0,6		0,6			3,4	

Table 1. Grave number, sex, age, bone fragment used, radiocarbon date and stable isotope values for all the individuals studied. Key: M=male, F=female, y=year, m=month, Ab=bottom sample, At=top sample. The struck-through sample failed to meet the quality criteria and has been excluded from the analysis.

Context	Species	∂13 C (‰)	%C	∂15N(‰)	% N	C/N	∂34S (‰)
F194	Cattle	-22,5	42,3	4,4	14,8	3,1	-3,2
F434	Horse	-23	43,1	4,3	15,4	3,3	
F921	Pig	-22,2	43,5	9.7	14,9	3,2	17,1
F154	Sheep/goat	-21,6	42,6	7,8	15,6	3,2	-1,1
A49	Sheep/goat	-21,3	35,4	3,3	12,9	3,2	
	Hare	-24,5	41,9	1,6	15,5	3,2	9,8
F965	Seal	-16,1	43,2	13,3	15,9	3,2	12,6
F440	Fish	-14,4	42,2	8,6	15,9	3,1	
Pukeborg	Salmon	-16,5	41,9	10,4	16	3,1	
Mean		-20,2		7,0			7,0
S.d.		3,6		3,9			8,8

Table 2. Context, species identification and stable isotope values for animals used as a reference material.

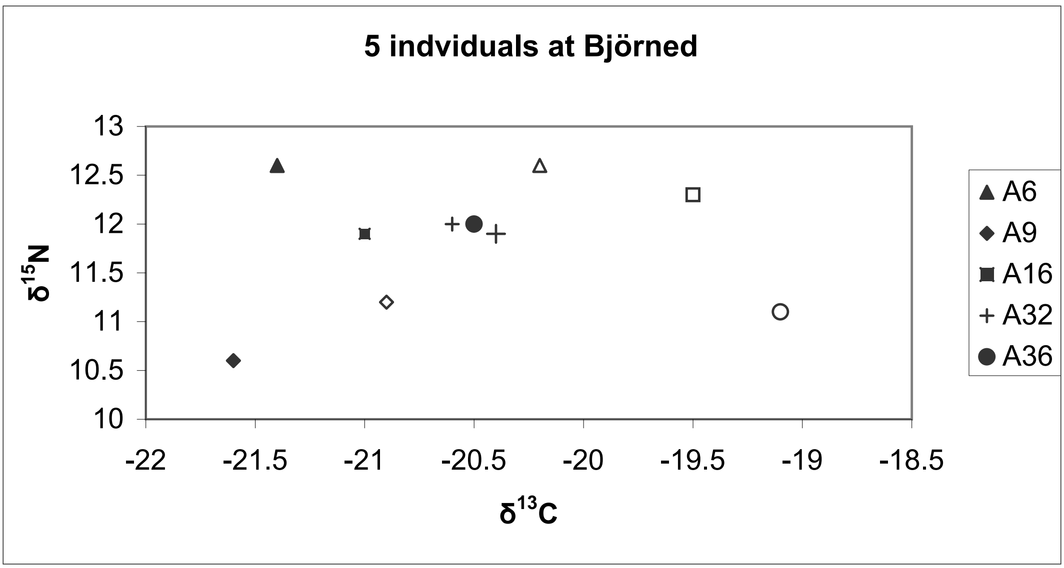

Fig. 3. Stable isotope measurements for five individuals in whom dietary shifts could be detected from childhood to adulthood. Child: small or unfilled symbols. Adult: large or filled symbols.

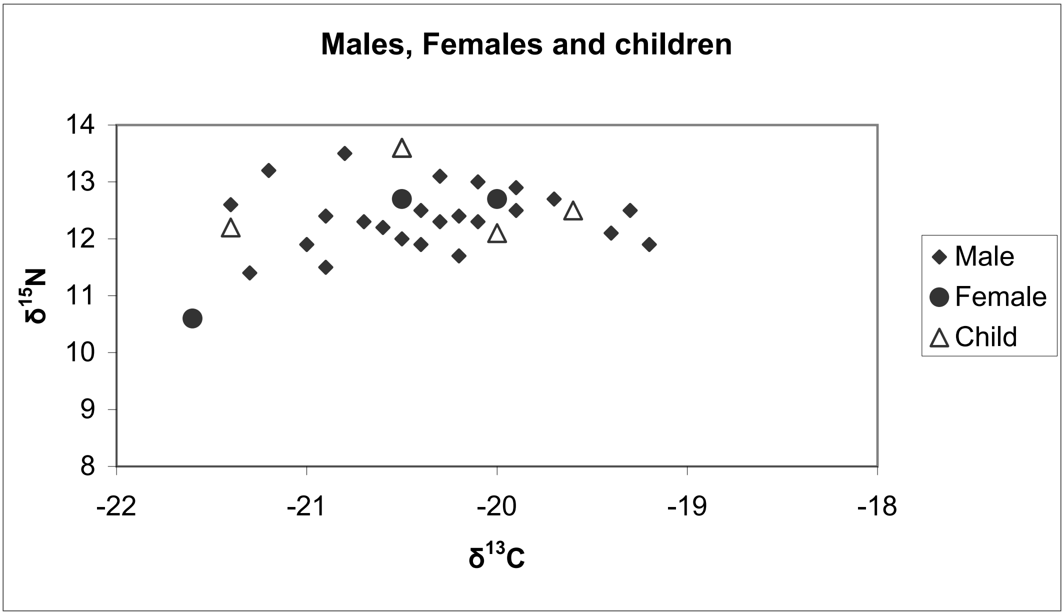

Fig. 4. Plot of carbon and nitrogen values for males, females, and children at Björned.

ed from 11.1–12.6‰ in childhood and from 10.6–12.6‰ as an adult, i.e. with no statistically significant difference ($p=0.93$ with ANOVA).

The results point to a fairly homogeneous diet among people buried at Björned, though the standard deviation for carbon (0.6‰) is higher than 0.3‰ which is considered typical of a population with a homogeneous diet (Lovell et al. 1986). The diet was mainly based on terrestrial resources, with a small contribution of protein from marine sources and in some cases a diet consisting of freshwater fish, providing elevated nitrogen values. This diet is also consistent with that of the pagans buried at Björkå and Holm (fig. 2).

There are no statistically significant differences between the males, females or children in either carbon values ($p=0.689$) nor nitrogen values ($p=0.213$), although very few females and children are represented in the analysis (fig. 4). There are indications, however, that some males buried at Björned may have had a higher proportion of freshwater fish in their diet than others, as seen in elevated nitrogen values. The fact that children have elevated $\partial^{15}N$ values ranging from 12.4–15.8‰ may indicate a breastfeeding effect as well as a supplementation of their diet with freshwater fish.

The amount of collagen needed to measure sulphur isotopes is much larger than for $\partial^{13}C$ and $\partial^{15}N$ measurements (4–5 mg and 0.5 mg respectively). There was thus not enough collagen to measure sulphur in all the samples. All in all, $\partial^{34}S$ was analysed in 25 human individuals and five animals (fig. 5). The values ranged from -1.7‰ to 15.5‰ in the humans, with a mean of 5.4‰ (s.d.= 3.4). In the animals, sulphur ranged from -3.2‰ (cow) to 17.1‰ (pig), with a mean of 7.0‰ (s.d.=8.8).

The sulphur values show a fairly large standard deviation, 3.4‰, indicating a varied origin for the diet. Unfortunately, the animals analysed have an even greater standard deviation than the humans, 8.8‰, making any discussion of the human population's origins difficult. The problem lies in a difficulty in deciding which animals may be regarded as local. The hare, for example, might be either a local animal or one brought in as a

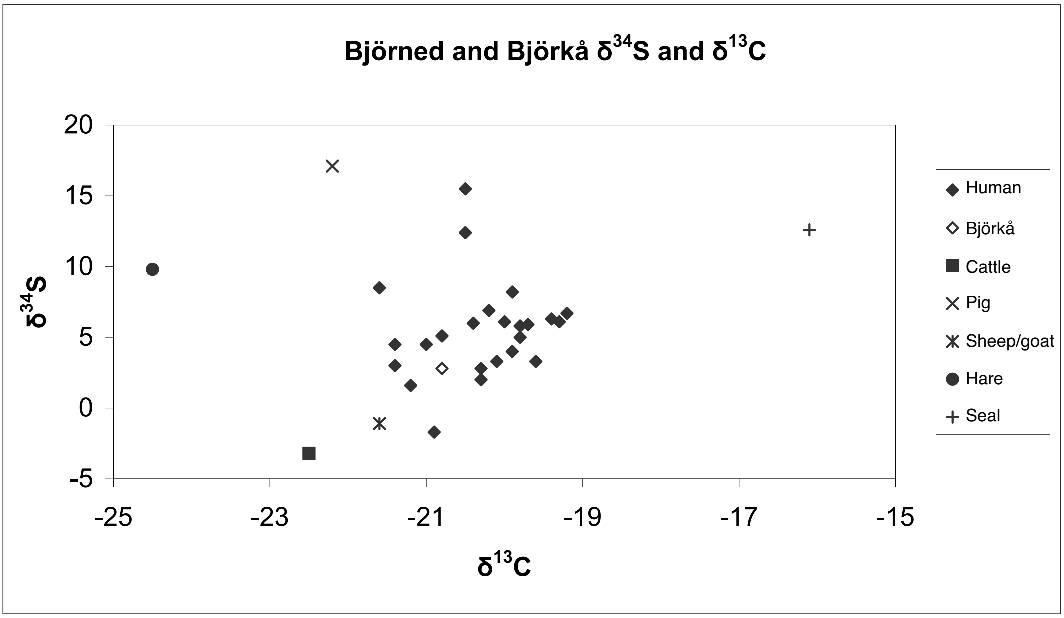

Fig. 5. Plot of sulphur values against carbon values for animals and humans at Björned and Björkå.

result of far-ranging hunting, while the pig with a very high sulphur value might also have been brought to Björned from somewhere else. All that remains, then, is to use the human individual from Björkå as a reference value for a possible local sulphur signature. This individual's sulphur value, +2.8‰, is much lower than the mean for Björned, thus indicating that most of the individuals from Björned would have originated from somewhere else. It is also interesting here that the possible "local" individual from Björkå is dated to approximately AD 800–950, and that most of the lower sulphur values at Björned appear at a much later date. This would indicate that the early individuals at Björned, with higher sulphur values than the local ones, originated from somewhere else, whereas the later individuals lived locally. There is a correlation between the $\partial^{34}S$ values and the calibrated radiocarbon dates, in that the sulphur isotope values are lower at later points in time ($r=-0.914$ and $p=0.011$; fig. 6), and the same holds true for the $\partial^{15}N$ values ($r=-0.926$ and $p=0.008$).

Discussion

Previous publications and studies on the material from Björned have focused on what the location of the site means, being situated in the northernmost area where great barrows (Sw. *storhögar*), Viking Period silver hoards and chamber graves are to be found, close to several hillforts, and also being the earliest known Christian cemetery in the area. The health status of the people buried at the cemetery has been studied using osteological and odontological material (Nuorala 2004; Grundberg 2006; Leden & Hårding ms; Alexandersen ms). Another aspect to be considered has been what sort of social group the buried population represents.

Who were the people buried at Björned? Did they all come from a local farm or did they originate from different places? A previously published biomolecular study of some of the Björned individuals based on aDNA aimed at determining whether the population represents one paternal lineage, i.e. that the site was a local farm cemetery. The study included ten male individuals and was based on alleles of a specific part

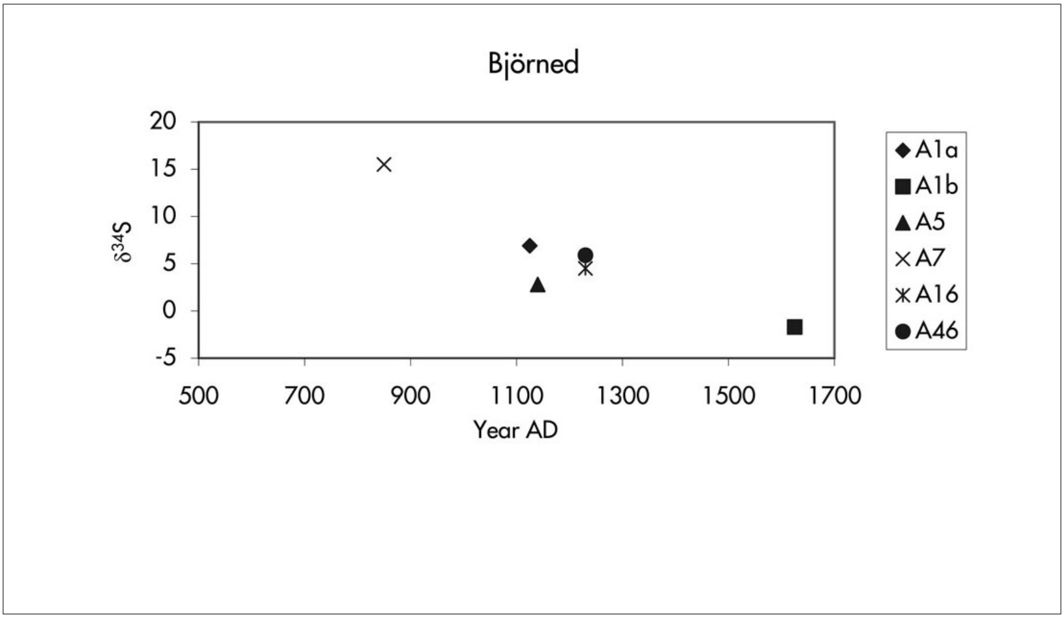

Fig. 6. Plot of sulphur values against time for six individuals from Björned.

of the Y-chromosome (DYS 388). In the light of the prevalence (83%) of a specific allele, it was deemed possible that all the males analysed except one could have been related (Grund-berg et al. 2005). This in turn would support the hypothesis that the site was a local farm cemetery.

Bearing this in mind, the results of the isotope analysis are even more interesting. The carbon and nitrogen isotope values suggest that the Christians at Björned and the partly contemporaneous pagans at Björkå and Holm all had the same diet, and that the Björned population ate pretty much the same type of food over the three centuries represented by the analysed individuals. Three men, however (#A30, A19, A24), have slightly higher $\partial^{15}N$ values than the rest, with a mean value of 13.3‰ compared with the group mean of 12.3‰. The standard deviation is also less for these three individuals than for the whole population measured, 0.2 and 0.6 respectively. The higher nitrogen values could be taken to indicate a terrestrial diet mixed with some freshwater fish rather than any increased marine diet input, since the $\partial^{13}C$ values support a terrestrial diet. One of the men, A24, also deviates from the norm in another respect: several of his teeth were missing, due both to aplasia and periodontitis (Alexandersen ms). This must have been a major handicap and would have meant that the man's food had to be puréed for him. He also had a stiff hip and suffered from rheumatism (Leden & Hårding ms).

There is also a correlation between the radiocarbon dates and nitrogen values ($r=-0.926$ and $p=0.008$), which in turn would indicate a reduction over time in the intake of freshwater fish or salmon, as the nitrogen values are lower in later times. It is also interesting that intra-individual differences were detected in five individuals, who progressed from a diet with a slighly a higher marine input in their childhood, as seen in the collagen extracted from their teeth, towards a more terrestrial diet with age. What this change represents is difficult to say. It might be due to children and adults having different diets in general, but this can be rejected since there is no statistical difference in either carbon nor nitrogen between the children and adults. Thus for the present we have no explanation for this change in carbon values. Although there is only low-level variation in carbon and nitrogen isotope values, indicating that the individuals at Björned all had a very similar diet, the greater variation in the $\partial^{34}S$ values indicates that the food they ate came from different geographical locations.

Although few applications of $\partial^{34}S$ analyses to archaeological material have been published to date, there are two other studies from Sweden that can be used for comparison with the Björned sample. The first concerns a Neolithic passage tomb at Rössberga, Central Sweden, that shows a remarkable uniformity in $\partial^{34}S$ values (Linderholm et al. ms). Here 30 analysed individuals had a mean sulphur value of +10.6‰ and a standard deviation of only 0.7. The low standard deviation together with a comparison with local animals made it quite clear that this population had had a very homogeneous diet of local origin. The other study, which is closer in time to Björned, is from Birka, the Viking Period trading post (Linderholm et al. 2008). Here 24 individuals were analysed, giving a mean value of +5.2‰ and a standard deviation of 2.6. They had a completely different mean value from the individuals at Rössberga and also a much larger standard deviation. That the individuals buried at Birka were of varying origins is uncontroversial in view of what the site represents. The large standard deviation at Birka is similar to the value at Björned, and, taking the large standard variation in Birka as a reference for mixed origins, it is quite clear that the individuals buried at Björned must also have varied in this respect.

This makes it interesting to look closer at the individuals at Björned whose $\partial^{34}S$ values deviate from the presumed local value of +2.8‰, i.e. the individual from Björkå. The highest $\partial^{34}S$ value obtained here is from individual A7, a 6-month-old baby. This infant, who also has the oldest radiocarbon date (1165+75 BP) and may well represent the arrival of a Christian population from elsewhere, has a $\partial^{34}S$ value as high as +15.5‰. That an infant or child should have such a high value is an exception at Björned, for in general the adults have higher $\partial^{34}S$ values than the children. This might be explained if the adults came from other geographical areas, with different $\partial^{34}S$ signatures, whereas most of the children had been born at Björned. The second highest $\partial^{34}S$ value, +12.4‰, was found in the case of individual A36, a male aged 37–46 years who also had a specific morphological epigenetic signature that sets him apart from the other individuals, being the only individual from Björned who had been exposed to violence, as seen from trauma to his skeleton (Grundberg & Hårding 2003). Could this further indicate that this individual was of a different origin?

The existence of a correlation between the sulphur values and radiocarbon dates, in that the younger the date, the lower the sulphur value, making it more similar to the presumed local sulphur signature, suggests that the founding population of this cemetery originated from a different area but that the later burials represent a local population.

To some extent, the isotope data contradict the genetic results published by Grundberg et al. (2005), in that the sulphur values indicate that the population at Björned originated from several different geographical locations, at least in the case of the early burials. The genetic data could be interpreted as suggesting that Björned was a patrilineal cemetery. On the other hand, the later generations of the buried population may represent a local farm, which would thus be corroborated by the DNA results.

Conclusions

Stable isotope analysis enables us to conclude that the diet of the adults buried at Björned did not change much over the 300 years represented by this material. There was no difference in diet between the Christians buried at Björned and the pagans buried at Björkå and Holm. However, intra-individual dietary differences over time were detectable in five individuals with a slightly more marine input in their childhood diet, as seen in the collagen extracted from their teeth, that became more terrestrial with age. The sulphur isotopes indicate that the people buried at Björned were of differing geographical origins, something seen most prominently in the early burials, with changes over time.

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Summary

We report here on analyses of skeletal material from the Late Viking Period and Early Medieval cemetery of Björned in the parish of Torsåker, province of Ångermanland, northern Sweden. The cemetery finds have been investigated extensively since the excavations in the 1980s and 90s. The change in burial customs from cremation to inhumation probably took place during the 10th century at Björned, making these some of the earliest Christian burials in northern Sweden. Of great interest has been what this early Christian cemetery represents and who the people buried there were. In order to answer these questions, stable isotope analyses of carbon, nitrogen and sulphur have been carried out. Of 50 identified individuals, 37 were analysed. In five individuals both teeth and bone were analysed, this to detect changes in diet from childhood to adulthood. Several animals were included as reference material for the dietary reconstruction and to identify the local sulphur signal at the site.

The carbon and nitrogen values show clearly that the diet had a terrestrial base and that it remained largely the same over the cemetery's three-century period of use. The $\partial^{13}C$ values ranged from -21.6‰ to -19.1‰ in the human samples, with a mean of -20.4‰ (s.d.= 0.6). The $\partial^{15}N$ values ranged from 10.6‰ to 13.6‰ in the human samples, with a mean of 12.3‰ (s.d.=0.6). These results point to a fairly homogeneous diet among this group of people.

Five individuals have been more extensively investigated. Here a change in the diet from childhood to adulthood can be traced. The trend seems to be a shift from a slightly marine diet towards a more terrestrial diet in adulthood, although this is not proven statistically.

The sulphur values decrease over time, which is in contrast to the nitrogen and carbon values that are more or less uniform over time. The sulphur values also show that the Björned population had varied geographical origins. Here twenty-five individuals were analysed: the $\partial^{34}S$ values ranged from -1.7‰ to 15.5‰, with a mean of 5.4‰ (s.d.= 3.4). There is a fairly large standard deviation in the sulphur values, 3.4‰, indicating a varied geographical origin of the diet. The correlation between the sulphur values and radiocarbon dates, in that the younger the date the lower is the sulphur value and the more similar to the presumed local sulphur signature, indicates that the founding population of this cemetery originated from a different area but that the later burials represent a local population.

In conclusion the people buried at the site seem to belong to a non-local early Christian congregation not mentioned in surviving written records.