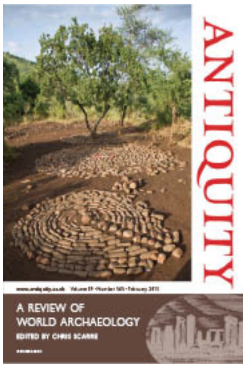

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Diet and status in Birka: stable isotopes and grave goods compared

Anna Linderholm, Charlotte Hedenstierna Jonson, Olle Svensk & Kerstin Lidén*

In this paper the authors investigate isotopic signatures of burials from the famous Viking period cemetery at Birka in Sweden, comparing their results on diet with the status and identities of individuals as interpreted from grave goods. These first observations offer a number of promising correlations, for example the shared diet of a group of women associated with trade, and a marine emphasis among men buried with weapons.

Keywords: Birka, Vikings, diet, stable isotopes, carbon, nitrogen, sulphur

Introduction

The use of stable isotopes as an indicator of diet now has a proven track record. An example of this is a study of the Iron Age to post-Roman (i.e. first-fourth century AD) cemetery in Poundbury Camp, Dorchester, England, where it was possible to conclude that individuals buried in high status lead coffins had regularly consumed marine foods as opposed to those buried in wooden coffins (Richards *et al.* 1998). In another study of human remains, this time from the Anglo-Saxon cemetery in Berinsfield, Oxfordshire, England, dated from the mid-fifth to the early seventh century AD, dietary differences were found between different age-groups in males (Privat *et al.* 2002). Males older than 30 years had higher δ^{15}N values than the others, indicating a higher intake of freshwater resources and perhaps pork. Differences in δ^{15}N values could also be seen in male graves with weapons, as opposed to graves without, where weapon graves had lower δ^{15}N values. There was also an overall difference in δ^{15}N values between wealthy as opposed to poor burials, explained by individuals buried in poor burials feeding more on freshwater foodstuffs. In another study from the pre-Roman Iron Age cemetery (fourth-second century BC) at Wetwang Slack, East Yorkshire, England, 62 individuals from different burial contexts of different status were analysed (Jay & Richards 2006). Here no dietary differences could be inferred and this was interpreted as the homogeneous diet of a local population without any great degree of mobility.

Studies on Vikings, although not from Birka, have been performed e.g. in the islands in northern Scotland where stable carbon isotopes have been used to infer Viking influence on the economy (Barrett *et al.* 2001). Here Barrett and colleagues found a correlation between marine isotope values in individuals buried with a material associated with Vikings, dated

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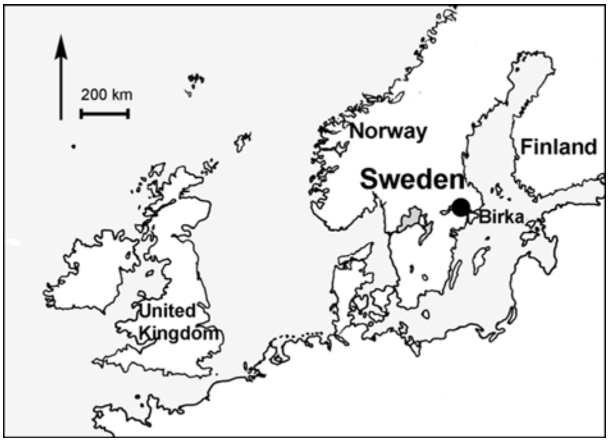

Figure 1. Birka in the region of Lake Mälaren.

to *c*. AD 800-1050, as opposed to the earlier Iron Age ('Pictish') burials dated to *c*. AD 300-800. Based on the faunal material, it was also possible to correlate the increase in marine isotope signature with an increase in offshore fishing. Further, Richards *et al.* (2006) found gender-based differences in stable isotopes in a study of skeletal material from Newark Bay, Orkney. Here males had statistically less negative carbon values indicating a greater marine diet, which was interpreted as a sign of Viking influence. A more complicated isotopic pattern emerged in a study, including more sites in the Orkneys, where a development towards a more hierarchical society from the Pictish period to the Viking period has been proposed (Barrett & Richards 2004).

In this study we combine grave goods, used as an expression of cultural and social identity, with the more subtle information on diet based on stable isotopes to enhance the interpretation of selected burials at the Viking Age trading station of Birka.

Site

Birka (Figure 1) was an important node in the trade network of the Scandinavian Viking Age and the extensive archaeological material reveals long distance trade and contacts with most parts of the known world. Founded in the middle of the eighth century AD, the trading post initially had its major contacts with other parts of Scandinavia and north-western Europe with a close counterpart in Hedeby (Haithabu) in the Danish realm. Some time in the late ninth or early tenth century a major change took place when the focus of trade and contacts switched from West to East and Birka became an active part in the trade with Islamic regions and the East Roman Empire of Byzantium (Ambrosiani 2002a; 2002b; 2005; Arbman 1939; 1940; 1943; Hedenstierna-Jonson 2001; in press; Jansson 1997).

Activities in the town-area of Birka, apart from trade, included various forms of craft activities that were closely connected to weaponry and warrior life. The martial aspect has put its mark on the settlement structure and even today the predominant features consist of extensive fortifications (Holmquist Olausson 2002).

Burial customs

The Birka burial customs differ in many ways from the Viking Age norm in Scandinavia, where there is a close connection between the 'farm cemeteries' and the family's farmstead and land. At Birka, instead, the graves are located in extensive grave-fields. More than half the excavated burials in Birka are cremations, but due to the nature of the analyses performed in this paper our study only deals with skeletal material from inhumation burials. Of the inhumation burials, three main types can be discerned; graves with coffins, graves without coffins and chamber-graves (Gräslund 1989). The chamber-graves are particularly divergent from the general burial custom and also regarded as especially wealthy. There are several hypotheses on the identity of those buried in the chamber-graves, ranging from members of the retinue (cf. Gräslund 1989: 162; Jansson 1997: 18) to people from a different geographical and cultural region (Ambrosiani 2005). The chamber-graves are predominantly clustered in particular areas of the burial ground, in places that could be interpreted as the most prestigious: the area north of the hillfort and in direct proximity to the town rampart. An imaginary line running from north to south separates the burials close to the town rampart (2 on Figure 2) from the burials in Hemlanden (1 on Figure 2). All the chamber-graves lie west of this line and the inhumation burials in general are in close proximity to the rampart (Gräslund 1980: 5). Out of Birka's approximately 3000 graves, over 1600 are situated in Hemlanden (Figure 2: 1A-F); of these approximately 670 have been excavated. The cemetery *Kärrbacka* (6) is situated almost 1km south-east of Hemlanden and consists of more than 30 stone settings of which 14 have been excavated (Arbman 1939: 80; Gräslund 1980: 6; Kyhlberg 1980).

Grave goods

The interpretation of grave goods and what they symbolise is not unproblematic and there is an ongoing discussion concerning the general analysis and social interpretation of burials (cf. Härke 2000 and references there cited). Weapons alone do not automatically turn a burial into a weapon grave or the deceased into a warrior. Still, the presence of weapons marks something of the social standing and role of the deceased. Bearing this in mind this study has defined a number of artefacts in the burials as potential indicators of rank and status, travel and trade, in order to provide contexts for the interpretation of the results of the isotope analysis.

The character of Birka and the numerous signs in the archaeological material of long-distance foreign contact naturally begs the question of whether and where the individuals in the graves had travelled. Artefacts suggesting trade and exchange, such as scales, weights and coins, and purses or pouches, could also indicate travel. These artefacts are not restricted to male burials, but are present in some of the female burials that have been analysed in this study.

Dress has always been an effective medium to communicate social standing, but also marital status, descent and affiliation. Archaeologically, however, dress can be very elusive as it is usually fragmentary at best. In Birka the traces of dress include exotic fabrics like silk and refined trimmings (passementerie) and metal-wire work, suggested to have had

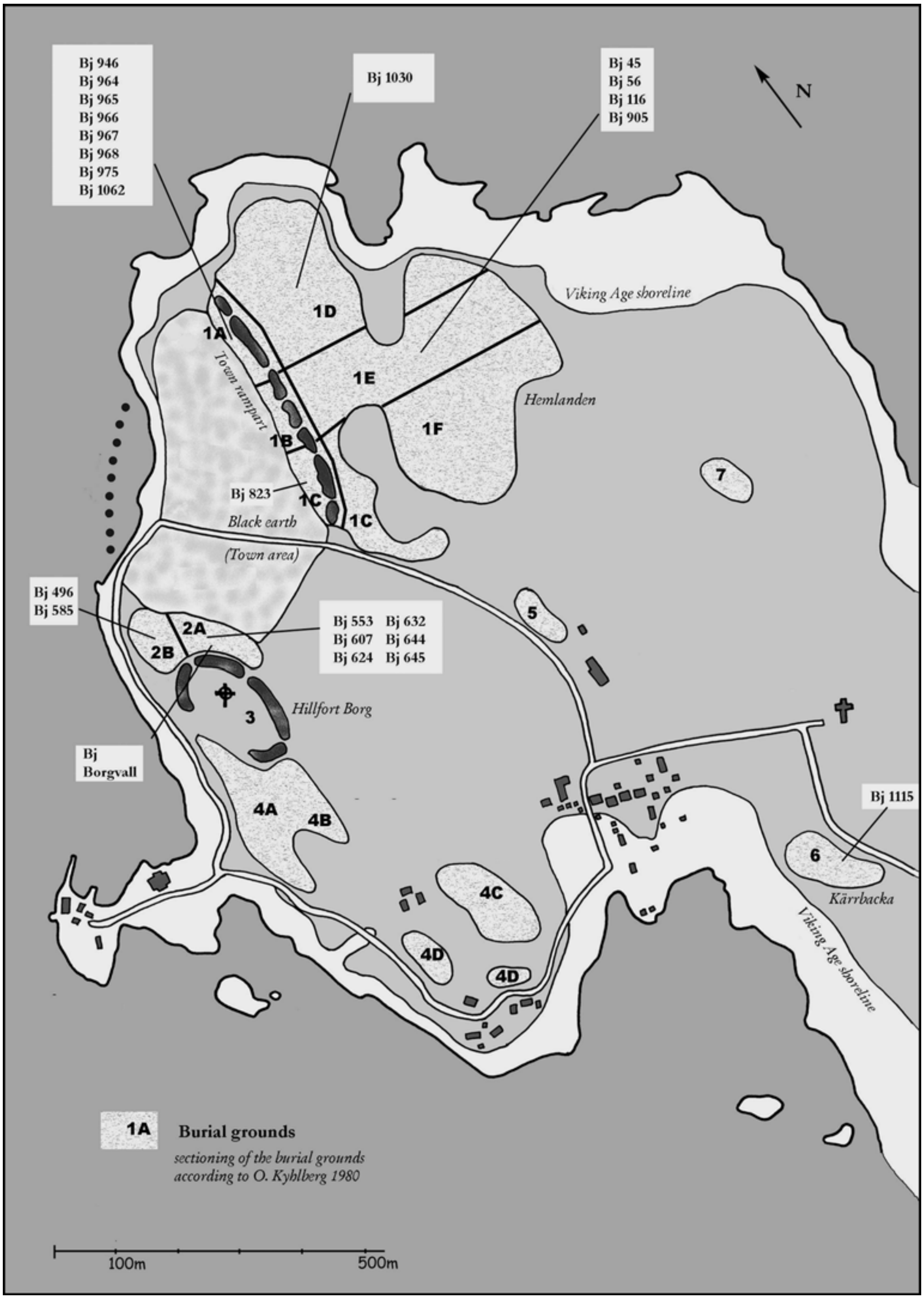

Figure 2. Map of Birka with cemeteries and burials included in the study marked.

rank-indicating functions (Hägg 1983; 2003). The passementeries in particular have been interpreted as symbols of different rank in the highest levels of society, in some cases even indicating a small number of royals (Hägg 2003).

Isotope analysis

Although isotopic analysis of humans buried at Birka was among the first Iron Age material to be published, the study only comprised three samples, all males that turned out to have had a diet based on terrestrial resources (Lidén & Nelson 1994).

Twenty-four human individuals were included in the new analysis reported here, eight from the part of Hemlanden referred to as 1A, four from the part of Hemlanden referred to as 1E, and one sample from each of Hemlanden 1C and 1D (Figure 2; Table 1). Of the remaining 10 samples, one is from the Kärrbacka cemetery, one from the hillfort rampart and eight from the cemetery north of Borg; 2A and 2B (Figure 2; Table 1).

Of these 24 samples, 12 have been osteologically determined as females, nine as males and three are indeterminate. Thirteen of the grave types represented are chamber-graves, while the remaining 11 are inhumation burials. Seven of the graves had weapons. The skeletal elements that have been analysed for each individual are listed in Table 1 together with types of grave goods.

Nineteen individuals have been analysed for δ^{13}C and δ^{15}N and 14 were analysed for δ^{34}S. Animals were included as reference material. Two pigs, two horses, a cow and a sheep were analysed for both δ^{13}C and δ^{15}N, and an additional horse for δ^{34}S. All of the animal bone originated from the cultural layers, the Black Earth (*Svarta jorden)* within the town rampart (Figure 2). As a comparison with local δ^{34}S values, we have added δ^{34}S values from animals from two other Swedish sites, Viking Age/medieval Björned in northern Sweden (Andersson 2006) and Neolithic Rössberga from central Sweden (Linderholm *et al.* n.d.) (Table 1).

The oldest burial included in this study is the grave under the hillfort rampart (RAÄ 34) dated to *c*. AD 750. There is one burial dated to the first half of the tenth century (Bj496), eight further burials dated no more precisely than to the tenth century (Bj823, Bj946, Bj964, Bj965, Bj966, Bj967, Bj968, Bj1062) and one dated to *c*. AD 950 (Bj644). The only other burial that has been dated is Bj632 that T.J. Arne (1946) placed around AD 850.

Method

Analyses of carbon (δ^{13}C) and nitrogen (δ^{15}N) isotopes provide dietary information on the protein intake of the individual studied, in this part of the world most notably whether the diet was based on marine or terrestrial protein (see for example Ambrose 1993; Chisholm 1989; Lidén *et al.* 1997; Muldner & Richards 2005). The use of these two isotopes in archaeology is now more or less standard procedure but for a review of application, methods and problems see Sealy (2001).

Analysis of the stable isotopes of sulphur (δ^{34}S) has been applied to archaeological materials more recently (Richards & Hedges 1999; Richards *et al.* 2001; 2003). Here sulphur isotopes indicate where the food ingested originates from, based on the fact that plants obtain sulphur from three natural sources i.e. organic matter, soil minerals and sulphur gases in the atmosphere (Brady & Weil 1999). Sulphur enters the food chain as the sulphide ion and is essential in animal diets. Trust & Fry (1992) showed that the fractionation of sulphur within plant ecosystems is small; the δ^{34}S value is only 1.5‰ lower than the environmental sulphur. However, the combination of sulphur sources varies between areas, and the δ^{34}S value varies accordingly. Thus, it should be possible to detect if people have derived sustenance from areas with differing δ^{34}S values. The range of sulphur isotopes values varies between systems, for marine and terrestrial systems the range is −10‰ to +20‰, whereas in a freshwater system the range is between −22‰ and +20‰ (Peterson & Fry 1987; Soloman *et al.* 1971). The analysed tissue in this study is collagen which was extracted in the laboratory, according to the modified Longin method (Brown *et al.* 1988; see Technical Appendix below).

Results

In the sample from Birka there is an overall diversity of diet to match the diversity of burial. The diet diversity can be seen in the δ^{13}C values with a mean of −20.0‰ and a standard deviation of 0.6 (Figure 3). According to Lovell *et al.* (1986), a population with a standard deviation less than 0.3 in δ^{13}C can be regarded as having a homogenous diet. There is also a large standard variation in the other isotopes (δ^{15}N mean = 13.6‰ s.d. = 1.1, δ^{34}S mean = 5.2‰ s.d. = 2.6). Statistically significant differences were tested using ANOVA (a one way analysis of variance).

Comparing burials with weapons with those without, we find that individuals buried with weapons have a significantly higher marine diet ($F(1,17) = 5.80$, $p = 0.03$). Since carbon and nitrogen are closely correlated, in that the more marine the carbon values the higher the nitrogen values, there is also a significant effect on nitrogen and weapons using an analysis of covariance ($F(1,16) = 6.44$, $p = 0.02$). In contrast, we find no differences in δ^{34}S values between individuals with weapons and those without (Figure 4).

There are no significant differences in δ^{13}C, δ^{15}N or δ^{34}S between the sexes. There are marked differences between chamber-graves and other burials, but only in δ^{34}S values ($F(1,15) = 4.51$, $p = 0.05$) and not for the other isotopes δ^{13}C or δ^{15}N. There are no significant differences in pooled isotope values between the different cemeteries, but if grave type is included as a covariate in the analysis, sulphur becomes statistically different between the cemeteries. Further, cemetery 1A differs from the other two in having more homogenous sulphur values (Figure 5).

The δ^{13}C values from the terrestrial reference animals from Birka turned out as expected with a mean of −21.4‰ and a standard deviation of 0.9. This value is in accordance with the mean value from the terrestrial animals from Björned (−22.6‰) and Rössberga (−21.9‰). The δ^{15}N samples from Birka on the other hand, are rather high with a mean of 8.0‰ and a standard deviation of 3.8, indicating a large variance in their food sources. The high nitrogen values most probably indicate that the animals, in this case the pigs, were still lactating individuals. This is also most likely for the δ^{15}N values from the almost contemporary animals from Björned where the terrestrial mean is 5.9‰. In Rössberga the δ^{15}N mean value is 4.7‰. The only animal δ^{34}S values from Birka are from two horses (mean = −2.7‰,

Table 1. Human and animals from Birka included in the study. Also animal reference samples from Early medieval Björned and Neolithic Rössberga. Cemetery refers to map in Figure 2, grave type I = inhumation, C = chamber-grave, W = weapon. Artefacts indicating T = trade, S = high social status, R = royal? Sex means biological sex, osteologically determined, m = male, f = female, mv = missing value.

Lab #	Cemetery	Date	Grave type	Artefacts	Sex	Bone element	Bone powder (mg)	Collagen (mg)	Collagen (%)	C %	N %	C/N	$d^{13}C$‰	$d^{15}N$‰	$d^{34}S$‰
Human samples															
Bj 45	1E	?	I W		?	Femur	153.1	14.7	9.6	38.5	13.4	3.4	−19.6	12.8	9.0
Bj 56	1E	?	I	T	m	Tibia	144.7	10.1	7.0	40.9	14.7	3.2	−19.6	12.0	9.7
Bj 116	1E	?	I W		m	Femur	201.9	8.7	4.3	42.3	14.6	3.4	−19.6	12.8	5.5
Bj 496	2B	<950	C W	T,S	m	Os occi.	103.9	4.1	3.9	42.2	14.8	3.3	−20.1	16.5	1.8
Bj 553	2A	?	I		m	Tibia	168.9	24.3	14.4	34.7	11.9	3.4	−21.1	15.1	n.a
Bj 585	2B	?	C		f	Os front.	170.9	14.1	8.2	43.1	14.5	3.5	−19.4	13.2	5.6
Bj 607	2A	?	C	T	f	Os front.	198.9	5.8	2.9	42.1	13.9	3.5	−20.9	13.8	3.4
Bj 624	2A	?	C W	R	m	Os front.	mv	mv	mv	42.8	14.9	3.3	−19.1	14.3	8.2
Bj 632	2A	*c.* 850	C	S	f	Femur	104.1	10.2	9.8	42.8	14.7	3.4	−19.7	13.4	4.7
Bj 644	2A	*c.* 950	C W	R,T	f?	Mandib.	129.5	4.7	3.6	38.5	13.1	3.4	−19.5	14.1	3.1
Bj 645	2A	?	I		f	Mandib.	189.5	6.8	3.6	40.7	13.8	3.4	−19.9	12.1	10.8
Bj 823	1C	*c.* 10th C.	C W	S	m/f	Os occi.	165.9	14.5	8.7	44.5	15.0	3.5	−20.2	13.9	5.7
Bj 905	1E	?	I	S	m	O. M.Tars.	104.6	9.9	9.4	39.7	13.3	3.5	−20.8	13.4	n.a
Bj 946	1A	*c.* 900	C	S	f	Os occi.	104.1	6.2	5.9	44.5	15.4	3.4	−19.8	13.9	3.9
Bj 964	1A	10th C.	C	T,S	f	Femur	189.1	18.0	9.5	44.0	15.0	3.4	−20.7	11.5	3.5
Bj 965	1A	10th C.	C	T,S	f	mv	96.7	4.5	4.6	mv	mv	mv	mv	mv	4.5
Bj 966	1A	10th C.	I		f	mv	115.7	4.1	3.6	mv	mv	mv	mv	mv	2.6
Bj 967	1A	10th C.	C	T	f	Os front.	253.6	5.5	2.2	40.3	14.5	3.2	−20.5	14.2	2.8
Bj 968	1A	10th C.	C	T	f	mv	96.2	6.0	6.2	46.7	16.0	3.4	−19.9	14.0	3.4
Bj 975	1A	?	C W		m	Os par.	144.3	2.9	2.0	36.5	13.4	3.2	−19.0	14.3	mv
Bj 1030	1D	?	I		m	Mandib.	129.0	10.1	7.8	37.8	13.0	3.4	−20.6	13.6	mv
Bj 1062	1A	10th C.	I		f	Os front.	130.6	4.5	3.4	39.9	13.9	3.3	−20.0	13.8	3.1
Bj 1115	Kärrbacka	?	I		?	Os occi.	101.4	14.2	14.0	39.4	13.9	3.3	−19.7	14.2	4.6
Borgv.	Within the Fort	*c.* 750	I	S	m	mv	126.4	8.2	6.5	46.7	16.0	3.4	−19.4	12.7	8.4
Mean													**−20.0**	**13.6**	**5.2**
Standard dev.													**0.6**	**1.1**	**2.5**

Animal Birka													
Bj 45:2	Black earth		Sus	Tibia	123.2	3.0	2.5	39.6	13.7	3.4	−19.9	9.7	mv
Bj 45:3	Black earth		Bos	Humerus	121.6	6.6	5.4	35.7	10.9	3.8	−22.0	5.1	mv
Sj 1	Black earth		Sus		169.3	7.3	4.3	41.5	14.0	3.4	−21.3	13.8	0.0
Sj 2	Black earth		Bos		94.0	1.8	1.9	34.3	12.1	3.3	−21.8	4.0	mv
Sj 3	Black earth		Ovis		154.8	15.1	9.8	38.5	13.2	3.4	−22.1	6.3	mv
Bj 26	Black earth		Equus		mv	mv	mv	mv	mv	mv	mv	mv	−2.2
Bj 28	Black earth		Equus		mv	mv	mv	mv	mv	mv	mv	mv	−3.2
Mean											**−21.4**	**7.8**	**−1.8**
Standard dev.											**0.9**	**4.0**	**1.6**
Animal Björned													
F194		10-11th C	Bos		mv	mv	mv	42.3	14.8	3.3	−22.5	4.4	−3.2
F921		10-11th C	Sus		mv	mv	mv	43.5	14.9	3.2	−22.2	9.7	17.1
F154		10-11th C	Ovis		mv	mv	mv	42.6	15.6	3.2	−21.6	7.8	−1.1
F–		10-11th C	Lepus		mv	mv	mv	41.9	15.5	mv	−24.5	1.6	9.8
F695		10-11th C	Seal sp.		mv	mv	mv	43.2	15.9	3.2	−16.1	13.3	12.6
Mean											**−21.4**	**7.4**	**6.5**
Standard dev.											**3.1**	**4.6**	**8.8**
Animal Rössberga													
Ros31D		Neolithic	Sus		mv	mv	8.12	mv	mv	3.3	−21.9	4.8	10.8
Ros32D		Neolithic	Sus		mv	mv	4.93	mv	mv	3.4	−22.4	4.8	11.3
Ros33D		Neolithic	Bos		mv	mv	2.51	mv	mv	3.3	−21.6	6.2	10.5
Ros34D		Neolithic	Vulpes		mv	mv	5.37	mv	mv	3.4	−21.0	6.4	10.5
Ros35D		Neolithic	Canis		mv	mv	2.89	mv	mv	3.4	−21.4	3.3	11.6
Ros36D		Neolithic	Lepus		mv	mv	5.25	mv	mv	3.4	−22.9	2.4	11.8
Mean											**−21.9**	**4.7**	**11.1**
Standard dev.											**0.7**	**1.6**	**0.6**

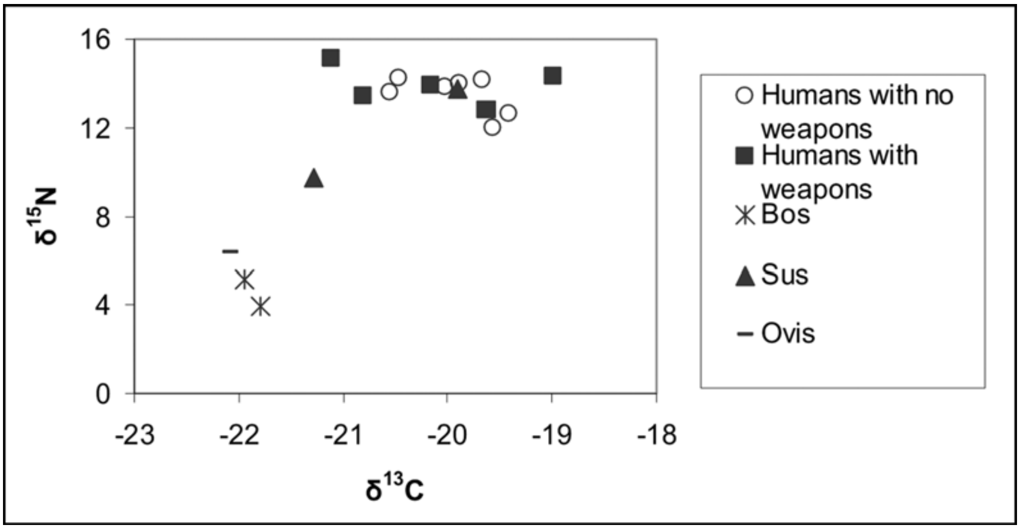

Figure 3. Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) values from humans and animals buried at Birka. Burials with and without weapons marked separately.

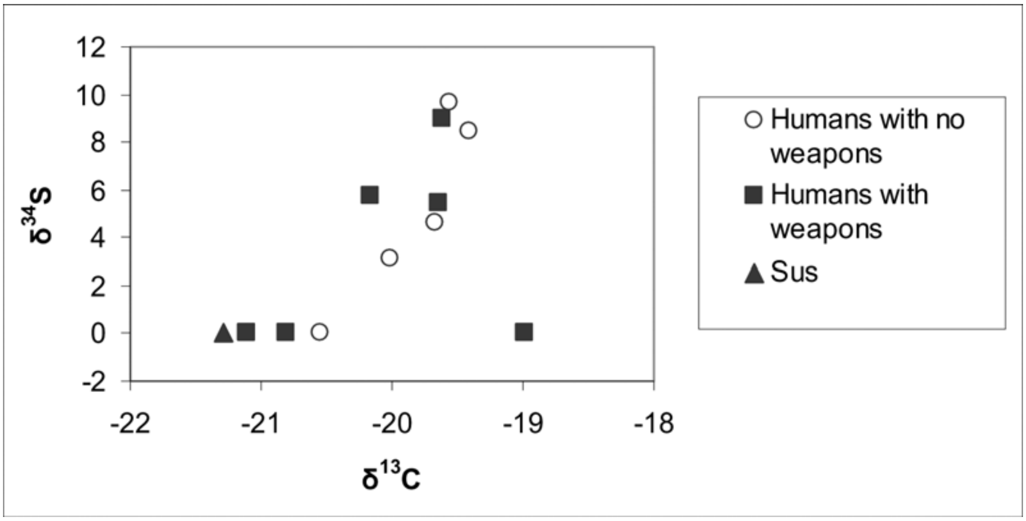

Figure 4. Carbon ($\delta^{13}C$) and sulphur ($\delta^{34}S$) values from humans and a pig buried at Birka. Burials with and without weapons marked separately.

s.d. = 0.7), and one pig $\delta^{34}S = 0.0$‰. These values are, however, clearly different from the mean $\delta^{34}S$ values of terrestrial animals from Björned (mean = 5.6, s.d. = 9.5) and Rössberga (mean = 11.1, s.d. = 0.6), demonstrating that different geographic locations within Sweden do have different $\delta^{34}S$ values.

In accordance with the interpretation of the isotope values from the Wetwang slack burials (Jay & Richards 2006), the large variation in nitrogen and carbon values at Birka could be interpreted as emanating from a heterogeneous population in terms of diet.

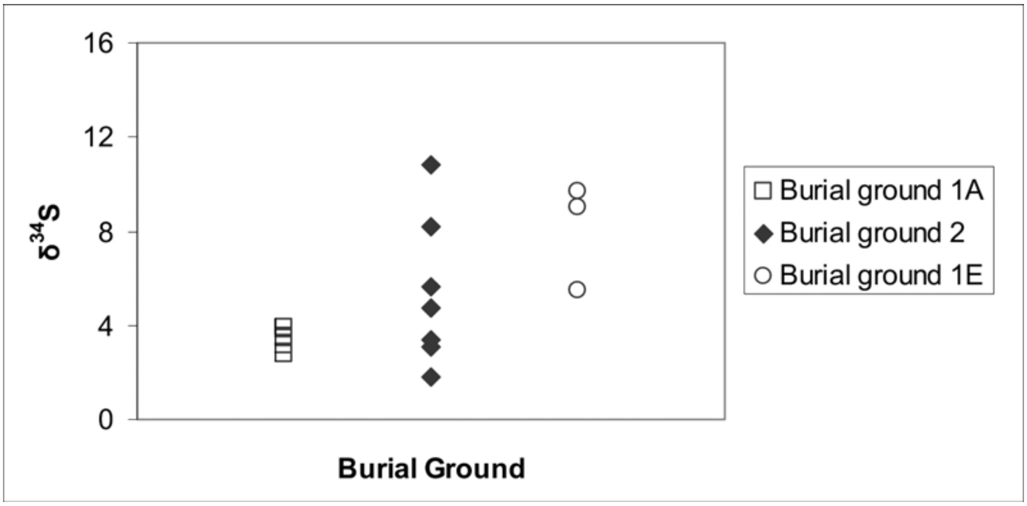

Figure 5. Sulphur (δ^{34} S) values plotted for three different cemeteries at Birka.

Consequently some buried individuals at Birka were non-locals and probably had a high mobility, which in this case could be confirmed by the δ^{34}S values. There is, however, one exception to this isotopic heterogeneity and that is the individuals buried in the cemetery in Hemlanden 1A, which is a very homogenous group in terms of sulphur values (Figure 5). This clearly indicates that these individuals could have a common geographic origin.

Another relatively homogenous and interesting group is formed by the female burials incorporating artefacts indicating trade activities. All these women display among the lowest levels in sulphur (mean = 3.4, s.d. = 0.6) and this is statistically different from the female burials without artefacts indicative of trade (mean = 5.1, s.d. = 3.0) implying a common place of origin or habitat during their last 10-15 years. These women could thus originate from the same area or could have practised trade in the same geographical area.

Since there is such a large overall heterogeneity, also within some subgroups, it is interesting to look at individuals with clearly deviating isotope values and study their burial context. The individuals chosen for this represent different aspects in terms of isotopic results, time-span and gender.

Bj496

The extensive and exclusive contents of grave goods accompanying the man buried in chamber-grave Bj496 (Figure 6) have raised the question of the presence of royal burials in Birka. The grave goods indicate a man of the highest social standing with passementeries that, according to Hägg (2003), have been identified as symbols of rank related to Byzantine court dress. The weaponry consisted of a spear, a shield, one arrowhead and a sword with a bronze chape decorating the sheath. The presence of horse-gear and a platform for the remains of a horse enhance the high status of the interred. The grave also contained weights

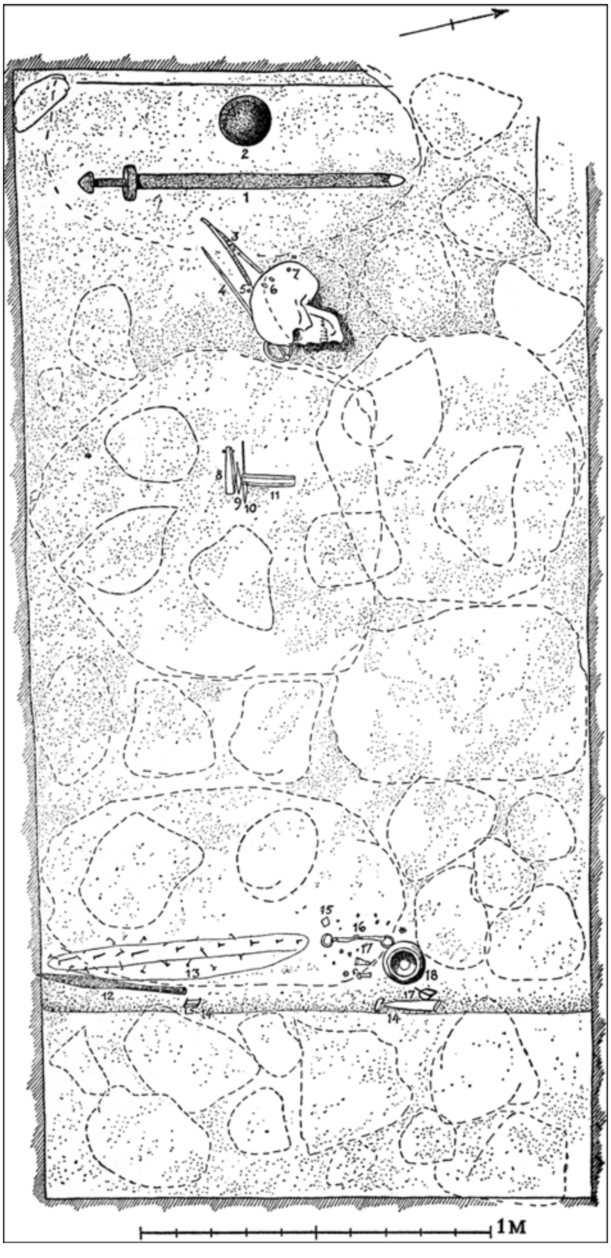

Figure 6. Burial Bj496, a chamber-grave dated to the first half of the tenth century. The grave goods included, among other things, a sword with a bronze chape decorating the sheath, a spear, a shield, an arrowhead and Islamic silver coins (Arbman 1940).

and Islamic silver coins. The burial is dated to the first half of the tenth century. The overall picture is that this is the burial of a ruler or an influential individual at the highest level of society and that he has been buried with symbols of his position, wealth and office.

In isotope analysis, the body of the buried person displays the lowest levels of sulphur (1.8‰) and the highest levels of nitrogen (16.5‰) among the studied individuals. The high nitrogen values must be interpreted in relation to the carbon value (−20.1‰) which in no way infers a marine diet. Thus the nitrogen value can, in this adult individual, only imply a high intake of brackish water or freshwater fish. Together with the very low sulphur value it seems likely that this individual originates from some place other than Birka or spent long periods in his life elsewhere. Notable is the resemblance in sulphur value with those of the trading women.

Bj632

This female burial is dated to the middle of the ninth century and displays an interesting mix of artefacts from different parts of the world. The most spectacular object in the burial is a necklace found close to the head, but not in a position suggesting that it had been worn around her neck. Beads of carnelian, rock crystal, glass and silver-foil were supplemented by various silver pendants. One of these pendants was a silver coin, minted during the reign of the Byzantine Emperor Theophilus (AD 829-832) (cf. Arne 1946). Coins from this period are rare and the majority has been found in Birka. Two of the other pendants on the necklace were originally mounts for belts of the so called 'oriental' or 'composite' type. The mounts have been remade into pendants, in a manner typical for import-goods of this type and date (Hedenstierna-Jonson & Holmquist Olausson 2006). On account of the remarkable necklace Neil Price (2002: 163ff.) has suggested that the buried woman was a sorceress – a volur (völva). It is interesting to note that there are virtually no indications in the isotope-analysis ($\delta^{13}C = -19.7‰$, $\delta^{15}N = 13.4‰$ and $\delta^{34}S = 4.7‰$) to suggest a divergent diet, implying a local origin.

Bj645

The woman in grave Bj645, in contrast to the male buried in the adjacent grave Bj496 (Figure 6), revealed the highest measured levels of sulphur and one of the lowest levels of nitrogen. Buried in the prominently situated burial ground (2A) close to Birka's hillfort (Figure 2), albeit not in a chamber-grave, this grave provided nothing exceptional in the grave goods. The oval brooches of gilded bronze together with a silver equal-armed brooch constituted the remaining grave goods. There were however, according to Hjalmar Stolpe, reasons to believe that the grave had been disturbed as the skeletal remains were not in their original position (Arbman 1943). The very high sulphur values clearly indicate that this individual originates from somewhere other than Birka.

Bj Borgvall: ***the grave below the hillfort rampart***

This grave contained a man and a horse that together with the burial custom and location of the grave indicated high social status (Fennö Muyingo 2000). In contrast to the chamber-graves in the area, grave goods were scarce, apart from a knife. A closer analysis of the organic material found in the grave, however, revealed remains of silk, fur and feathers. The dating of the grave to about AD 750 makes this one of the first individuals to be buried at Birka (Holmquist Olausson & Götherström 1998). This individual has a very high sulphur value (8.4‰) and is the only burial included in this study that pre-dates the shift in trade from West to East. It would have been interesting to examine if there was a shift in sulphur values that correlates with the shift in trade and contacts that occurred in the late ninth century. Unfortunately, there are too few dated burials included in this study to test this.

Discussion

Given the character of the site, we would not expect the population buried at Birka to represent a homogenous population. So some diversity in diet should come as no surprise. However, not even the different subpopulations, based on categories such as sex, burial custom, cemetery or social status are particularly homogenous in terms of diet. This can be seen in the standard deviations for the different stable isotope mean values for the different subpopulations. It is striking that there are still statistically significant differences in diet between some burial categories, for example individuals buried with weapons as opposed to those buried without. The most obvious explanation for this difference in carbon and nitrogen isotope values, where weapon burials on average have 0.5‰ lower carbon values and 0.6‰ higher nitrogen values, is that individuals buried with weapons had a more marine-based diet. Marine food can be obtained in many different ways, but since we like to regard these weapon-carrying persons as special, maybe Vikings, this marine food could have been obtained on overseas travels.

These marine values correlate with the results of Barrett *et al.* (2001) and Richards *et al.* (2006) in their studies of individuals of Viking descent buried in Orkney and Scotland. That weapon burials have higher nitrogen values is otherwise quite contrary to what was found in the Anglo-Saxon cemetery in Berinsfield, where those buried in weapon burials had lower nitrogen values (Privat *et al.* 2002). In Berinsfield, lower nitrogen values were found in individuals buried in 'wealthy' burials as opposed to 'poor' burials from the same cemetery, indicating a quite different cultural concept of high status food between Anglo-Saxon England and Viking Age Sweden. In our study we found no differences in nitrogen or carbon values between the high status chamber burials and the more ordinary inhumation burials.

However, it is notable that some of the chamber-graves of highest rank, notably the princely burial Bj496 and the ritual specialist Bj632, were local and terrestrial in their diet.

The large variation in sulphur isotopes further supports the supposition that the population in Birka is heterogeneous and might originate from different geographic locations. This is also in accordance with the animal reference values, if we assume that the horses analysed were local. The mean sulphur isotope value from the Neolithic burials at Rössberga in central Sweden has a very low standard deviation indicating a common and local origin of those animals. The Rössberga mean value ($\delta^{34}S = 11.1$) is clearly different from the animal mean value in Birka ($\delta^{34}S = -1.8$) which is also true for the mean animal sulphur value ($\delta^{34}S = 5.6$) from the more contemporary burials in Björned, northern Sweden.

This method therefore has some potential to add to the evidence of grave goods and burial rites, the comparable, although less obvious, evidence for diversity and ranking in diet.

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Technical Appendix

Samples for isotope analysis were demineralised in a 0.25 M HCl solution for approximately 48 hours at room temperature, the solution is filtered and washed with deionised water through a glass filter to remove the 0.25 M HCl. A solution of 0.01 M HCl is then added to the sample and this is incubated at 58°C for approximately 16 hours to dissolve the organic material. The dissolved organic residue is filtered and washed with deionised water through an ultra filter (30 000 MWCO Amicon Ultra-15 Centrifugal filter device (Millipore)), removing particles <30kDa. Particles >30kDalton are considered to be intact collagen, and thus, fragmented chains and humic substances are removed. The residual solvent is then transferred to a 2ml microtube and frozen to approximately −80°C, after which it is freeze-dried and weighed. Stable isotope analyses were performed on a Carlo Erba NC2500 elemental analyser connected to a Finnigan MAT Delta+ isotope rate mass spectrometer (IRMS). The precision was ±0.1‰ for both δ^{13}C and δ^{15}N and ±0.2‰ δ^{34}S.

Method

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