Hierarchy through Diet

Stable isotope analysis of male graves of the estate church graveyard in Varnhem

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Abstract
Den här uppsatsen behandlar ett antal individer begravda mellan 800 e.Kr. och 1150 e.Kr i ett tidigt kristet gravfält kring ruinen av Varnhems gårdskyrka. Av speciellt intresse är den placeringen som gravarna har i förhållande till kyrkomurarna och vad dessa placeringar innebär statusläten. Analys av stabila isotoper har därför utförts på de manliga individerna så att deras diet kan fastämmas och agera som en markör för vad som kännetecknas som hög och lågstatus bland de begravda männen i Varnhem.
1. Introduction

From approximately 1000 AD to 1150 AD in Västergötland, Sweden; Varnhem’s parish contained an estate church with a surrounding graveyard. The graveyard preludes the church by several years, its oldest grave $^{14}$C dated to the late 800s A.D (Vretemark, 2012:59). In 2005, the graveyard was partly excavated and about 200 graves were uncovered and studied. Finds included skeletal remains and burial paraphernalia. Containing several Christian motives, the graveyard has been characterized as an early Christian graveyard.

A discussion surrounding Christian graveyards is whether hierarchy is illustrated through burial location. An overview of the graveyard reveals no such pattern (Fig. 3.). However differences in social stratas can also be reflected in diet. In medieval Sigtuna during periods of starvation, only the rich could afford meat whereas the poor could only afford vegetables and fish (Kjellström, 2005). Diet is best determined through a stable isotope analysis, a tracing of isotopic signatures in all food webs. Through extraction of collagen from the bones and teeth of the Varnhem individuals, a stable isotope analysis can reveal what they ate, where the food was approximately located in the trophic levels and identify non-local individuals. Using a premise similar to medieval Sigtuna, I think that diet can determine a hierarchical structure throughout the Varnhem burial ground.

1.1 Question and Aim

Through earlier archaeological studies on hierarchy (Jonsson, 2009) and several historical sources, it has been discussed that at certain times, high-status individuals during the late Viking Age and early medieval period were buried to the east in close proximity to the church. With this information as a vantage point I mean to investigate the following.

Is there a dietary difference between those graves close to the church and those farther away?

This thesis's aim is to understand whether social status can be determined through diet during the late Viking Age and early medieval period.

1.2 Method and Material

To determine hierarchy through diet, a stable isotope analysis has been performed on 16 males buried in the Varnhem estate church graveyard. Analysis of the stable isotopes of carbon ($\delta^{13}$C), nitrogen ($\delta^{15}$N) and sulfur ($\delta^{34}$S) can show through $\delta^{13}$C, if diet is predominantly terrestrial or marine. $\delta^{15}$N will allow for the pinpointing of an individual’s location in the trophic levels. $\delta^{34}$S allows for identifying possible non-locals. Results from seven of the 16 males were provided from an earlier stable isotopic analysis (Lidén et al., unpublished data) while the remaining nine have been analyzed for this particular thesis. Remains from three animals have also been provided as reference. Faunal references are particularly important when determining source of origin. The chemicals markers in the buried individual’s diet must coincide with something
locally analyzed in order to be considered to be from that particular area. Human material has been confined to femurs and teeth, from which collagen is extracted. Due to collagen’s rate of turnover in bone, the dietary information derived through analysis is of the individual’s last years. In teeth unlike bone, collagen is not remodeled and a stable isotope analysis on teeth will therefore reveal the dietary information provided for the early stages of an individual’s life during the teeth’s formation. After the extraction of collagen is complete, samples are run through an isotope ratio mass spectrometer (IRMS).

1.3 Limits & Obstacles

This study has been confined to 16 adult male individuals provided for by Maria Vretemark. All skeletal remains are from Varnhem’s estate church graveyard during the 2005-2008 expedition led by Maria Vretemark. All male burials exhumed during the expedition have not been provided for in this thesis, and a portion of the graveyard still remains uncovered.

This study has chosen to focus exclusively on the male graves. This choice is mostly due to the discussed period’s view on males as lawmakers and custom deciders as evident by the later discussed Norwegians Borgarthing and Eidsivatheing laws. Several females and infants have been analyzed as part of this greater project but an inclusion of females and infants results as well as an immersion into the their hierarchical and social boundaries are not possible due to the space constraint of this thesis.

A possible hindrance in choosing stable isotope analysis is the destructiveness of the extraction process prior to analyzing. Sampling of material is performed by drilling through bone and teeth, which damages the material irreparably. Care and respect has therefore been applied when handling all material.

Of particular importance is the knowledge that the excavation of the Varnhem estate church graveyard is not complete. Several graves still remain to be uncovered and excavated. What this might prove for future discussions could be the exact opposite of what this thesis’s premise is.

2. Background

For the sake of context a brief geographical and historical background about Varnhem will be provided.

2.1 Geography

Varnhem’s parish in Valle hundred is located along the western foot of Billingen (Fig. 1.); a limestone and alunslate mountainous plateau (Fries, 1958:11).
Likened to a camel’s humps, the area contains small hills turning into small lakes and watercourse filled valleys. Approximately five miles south lies the largest lake in the area, Hornborga lake (Vretemark, 2002:2 & Sahlström, 1939:5). The soil consists primarily of till and has as far back as possible provided favorable conditions for flora and farming. Pre-agriculture, Valle hundred would have been composed of rich forests of oak, elm, and lime (Fries, 1958:21).

2.2 Varnhem pre-church

For a location with such a rich archaeological history of finds dating back to the Stone Age, Varnhem during the Viking Age is in comparison a place surprisingly void of archaeological evidence. The area during this particular time is predominately marked by the emergence of Christianity, Varnhem estate church being the primary example. Megalithic graves, gallery graves and mounds still shared space with ongoing burial grounds such as Pickagården but were no longer built in Varnhem(Fig. 2.). An excavated burial site by Skara-Skövdevägen in Varnhem resulted in 18 graves, dated from 600 to 700 AD, and among noticeable burials in the area is grave A3. The buried individual was a female with accompanying artifacts of around 22 pearls, a bronze- ring and key, an animal ornamented hoop and chain links(Vretemark, 2002:19). Last dated burials in Pickagården are from 800 AD and marks as of yet the latest pre-Christian burials
(Elfstrand, 1983:25). Excluding the estate church graveyard with graves dated the earliest from late 800 AD, the next excavated find would be the famous coin treasure found in the Varnhem monastery garden. Dated from the late 900’s AD to early 1000’s AD. The treasure consisted of 476 coins. Majority of coins were mostly Anglo-Saxon but also included coins of Norwegian, German, Irish, Easter Roman and Arabian origin (Wideen, 1995:83).

Fig. 2. Varnhem. Scale 1:10K © Lantmäteriverket 2012. Allowed 2012-12-07

2.3 Varnhem estate church

Predating the actual church’s building in 1000 AD are burials dating to the late 800s and forward. Why several burials predates the estate church is unknown at this point. Only Pickagården and Kusebacke along with the estate church graveyard contains excavated burials past 800 AD. Pickagården and Kusebacke are burial grounds of pagan characteristics and the earliest estate church burials might simply have been an attempt in the newfound Christian customs to distance itself from past religious traditions (Vretemark, 2012:57-59).

Grave 96, dated to around 920 AD, includes finds of a dagger with a silver handle and coffin nail presumably from a wooden coffin. Graves 80 and 5 include limestone, the former a headboard and the latter a whole coffin (Fig. 3.). Each grave has been dated to 925 AD and 990 AD with a margin of about +/- 30 years. Leeway has to be allowed chronologically but evidence points to the church being built more to accommodate the graveyard than vice versa (Vretemark, 2012:59). The first church was initially built of wood in about 1000 AD and was after a couple of decades for an unknown reason either expanded upon or torn down to be built anew (Vretemark, 2008:211). What sets this later construction apart from its greater size was the addition of a limestone cellar built to the east. The cellar holds a significant cultural importance due to the
area’s previous history of a lack of skill and expertise when working with limestone. A relatively unknown craft at a local level, the skill was at the time prominent in Denmark, Germany and England (Vretemark, 2009:9-10). Tied together with the foreign coins contained within the monastery garden treasure, evidence would suggest some form of aid or expertise brought forth by connections abroad. With the cellar completely empty at the time of excavation, the function of the room remains a mystery (Vretemark, 2008:213).

Another rebuilding process followed with the church’s current wooden walls torn down and stone walls erected in their stead. The church would remain in this condition until its donation in 1150 AD to the Cistercian order. No burials around the surrounding church graveyard postdate 1150 AD and it can therefore possibly be presumed that the church or at least the graveyard was abandoned for the nearby built monastery.

2.4 Estate church graveyard

The graveyard contains at least 2000 graves. As of today approximately 200 of those graves have been excavated (Vretemark, 2008:214-215). As noted by the burial map(Fig. 3.), the number of currently excavated burials are primarily located by the northern, southern and eastern side of the church. A small contingent of burials is located to the south west of the church.

Overall the graveyard doesn’t appear particularly organized in any significant way. Female and male burials are not segregated by gender. Certain exceptions can be allocated to those graves situated closest to the walls, two males to the south and three females to the north. Among them is burial 135 which contains like several other surrounding graves, a wooden coffin with a coffin nail but the accompanying stand miniature altar hints at someone not necessarily powerful but of religious stature.

To the north, female graves 20 and 161 both contained wooden coffins with 161 also including a dagger. The graves don’t however distinguish themselves from the more distanced burials 80 and 72. The latter graves 80 and 72 predates the former 20 and 61 but its grave 72 that projects a higher standard with its addition of limestone. A limestone coffin was also found in infant grave 6A, among the closest to the wall on the northern side. Per Christian custom, skeletal remains were unburned and by the archaeological evidence buried in coffins if possible. Coffin material varied between limestone and wood. The most common male burial finds were knives, whetstones and coins. Female graves were dominated by buckles and different glass beads (Vretemark, 2008:216). Inclusions of coffin nails where found in both gender’s graves and might have signified either a wooden coffin, religious artifacts or a form of stature. Earliest graves have been dated to late 800 AD with the latest known dated to around the middle of 1100 AD (Vretemark 2012:59).
2.6 Hierarchy in death

From a religious doctrinal standpoint, Christianity is a religion of polarizing factors, illustrated and presented through forms of holy-unholy and faith-unfaith, this was similarly showed in burials. A notable observation is the level of sanctity around the architectural church room, the chancel, which inside contained relics but outside was the central point of the most flaunted and important burials (Jonsson 2009:52-53). In the discussed estate church graveyard, a possibly similar segregation can be noticeable in the group of graves clustered around the eastern part of the church. The western part is also populated but in much scarcer numbers. Segregation between burials gender wise were males to the south and females to the north (Risan 1998:23f). From a
historical legislative standpoint, the originally 11th century Norwegian Borgarting and Eidsivatheing laws enforced a code of segregation concerning burials (Rindal 1995:8ff, 2004:108ff). A special focus lied on men called lendmenn who either had been in service to the king or obtained land from him. Status in life was represented through closeness to the actual church (Kjellström 2005:87) and in the lendmenn's case as close as possible to the south and east of the church. Conditions among the followed custom of being buried as close as possible was determined by participation in building the church. Non-participation meant being buried farther away with the farmers which acted as a sliding down the social ladder (Riisøy 2005:63). The subsequent levels/burials hierarchies past and beyond the lendmenn were free-born farmers, followed by freed thralls and after concluded by thralls and societal outcasts such as executions, suicides (Jonsson 2009:51-52).

Notable dietary differences in social classes during the late Viking Age and early medieval period has mostly been discussed with medieval Sigtuna as a premise (Kjellström, 2005). Whether Sigtuna, a developed city as of the early medieval period, can be compared to Varnhem, a prosperous yet rural town, dietary differences in Sigtuna has boiled down to a situation of production vs. Growth. In medieval Sigtuna where city food production did not equal the population growth meant a subsequent rise in meat costs. So where there once had been a possibly overall homogenous diet across the social classes consisting of terrestrial or marine meat, the result after the rise in costs were probably a strictly meat diet affordable by those more prosperous. A diet for the considerable poorer would have been a diet of mainly vegetables and fish (Lagerqvist & Åberg 2004:21).

3. Method

3.1 Method history

The first published archaeological study of a stable isotope analysis and diet can be attributed to Nikolaas van der Merwe and J. C. Vogel (Vogel, J. C. & van der Merwe, 1977). The study was an attempt in trying to establish the chronological introduction of maize into the New York area. A stable isotope analysis was performed on human ribs found on four different chronologically dated archaeological sites in New York. Results were fruitful and showed that maize had not been present in the early periods but had become a predominant food during a later period.

Continued dietary and isotopic work would be followed by scholars DeNiro and Epstein who in 1977 performed controlled dietary experiments to determine the transfer of stable isotopes through animal tissue in regards to the varying trophic levels an animal can occupy (DeNiro & Epstein, 1978). The 1980s saw advances in equipment and the development of analyzing stable nitrogen isotopes. The 1990s would follow with an increased use of stable isotope analysis in studies concerning bone chemistry (Katzenberg, 2007:414). In 1994 Lidén and Nelson published the first survey of stable isotopes in medieval individuals around the Baltic Sea. Modern strides
in stable isotope analysis have provided for more than just analysis of carbon and nitrogen but also sulfur during the last decades. A direct continuation of stable isotope research in archaeology has today made it an increasing routine in determining prehistoric diets and migration patterns.

3.2. Bones, teeth and the material in question

3.2.1 Bones

Bones come in a myriad of sizes and shapes but can for simplicity be segmented into a few basic but overlapping shapes. Bones of the appendages and several of the hands and feet share the long and tubular characteristic which has given them the name, long bones. The collar bone, shoulder blades, pelvis and ribcage tend to be flat and shield like. The wrist- , anklebones and spinal vertebrae are boxlike and irregular (White, 2005:40).

All bones whether size or shape combines the two properties of strength and lightness of weight (Goffer, 2007:380 & Bilezikian, Raisz & Martin, 2008:31-32). This is further broken down into the two structural components of being compact and spongy. The solid, dense bone found in the outer layer and walls of bone is called cortical bone tissue, Moving to the ends of bones(Meta- & epiphysis) and the texture gains pervious and spongy quality called cancellous bone(Pollard & Heron, 2008:273). Cancellous bone is often characterized by exterior outgrowths where tendons attach. The inner spongiosa is actually for the containment of red matter and blood cells which flow through the cancellous network within the bone (Deng, Yao-Zhong & Chun-Yuan, 2005:12-13 and White, 2005:40). In archaeology, extracting collagen from bone hinges on available parts. For stable isotope analysis the compact part of bone can yield the larger amount of bonepowder but more fibrous bone such as the ribs can and have been used. An advantage of possibly using long bones lies in the possibility of not completely destroying the bone when extracting bonepowder.

On a molecular level bone consists of about 35% organic and 65% inorganic material. Largest organic component is a protein molecule called collagen. Lacing together with the inorganic components, collagen molecules provide bone with its flexibility against any pulling or stretching. The 65% of inorganic material is composed of a biomineral, a form of calcium phosphate called hydroxyapatite. Hydroxyapatite is what gives bone its hard and rigid structure (Goffer, 2007:80 & White, 2005:42).

Bones has the ability to constantly renew itself throughout a lifetime. This act called bone remodeling is performed through osteoclasts breaking down bone and following osteoblasts replenishing with new bone tissue. Since bone is constantly undergoing bone remodeling, its isotopic structure reflects dietary information over the last several years of an individual’s life (Bell, 2001:67 & Plate, 1994:165). In adults, the average rate of bone remodeling is about 7-20
years (Hedges et al., 2007). Therefore, the collagen removed from the Varnhem bones and later stable isotope analyzed provides an approximate ten year record of what the males buried in the estate church graveyard ate.

3.2.2. Teeth

Teeth, used by jawed vertebrates to chew food consists of two layers of hard substance covering a center of living tissue. The thin outmost layer is composed of enamel, a 97% mineralized and extremely hard coating. The inner layer is composed of dentine, a calcified connective tissue which while harder than bone is softer than enamel (White, 2005:130).

Throughout a lifetime a human being has four types of teeth. Those types are the incisors, canines, premolars and molars. Incisors are shovel shaped and used for shearing. Canines, conical in shape are for tearing, premolars and molars, differentiated by smaller to larger are square-like and used for crushing and grinding (Bass, 1995 and White, 2005:128). While a human's exact number of teeth can vary, an initially healthy person has during a lifetime two sets of different teeth. Deciduous teeth are the first set of teeth developed, initially 3 months in utero. By 3 years of age the deciduous teeth are fully formed only to be completely replaced by permanent teeth at around 11(+/−2.5 years). In permanent teeth, the first molar’s (M1) hard tissue begins to form at birth and is fully formed at around 12-13 years. The second molar (M2) begins forming around ages 2½-3 and is fully formed around 14-16 years. The third and last molar (M3) begins forming at around 7-9 years and is fully formed around 18-25 years (Scheid & Weiss:2011:167).

Skeletal bones renew collagen at a slow constant pace, but teeth’s primary dentin (with the exception of secondary dentin) does not remodel during life. Similar to small time capsules of dietary information, isotopic analysis of teeth provides archaeologists with the ability to study an individual’s early years as opposed to the last years provided through analyzing bone. Teeth provides archaeologists with an introductory frameset to an individual, a possibility to discuss, study and combine more than just one piece of an ancient individual’s dietary habits. To gain the greatest overall dietary view of an individual’s early life, the molars which form in three chronologically solitary stages can be helpful when performing stable isotope analysis (Eriksson & Lidén, 2012:3-4). Among other possible archaeological benefits provided by particularly studying the dietary shifts through bones and teeth help not only in discerning eating habits but specific acts such a change in food due to migration or famine.

3.2.3. Material and Method

All material used during this study are a result of the 2005-2008 excavation of the Varnem estate church burial ground.
The material consists of 16 males each excavated from separate graves. As reference, two locally excavated voles and one horse have been analyzed. Human bone types have been limited to femurs for a homogenous testing pool. Teeth material has been analyzed in accordance to availability with a focus on molars.

All animal remains have been excavated from around the graveyard and has not been dated to any specific period. Vole remains consisted of one sample, cranial fragments and the other a mandibula which were individually crushed in a mortar for best possible sample size.

Permanent dentition samples have been primarily extracted from under the crown. Information concerning permanent tooth formation has been taken from Smith(1991) by way of Howcroft(2012). The M1’s beginning of sample formation is calculated to 3 years with a cessation of sample formation at 5 years. The M2 begins at 7,5 years and ceases at 10 years. The M3 begins at 13 years and ceases at 15 years.

Table 1. List of studied and analyzed bones from Varnhem estate church’s burial site. Provided for by Maria Vretemark.

<table>
<thead>
<tr>
<th>grave#/individual</th>
<th>element</th>
<th>age</th>
<th>radiocarbon dating</th>
<th>Distance from church</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Femur (sin)</td>
<td>30-35</td>
<td>Ua 1005± 30 BP</td>
<td>Close</td>
</tr>
<tr>
<td>18</td>
<td>Femur (sin)</td>
<td>45-60</td>
<td></td>
<td>Far</td>
</tr>
<tr>
<td>31</td>
<td>Femur (sin)</td>
<td>45-60</td>
<td></td>
<td>Far</td>
</tr>
<tr>
<td>33</td>
<td>Femur (sin)</td>
<td>40-45</td>
<td>Ua 1175± 30 BP</td>
<td>Far</td>
</tr>
<tr>
<td>39</td>
<td>M1, Femur</td>
<td>20-25</td>
<td>Ua 1025± 25 BP</td>
<td>Far</td>
</tr>
<tr>
<td>53</td>
<td>M1, Femur</td>
<td>40-45</td>
<td></td>
<td>Far</td>
</tr>
<tr>
<td>62</td>
<td>M1, Femur</td>
<td>35-50</td>
<td></td>
<td>Far</td>
</tr>
<tr>
<td>94</td>
<td>M1, M2</td>
<td>25-30</td>
<td></td>
<td>Far</td>
</tr>
<tr>
<td>99</td>
<td>M1, M2, Femur</td>
<td>30-40</td>
<td></td>
<td>Far</td>
</tr>
<tr>
<td>102</td>
<td>M1, M2, M3, Femur</td>
<td>35-45</td>
<td></td>
<td>Far</td>
</tr>
<tr>
<td>105</td>
<td>Femur (dx)</td>
<td>30-40</td>
<td>Ua 1005± 35 BP</td>
<td>Far</td>
</tr>
<tr>
<td>130</td>
<td>M1, Femur</td>
<td>35-45</td>
<td>Ua 910± 35 BP</td>
<td>Far</td>
</tr>
<tr>
<td>135</td>
<td>Femur</td>
<td>30-35</td>
<td>NZA 960±50 BP and Ua 770± 35 BP</td>
<td>Close</td>
</tr>
<tr>
<td>152</td>
<td>M1, M2, M3, Femur</td>
<td>35-40</td>
<td>UBA 1083± 23 BP</td>
<td>Close</td>
</tr>
<tr>
<td>181</td>
<td>Femur (dx)</td>
<td>45-60</td>
<td>NZA 1101± 50 BP</td>
<td>Close</td>
</tr>
<tr>
<td>194</td>
<td>Femur (dx)</td>
<td>25-30</td>
<td>NZA 978± 50 BP</td>
<td>Close</td>
</tr>
</tbody>
</table>

3.3. Collagen

Collagen is probably the most plentiful protein in mammals. It forms most of the organic matrix of bones, teeth, and greater parts of tendons and ligaments. It is present in skin, arteries, cartilage and in most of the extracellular matrix in general (Fratzl, 2008:1). Collagen is a complex protein comprised of three polypeptide chains coiled together into a triple helix (Phillips, 2004:93).
Each of the chains is composed of over 1400 amino acids in a repeated series of three, one part always glycine (Goffer, 2007:327). Different tissues in the body have different types of collagen. There are 27 types of collagen with type 1 being the most widespread. Type 1 collagen makes up bone, tendons, ligaments, skin and cornea (Brinckmann etc. 2005:2-5).

3.4. Collagen extraction

Extraction of collagen has been performed according to the method published by Brown et al (1988). Prior to any labwork, all bones are photographed and documented for future references. Introductory to any extraction requires a clean working environment. This entails protective labcoats, rubber gloves, cleaning of work surfaces and equipment using distilled water or at certain periods a controlled ethanol flame. Skeletal remains can sometimes arrive in states which require adequate cleaning. If cleaning was deemed necessary (which they weren’t in this study), bones or teeth can be immersed in deionized water in an ultrasonic cleaner for the necessary time. Bone or dentine powder is removed through drilling. A minimum of 100 mg was removed from the femurs, and a minimum of 50 mg of dentine was removed from the teeth. Bones too small to drill have been crushed using a mortar.

Placed in glass filter funnels, the bone or dentine powder samples are demineralized in a 48 hour soaking in 0.25 M HCl. After, the combined solution is filtered, removing any insoluble material. 0.01 M HCl is added and placed in a 58ºC oven for 16 hours.

Remaining collagen is ultrafiltrated excluding any particles less than 30 kDalton. The solution is transferred to microcentrifuge tubes and frozen in -80 ºC. Frozen solid, the substance is placed in a freezedryer, which seals and prevents the reabsorption of moisture. After several hours, resulting collagen is removed solid and freezedried.

3.5. IRMS(Isotope Ratio Mass Spectrometry)

Isotope ratio mass spectrometry is an analytical tool used to measure the molecular mass of a sample. In general, a mass spectrometer is the separation of molecules by a form of ionization. This separation is based on their mass-to-charge (m/z) ratios and controlled by moving the atoms and molecules through an electrically charged field (Georgi, 2009:37 & Goffer, 2007:36).

By a form of sublimation, the collagen is turned into gas. Ionization is caused by pushing the gas into a vacuum system where it is blasted with a beam of electrons. The ionized particles are then subjected to fixed energy causing an acceleration. Depending on its specific mass-to-charge ratios each particle will while traveling through several electric/magnetic fields’ exhibit different curvatures due to the deceleration (Pollard & Heron, 2008:57).
Mass spectral analysis during this particular study was performed by the Stable Isotope Laboratory (SIL) of the Department of Geological Sciences, Stockholm University. Equipment used for analyzing samples for carbon and nitrogen consisted of a CarloErba NC2500 elemental analyzer connected through a ConfloIV open split interface in order to regulate the gas volume to a Finnigan DeltaV advantage mass spectrometer run in continuous flow. For sulfur, a CarloErba NC2500 elemental analyzer connected through a ConfloII open split interface to a Finnigan Delta plus was used.

3.6 Stable Isotopes and notation basics

Isotopes are chemical variants of the same element. The differentiating factor is the number of neutrons which when added with the number of protons equals the atomic weight. In most cases adding a neutron keeps the isotope structurally stable but the addition of too many will through the extra weight destabilize the isotope causing it to turn radioactive and decay (Fry, 2006:4). Isotopic values have their own special symbol or notation.

$$\delta$$

The Delta notation ($\delta$) is defined as the comparative variation in parts per thousand between a sample isotope ratio and the isotope ratio of an internationally determined standard (Slater et al., 2001:1270). Expressed through the formula using carbon as an example.

$$\delta^{13}C = ( \frac{^{12}C/^{13}C}_{\text{sample}} / \frac{^{12}C/^{13}C}{\text{standard}} ) - 1 \times 1000 \text{ ‰}$$

Stable or unstable, elemental isotopes have become an important tool in archaeology. Of special interest are isotopes of those elements that are inherited in all organic matter, especially elements H, C, N, O, and S.

In turn isotope analysis has become a premiere tool in discerning dietary habits, dating, and environmental history. When discerning dietary habits through stable isotope analysis, bone and teeth is the most available and satisfactory material. $\delta^{13}C$, $\delta^{15}N$ are the most frequently analyzed isotopes in Archaeology (Sealy, 2001:269).

3.6.1 Carbon

Carbon exists in two stable isotope forms, $^{12}C$ and $^{13}C$. Around 99% of all carbon exists in the form of $^{12}C$ and about 1% in the form of $^{13}C$(Lambert, 1997:214).

All carbon present in biomass is initially taken up as CO$_2$. The largest source of carbon, through the process of photosynthesis. When stored in photosynthesizing organisms, carbon is continuously moved through a cycle of plant, herbivore, and carnivore (Lee-Thorpe, Sealy & van
der Merwe. 1989). Commonly called the carbon cycle, it is the capital exchange of CO$_2$ in the atmosphere, ocean and terrestrial ecosystem (Fry, 2006:45).

As carbon is consumed by plants through photosynthesis there occurs a small discrimination against $^{13}$C because of small physical and chemical properties conveyed by the difference in mass. This small discrimination is called isotopic fractionation and is completely dependent on the form of photosynthesis performed by the plant (Lambert, 1997:215 & Goffer 2007:308). Due to certain ecological and geographical factors the plants in accordance with their own process of photosynthesis are known as C3, C4 and CAM plants.

C3 plants are marked by their large isotopic fractionation. δ$^{13}$C values usually land between -23 and -33‰, with an average of about -26‰ (Lambert, 1997, 215). Scandinavians natural ecosystem consists entirely of C3 plants (Eriksson & Lidén, 2012:2). C4 plants are characterized by hot habitats short on water (Ehleringer & Cerling, 2002:1). C4 plants have δ$^{13}$C values of around -12 ‰ (Lambert, 1997:215).

CAM plants can use either the C3 or C4 process resulting in a myriad of possible δ$^{13}$C values. Human beings located in the northern latitude and on a strictly terrestrial diet are believed to have demonstrated collagen δ$^{13}$C values of -20 to -21‰ (Lidén & Nelson, 1994:14).

In the oceans carbon exists in the form of bicarbonate ions and dissolved carbon dioxide. Due to the difference in the oceanic $^{13}$C/$^{12}$C ratio to atmospheric CO2, a marine diet will display contrasting δ$^{13}$C values as to a terrestrial diet. A human being living in the northern latitude will exhibit a δ$^{13}$C value of -12 to -13‰ when strictly on a marine diet.

In Scandinavia, an individual using the Baltic Sea as his/hers main marine food source has been estimated to a δ$^{13}$C value of -14 to -15 ‰. However due to the Baltic Sea varying levels of salinity, values have varied chronologically (Eriksson & Lidén, 2002).

The determined standard for $^{13}$C/$^{12}$C is the fossil geological formation Pee Dee Belemnite (PDB). (Slater et al., 2001:1271).

The application of $^{13}$C/$^{12}$C analysis in archaeology is foremost to determine in broad strokes what was eaten. Results whether an individual ate marine or terrestrial based foods can and has had important implications in determining not only cultural stigmas to certain foods but the emergence of certain foods into an area.

### 3.6.2 Nitrogen

Nitrogen consists of two stable isotopes, $^{14}$N and $^{15}$N. About 78% of the atmosphere is composed of nitrogen in the form of nitrogen gas (N$_2$). Despite its abundance N$_2$ is non-processable by most organic organisms and must first be transformed into ammonia (NH$_3$), nitrates (NO$_3$) and nitrite (NO$_2$–) (Cravotta, 1997:9). This process of transformation is called nitrogen fixation and can be
achieved either through lightning (atmospheric fixation) or bacteria (biological) situated at the roots of certain plants. Similarly to carbon, fractionation occurs in the nitrogen cycle (Fry, 2006:46). Legumes for example fix atmospheric nitrogen without any isotopic fractionation setting the δ\(^{15}\)N value at around 0‰. Other plants presents the higher values of 3-10‰ (Lambert, 1997:218).

The determined standard for \(^{15}\)N/\(^{14}\)N is atmospheric nitrogen. (Slater et al., 2001:1271).

Nitrogen isotope analysis is primarily used in order to track \(^{15}\)N through the trophic levels (Schoeller, 1998:667). Each step up in the trophic levels marks an approximately 3‰ increase in δ\(^{15}\)N values (Eriksson, 2013). However with presented reports of 5‰ increases between trophic levels, results must be discussed viewed with a certain degree of openness (Sponheimer et al., 2003:81).

Considerations to be made are the differentiating lengths of certain trophic chains depending on environment and size. Trophic chains in marine ecosystem have a tendency to be much longer than terrestrial chains (Eriksson, 2013 & Pate, 1994:180). Certain discussions have centered around the need to account for size as life (especially marine life) has a tendency to occupy several different trophic and predatory levels throughout its lifespan (Jennings et al., 2008).

Another major factor is the correlation between breastfeeding and δ\(^{15}\)N values. Since breastfeeding essentially is a predatory action infants are located one trophic level above their mothers. As a more adult diet is introduced the δ\(^{15}\)N value in turn decreases making nitrogen isotopic studies a viable tool in calculating child weaning (Eriksson, 2013).

As such, nitrogen in a stable isotope analysis is used to primarily differentiate between terrestrial, marine, carnivorous and herbivorous diets.

### 3.6.3 Sulfur

Existant in both the earth’s crust and ocean in large amounts sulfur has four stable isotopes, \(^{32}\)S, \(^{33}\)S, \(^{34}\)S and \(^{36}\)S. \(^{32}\)S and \(^{34}\)S ranks among the two most common, with a percentage base of 4.21% and 95.02% (Richards, 2003:38).

The determined standard for \(^{34}\)S/\(^{32}\)S is Canyon Diablo Troilite meteorite. (Slater et al., 2001:1271).

Sulfur is predominately taken up by plants from the underlying local rock sediment and at certain times from atmospheric deposition, such as acid or ocean rain. (Privat et al., 2006:1198).

Terrestrial δ\(^{34}\)S values can vary between as high as 22‰ to as low as -22‰ (Richards et al., 2003:38)). Another significant factor is the varying δ\(^{34}\)S values depending on marine salt or freshwater environments. In saltwater organisms, δ\(^{34}\)S values lie on an average of 21‰ (Richards et al., 2003:38). In freshwater values can fluctuate between +22‰ and -22‰ (Richards et al., 2003:38).
This great change in values is due to sulfur reducing anaerobic bacteria who in layman's terms breathe sulfur (Goevert & Conrad, 2009). Sulfur values are essentially locally tied down and greatly determined by local geographical characteristics and plant species. However δ\textsuperscript{34}S values cannot be determined through general geological characteristics but has to be measured against local faunal references (Eriksson, 2013). In New Zealand events have occurred where oceanic sprays have covered the entire island, infusing terrestrial plant life with marine sulfur isotope properties (Wadleigh et al. 1993).

4. Results

Results are presented in Table 2-5 and Figs. 4-6. Analysis of VHM 21 could not be conducted due to a container malfunctioning in the IRMS. Results from females and children have been referenced from Forsetløkken(2013) and Roman(2013)

All male samples fulfilled the quality criteria and fell within the accepted C/N interval 2.9-3.6 in accordance with DeNiro (1985), and carbon concentration >30% and nitrogen concentrations >10% in accordance with Ambrose (1990).

Of the 22 samples subjected to δ\textsuperscript{34}S analysis, only one (VHM 14) had to be excluded due to its low %S and high C/S, following criteria suggested by Nehlich and Richards (2009), where acceptable quality for mammals is %S= 0.15-0.35 and C/S ratio 300-900.

Table 2. Results for males and fauna from Varnhem, sorted by grave #.

<table>
<thead>
<tr>
<th>sample#</th>
<th>gravenr / individual / Species</th>
<th>element</th>
<th>bonepowder (mg)</th>
<th>collagen (mg)</th>
<th>collagen (%)</th>
<th>δ\textsuperscript{13}C (‰)</th>
<th>δ\textsuperscript{15}N (‰)</th>
<th>δ\textsuperscript{34}S (‰)</th>
<th>% C</th>
<th>% N</th>
<th>% S</th>
<th>C/N</th>
<th>C/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varnhem 17</td>
<td>17 Femur (sin)</td>
<td>98.2</td>
<td>1.65</td>
<td>1.7</td>
<td>-20.37</td>
<td>11.77</td>
<td>10.48</td>
<td>36.11</td>
<td>13.22</td>
<td>0.17</td>
<td>3.18</td>
<td>566.9</td>
<td></td>
</tr>
<tr>
<td>Varnhem 18</td>
<td>18 Femur (sin)</td>
<td>97.0</td>
<td>5.08</td>
<td>5.2</td>
<td>-19.95</td>
<td>10.42</td>
<td>10.84</td>
<td>33.62</td>
<td>12.19</td>
<td>0.24</td>
<td>3.22</td>
<td>373.9</td>
<td></td>
</tr>
<tr>
<td>Varnhem 31</td>
<td>31 Femur (sin)</td>
<td>114.1</td>
<td>3.92</td>
<td>3.4</td>
<td>-20.86</td>
<td>11.12</td>
<td>11.28</td>
<td>38.09</td>
<td>13.82</td>
<td>0.22</td>
<td>3.21</td>
<td>462.2</td>
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<tr>
<td>Varnhem 33</td>
<td>33 Femur (sin)</td>
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<td>-</td>
<td>-</td>
<td>-19.70</td>
<td>12.27</td>
<td>10.89</td>
<td>36.81</td>
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<td>517.1</td>
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<td>-21.0</td>
<td>11.3</td>
<td>37.7</td>
<td>13.5</td>
<td>3.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VHM 12</td>
<td>39 M1</td>
<td>63.06</td>
<td>3.90</td>
<td>6.2</td>
<td>-21.1</td>
<td>11.9</td>
<td>4.87</td>
<td>41.6</td>
<td>15.3</td>
<td>0.26</td>
<td>3.18</td>
<td>421.8</td>
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</tr>
<tr>
<td>VHM 17</td>
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<td>114.23</td>
<td>5.18</td>
<td>4.5</td>
<td>-20.4</td>
<td>9.5</td>
<td>10.70</td>
<td>40.2</td>
<td>14.5</td>
<td>0.25</td>
<td>3.22</td>
<td>430.7</td>
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<td>1.56</td>
<td>2.0</td>
<td>-20.8</td>
<td>10.1</td>
<td>38.1</td>
<td>13.7</td>
<td>3.25</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VHM 19</td>
<td>62 Femur</td>
<td>119.42</td>
<td>6.10</td>
<td>5.1</td>
<td>-20.4</td>
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<td>9.56</td>
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<td>8.9</td>
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<td>10.3</td>
<td>9.69</td>
<td>39.6</td>
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<td>3.21</td>
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<td>2.32</td>
<td>2.5</td>
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<td>11.0</td>
<td>39.7</td>
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<td>3.17</td>
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</tr>
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<td>VHM 22</td>
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<td>99.79</td>
<td>4.13</td>
<td>4.1</td>
<td>-20.3</td>
<td>10.6</td>
<td>11.13</td>
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<td>3.19</td>
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</tr>
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<td>2.99</td>
<td>2.7</td>
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<td>12.3</td>
<td>40.8</td>
<td>14.7</td>
<td>3.23</td>
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</tr>
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<td>VHM 09</td>
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<td>105.59</td>
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<td>-21.1</td>
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<td>2.0</td>
<td>-20.2</td>
<td>10.9</td>
<td>10.01</td>
<td>43.5</td>
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<td>Sample</td>
<td>Bone Type</td>
<td>Age</td>
<td>δ¹³C</td>
<td>δ¹⁵N</td>
<td>Ind. 99</td>
<td>Ind. 94</td>
<td>Ind. 62</td>
<td>Ind. 53</td>
<td>Ind. 39</td>
<td>Ind. 33</td>
<td>Ind. 31</td>
<td>Ind. 194</td>
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<tr>
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<td>Femur</td>
<td>114.47</td>
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<td>-20.1</td>
<td>13.32</td>
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<td>102</td>
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<td>102</td>
<td>M2</td>
<td>136.31</td>
<td>11.63</td>
<td>-19.7</td>
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<td>41.3</td>
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<td>3.19</td>
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<tr>
<td>Varnhem 105</td>
<td>105</td>
<td>Femur (dx)</td>
<td>115.58</td>
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<td>Femur</td>
<td>109.61</td>
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<td>-19.8</td>
<td>12.2</td>
<td>11.68</td>
<td>41.9</td>
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<td>0.25</td>
<td>3.22</td>
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<tr>
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<td>M1</td>
<td>118.83</td>
<td>4.83</td>
<td>-19.7</td>
<td>11.2</td>
<td>13.93</td>
<td>43.3</td>
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<td>0.29</td>
<td>3.22</td>
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<td>152</td>
<td>M2</td>
<td>69.18</td>
<td>1.89</td>
<td>-19.8</td>
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<td>-20.07</td>
<td>14.20</td>
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<td>194</td>
<td>Femur (dx)</td>
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<td>3.10</td>
<td>-19.81</td>
<td>11.79</td>
<td>11.29</td>
<td>36.78</td>
<td>13.39</td>
<td>0.29</td>
<td>3.20</td>
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</tr>
<tr>
<td>VHM 44</td>
<td>Equus</td>
<td>Femur</td>
<td>79.36</td>
<td>-22.0</td>
<td>5.1</td>
<td>42.4</td>
<td>15.3</td>
<td>3.22</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>VHM 43</td>
<td>Microtus</td>
<td>Cranium</td>
<td>89.99</td>
<td>-22.2</td>
<td>5.7</td>
<td>42.1</td>
<td>15.5</td>
<td>3.17</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

| VHM 65 | Microtus | Mand.    | 86.12  | 2.46 | -22.41| 7.02    | 42.54   | 15.04   | 3.30    |         |         |         |         |         |         |         |         |         |         |         |         |         |

**4.1 Carbon**

![](image.png)

**Fig. 4.** Overview of carbon and nitrogen change from childhood (teeth in crosses, stars & underscores) to within the 10-20 last years (femora in squares and circles).
The $\delta^{13}$C values are overall varying from individual to individual. The values are within the limits of $-21.2$ and $-19.3\%$, which suggests a predominantly terrestrial diet with aquatic inclusions. This assessment is fair within the overall confines but each graves/individuals exhibits unique dietary habits (Fig. 4).

With $0.3\%$ as the standard deviating limit for a homogenous diet, bone and teeth respectively resulted in $0.55\%$ and $0.54\%$, each above the threshold.

Table 3. $\delta^{13}$C Mean and Standard deviation for the buried individuals in Varnhem

<table>
<thead>
<tr>
<th></th>
<th>Bones</th>
<th>Teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male $\delta^{13}$C Mean</td>
<td>-20.22</td>
<td>-20.25</td>
</tr>
<tr>
<td>Male Standard Deviation</td>
<td>0.55</td>
<td>0.54</td>
</tr>
<tr>
<td>Female $\delta^{13}$C Mean</td>
<td>-20.39</td>
<td>-20.24</td>
</tr>
<tr>
<td>Female Standard Deviation</td>
<td>0.30</td>
<td>0.35</td>
</tr>
<tr>
<td>Child $\delta^{13}$C Mean</td>
<td>-20.57</td>
<td>-20.75</td>
</tr>
<tr>
<td>Child Standard Deviation</td>
<td>0.47</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Fig. 5. Carbon and Nitrogen results of all analyzed individuals
4.2 Nitrogen

$\delta^{15}N$ values are within 9.5 and 14.20, suggesting that the studied male’s diet contained aquatic foods. This suggestion is supported by that often enough higher $\delta^{15}N$ values proposes a longer food chain, often found in aquatic ecosystems. For comparison, the $\delta^{13}C$ and $\delta^{15}N$ values of horse and vole have been included in Fig. 5. With the horse at such a low $\delta^{15}N$ value, 5.1‰, in comparison with the $\delta^{15}N$ Mean of the Varnhem males, the overall diet must have consisted of aquatic foods to some extent.

Table 4. $\delta^{15}N$ Mean and Standard deviation for the buried individuals in Varnhem

<table>
<thead>
<tr>
<th></th>
<th>Bones</th>
<th>Teeth</th>
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</thead>
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<tr>
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<td>11.71</td>
<td>11.16</td>
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<td>Male Standard Deviation</td>
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<tr>
<td>Female $\delta^{15}N$ Mean</td>
<td>10.91</td>
<td>0.50</td>
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<td>Female Standard Deviation</td>
<td>0.50</td>
<td>0.57</td>
</tr>
<tr>
<td>Child $\delta^{15}N$ Mean</td>
<td>10.91</td>
<td>12.32</td>
</tr>
<tr>
<td>Child Standard Deviation</td>
<td>1.54</td>
<td>1.27</td>
</tr>
</tbody>
</table>
4.3 Sulfur

Due to the necessity for larger amounts of collagen when analyzing $\delta^{34}S$ values in comparison with what was needed for $\delta^{13}C$ and $\delta^{15}N$, analysis is not always possible. Therefore 15 of the original 23 collagen samples were analyzed for $\delta^{34}S$. Another seven samples (Lidén et al., Unpublished data), were added to the hereby studied samples. As mentioned earlier, no results were yielded for the animal samples and no true substantial comparison can therefore be made concerning if any of the individual’s origin is non-local.

Table 5. $\delta^{34}S$ Mean and Standard deviation for the buried individuals in Varnhem

<table>
<thead>
<tr>
<th></th>
<th>Bones</th>
<th>Teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male $\delta^{34}S$ Mean</td>
<td>10.41</td>
<td>10.39</td>
</tr>
<tr>
<td>Male Standard Deviation</td>
<td>2.27</td>
<td>3.48</td>
</tr>
<tr>
<td>Female $\delta^{34}S$ Mean</td>
<td>9.75</td>
<td>11.6</td>
</tr>
<tr>
<td>Female Standard Deviation</td>
<td>1.66</td>
<td>1.18</td>
</tr>
<tr>
<td>Child $\delta^{34}S$ Mean</td>
<td>10.52</td>
<td>9.95</td>
</tr>
<tr>
<td>Child Standard Deviation</td>
<td>0.00</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Fig. 7. Sulfur results of all analyzed individuals
Fig. 8. Overview of sulfur change from childhood (teeth in crosses and stars) to within the 10-20 last years (femora in squares and circles).

Fig. 9. Sulfur diagram over Varnhem male samples separated into bone and teeth type.
5. Discussion

*Overall results*

The majority of buried individuals in Varnhem exhibit a predominately terrestrial diet with inclusions of freshwater fish. Food sources included vegetables, animals and aquatic foods. Varnhem is located geographically inland and surrounded by several local freshwater lakes, ex. Hornborga lake. Most would have resorted to animal husbandry, farming and fishing around the local freshwater lakes, rather than travel far to the west where the sea was located. People who rely exclusively on marine food in his/hers diet exhibits $\delta^{13}C$ values around -14 to -15‰. Varnhem results exhibits $\delta^{13}C$ values around -18.50 to -22.50‰ so it is likely that marine food intake was small(Fig. 5).

The males exhibit a predominantly terrestrial diet but with inclusions of aquatic food. In a population were the diet is homogenous the standard deviation is about 0.3‰(Lovell et al. 1986).The male’s standard deviation in femora were 0.55 and 0.54‰ in the teeth. Supported by figure 4, the male’s diets differed between the early and later years. $\delta^{15}N$ values between 9.5 to 14‰ further suggests aquatic food as part of several males diet. All genders are within $\delta^{15}N$ values of 5‰ between each other which has been in certain documented cases only one trophic level. However the $\delta^{13}C$ standard deviation among the males shows that their diet was not homogenous.

$\delta^{34}S$ results suggests most children being locals due to their similar $\delta^{34}S$ values(table 5). The child $\delta^{34}S$ mean is 10.23‰. Those males around the same child $\delta^{34}S$ values are probably locals. A number of males exhibit $\delta^{34}S$ values higher than 13 and lower than 8‰. There is a strong possibility that those males were either locals who emigrated or non-locals who immigrated(Fig 7.).

*Individuals*

Certain male individuals differs from the majority(Fig 4 & 8). Individual 99’s results shows that he was a local who emigrated from Varnhem. His teeth results illustrates $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values similar to the majority. Results from his bones however indicates that he had emigrated to a community where the diet was more freshwater fish oriented.

Values for individual 152 illustrate a non-local who immigrated. 152’s teeth shows a higher $\delta^{34}S$ value than the majority but his femur has a $\delta^{34}S$ value similar to the locals in Varnhem. The $\delta^{13}C$ and $\delta^{15}N$ values from his M1 and M2 suggests that 152 came from a location with a food culture similar to Varnhem. There is however a rise in the $\delta^{13}C$ and $\delta^{15}N$ values of his M3. This suggests that during his early teens, 152 ate more marine food and might have lived by the sea. Individual 102 illustrates the same dietary path as 152 but to a smaller degree. This suggests that 102 either
was a non-local who occasionally visited Varnhem or a non-local who spent the shorter part of his last years there. Individuals 39, 53, 105, 181, and 130 are also probable nonlocals due to their high and low δ¹³C, δ¹⁵N and δ³⁴S values. Male 181 exhibits the highest δ¹³C and δ¹⁵N values but also among the lowest δ³⁴S value. In all probability, 181 was a non-local who came from a location where marine foods was a large part of the diet.

Individual 135, who was found with a miniature altar (Ch. 2.4), is only represented by a femur. δ¹³C, δ¹⁵N, and δ³⁴S results suggest he spent his last years in the vicinities where the diet was similar to Varnhem.

It must be added that the δ³⁴S analysis of the faunal samples yielded no reference data. Therefore the δ³⁴S results are only precise in pointing out nonlocals. Several individuals have a similar sulfur result but those values only indicate a similar diet and not that they all came from Varnhem. This is exemplified by individual 53 who exhibits sulfur values similar to the majority. However, while 53’s carbon and nitrogen results indicate a predominantly terrestrial diet with inclusions of freshwater food, 53’s lower δ¹⁵N values suggests that he only came from a location with a similar food culture.

**Hypothesis**

The hypothesis in this essay is based on that all male graves within 4 meters of the estate church would exhibit low δ¹³C values around -20 to -21‰. Such low δ¹³C values would suggest a predominantly terrestrial diet, specifically meat. Those outside 4 meters would exhibit high δ¹³C values around -14 to -15‰. Such high δ¹³C values would suggest a predominantly marine diet.

There is also the possibility of δ¹³C and δ¹⁵N values in between those extremes which would suggest a mixed diet of terrestrial and aquatic foods.

δ¹⁵N values in those graves buried close was predicted to exhibit δ¹⁵N values between 8 and 10‰ since the analyzed ruminant displayed a δ¹⁵N value of 5.1‰ (Table 2). This prediction is based on the approximate 3 -5‰ trophic level increase.

δ¹⁵N values in those graves buried far away would be both low and high. Low because of a large intake of vegetables and high due to the long aquatic food chains. If the individual had a mixed diet of vegetables and marine, the δ¹⁵N values would even out and be comparable to the same levels as those buried close. My hypothesis proved to be false.

I designated in table 1, 5 graves as close and 10 graves as far away. Figures 10 and 11 illustrate that there is variation in diet in-between the males δ¹³C and δ¹⁵N values but not in terms of buried close or far away. Comparing the overall dietary results with the burial’s locations shows that the hypothesis does not work.

Another problem in determining a hierarchical structure by only using distance is that there is no accountability for time or space. Diets can change through generations due to newly imported goods, seasonal harvests, and livestock availability.
The hypothesis is also based on that there will always be available burial space close to the church. This seems unlikely as more and more are buried.

Vretemark and Axelsson (2008) states that the burial ground around Varnhem’s estate church was utilized by a variety people from different locations. They believe that the estate church was privately owned and designated for the elite in Västergötland. If so, then my hypothesis has no bearing since there would be no class system between the graves. The dietary results between the individuals lends more strength to Vretemark’s and Axelsson’s theory than my own hypothesis of a class oriented burial ground segregated by distance.
I therefore draw the conclusion that my hypothesis is false. Dietary results do not support that being buried close to the estate church in Varnhem is a symbol for high social status. I believe the stable isotope analysis performed in this essay proved a successful method in proving my hypothesis false. In this same regard the stable isotope analysis helped in fleshing out the dietary culture around Varnhem. Food sources were farms and local freshwater lakes. Eating marine food was an occurrence but it was never part of the predominant food culture. With this addition of further reinforced evidence about Varnhem, do I feel that this stable isotope analysis was a success for archaeology as a whole.

7. Summary

This thesis’s aim was to use diet as a complementary tool in determining hierarchy among the buried male individuals around Varnhem’s estate church. Dietary information was provided through a stable isotope analysis, specifically the stable carbon, nitrogen and sulfur isotopes.

The question posed in this essay is whether there is a dietary difference between those graves close to the church and those farther away?

A 4 meter peripheral from the church was set to distinguish close and far away buried individuals. Material included 16 male individuals and three animals, both teeth and bone analyzed. The analysis was successful in regards to the δ¹³C and δ¹⁵N analysis. δ¹³C and δ¹⁵N dietary results were not completely aligned with the prospect of all graves exhibiting a certain degree of dietary difference, the longer the graves distance from the church. Certain closely situated graves exhibited a difference from those situated farther away. However exempting these graves, no correlation between diet and burial location could be found. δ³⁴S results were varied suggesting a large group of non-locals. Faunal δ³⁴S references were unfortunately inconclusive but the results were nonetheless insightful in presenting the graveyard as a place for where several had been brought to be buried.

I feel that this thesis’ question was unfortunately a failure. As of yet dietary results do not support that being buried close to the church is a symbol for high social status.

Another possible problem could be due to the small amount of material used in this study. I therefore suggest a larger continued research would be to include females and infants. Second, continuing excavations of the Varnhem burial site in order to determine spatial availability. Third, further grave carbon datings would help in supporting a possible dietary analysis broken down into smaller time periods.

8. References


