The importance of Animal Baselines: Using Isotope Analysis to Compare Diet in a British Medieval Hospital and Lay Population

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Abstract

The results of carbon and nitrogen isotope analysis from two medieval populations are presented here, in a study investigating dietary habits within a medieval hospital population in England. We used $\delta^{13}C$ and $\delta^{15}N$ measurements of bone collagen in order to attempt to identify a distinct group diet within the medieval hospital of St Giles, Brough, Yorkshire, and examine the reasons why the dietary habits within the institution may have been noticeably different from that of a comparative lay population. Following the results and tentative conclusions of a study conducted by Müldner and Richards (2005), it was hypothesised that religious fasting rules would result in there being evidence of greater consumption marine fish at St. Giles than at the rural township of Box Lane, Pontefract, Yorkshire. While more dietary variation was found at the hospital, it can be seen that the differences in $\delta^{13}C$ and $\delta^{15}N$ isotope values vary in relation to the animal baselines. Thus, differences between the human populations can be attributed to geological and environmental factors as opposed to dietary differences.

Highlights

- We summarise evidence of diet in medieval towns, monasteries and hospitals.
- $\delta^{13}C$ and $\delta^{15}N$ analysis was used to recreate the diet of two medieval populations.
- Inter-population difference in isotope ratios was attributed to baseline environmental variation.
- Social diversity may explain intra-population variation in individuals buried at St Giles.

Keywords: Medieval hospital; Yorkshire; Diet; Middle ages; Stable isotope analysis, animal baseline.

1. Introduction

Hospitals in Medieval England served multiple functions within the local community. They were owned and administrated by the Catholic Church and operated as a 'sanctuary' for the sick, the poor and the elderly, as well as providing respite for passing traveller: these people predominantly belonged to the lower social classes. Residents of a hospital were 'inmates', rather than patients, and would be required to exchange their life's possessions in return for life-long care within the institution (Orme & Webster, 1995, pp. 57-64). This meant that many inmates spent their final years within the hospital and, in this way, the institutions could be viewed as resembling Victorian workhouses closer than the modern form of hospitals we are familiar with. Medical treatment was not the primary focus of the hospitals – rather, they cared for the inmates' souls by purging them of sin through a daily ritual of prayer and religious observation (Magilton, 2008, pp. 18-19).

After the reformation of the Church, which was instigated by King Henry VIII in the 1530s, many of the hospital buildings and their records were destroyed (Knowles, 1977, 266). This has resulted, in many cases, in the loss of primary source documents, such as inventories, orders and charters, which could be used to inform us about life within the hospitals. This is the case at St. Giles in Brough, the hospital investigated here, whereby no original documents survive. While we understand broadly what was like in English Medieval hospitals, there is no evidence of what day-to-day life was like for the inmates of St. Giles, Brough. We must use, therefore, utilise evidence from material which does survive: the human remains.

This research expands upon findings of a previous study by Müldner and Richards (2005), which compared the diets of a variety of English medieval populations. Müldner and Richards reconstructed diet using stable isotope analysis, and explored potential dietary differences across different social groups. In the case of the hospital of St. Giles, Brough, unusually enriched $\delta^{15}N$ values were found in the sample population of seventeen individuals in comparison with a sample from the lay medieval village of Wharram Percy. Müldner (2005) suggested that this difference may be the result of social factors related to religious fasting, but recommended further investigation into the issue to verify this hypothesis.

The aims of the study were as follows:

1. To establish whether the occupants of St. Giles consumed animal protein and fish and to compare this with the dietary evidence from the lay site of Box Lane, using appropriate animal baselines to facilitate interpretation.
2. To investigate whether priests at the hospital may have consumed a diet which was different to that consumed by the hospital inmates.
3. To confirm whether historical sources and archaeological evidence support or refute the isotope ratio analysis findings about diet at St. Giles, Brough period based on isotope analysis.

2 Diet in medieval hospitals and lay communities

2.1 The Diet of the Medieval Low Status Majority

Any investigation into population-wide dietary habits cannot avoid generalisations. What people ate in medieval England on a daily basis depended on an individual's wealth, social status, age, location and personal preference (Miller & Hatcher, 1980: 159), as well as on seasonal fluctuations in what was available (Dyer, 2006: 209). For the lay majority – that is, the typical low ranking working family living in large villages or small towns – diet depended on available resources and the level of family income.

Documentary sources which are used when determining the diet of the low status laity include grain storage records (McCloskey & Nash, 1984), the production and sale of field crops (Dyer, 1989:127; Campbell, 1997), manorial inventories of the food supplied by lords to his labourers (Bennett, 1937: 235) and information about wages, since workers were often paid in grain, bread or pasture land for the purpose of animal husbandry (Penn & Dyer, 1990). Caution must always be exercised when referring to these sources which only record the food provisions bought and stored. While they are the best sources available to the historian, such records do not accurately depict what was actually consumed by the population, who may have foraged to supplement their diet.

The low status laity probably ate meals which were rich in carbohydrates such as bread, pottage (a grain based stew) and ale (Stone, 2006: 11; Yoder, 2012). The quality and mix of the grains consumed would depend on what could be afforded, and pulses such as peas or beans were included in cheaper bread. Wheat was an expensive commodity, so while some bread had a small proportion of the grains as wheat, wheat based ale was available only to the wealthy ranks of society (Stone, 2006: 14). Foraging and living from the land was an important supplement to the lower status diet. Fruit, vegetables, nuts and berries are likely to have been gathered from kitchen gardens and common land (Crackles, 1986). For this reason, the high status ranks considered fruit and vegetables to be the food of the poor, foraged from wherever they were available.

Protein in the lower status diet made up a very small proportion of meals, again because of expense. Meat and fish would be consumed in small quantities, but to a much lesser degree than those of higher social status (Bennett, 1937: 235). Isotopic evidence from the analysis of bone collagen of adults and children from Wharram Percy, Yorkshire indicated a small amount of fish protein in the adult diet and estimated the weaning age of children to be c.2 years (Richards, et al., 2002). These findings match dietary trends identified in adults and children from Medieval Fishergate House, York (Burt, 2013). This suggests that the Medieval laity may have attempted to observe religious fasting rules, but were more likely to supplement meat with fish in fasting days.

2.3 The Diet of Hospital Inmates

Less is known about what food was consumed in medieval hospitals by the inmates who lived there. Inmates were generally from poor backgrounds and the function of hospitals was not only to provide care for the sick and disabled, but also to house the poor and elderly who could no longer care for themselves (Orme & Webster, 1995: 57-64; Roffey, 2012). It would seem logical then that the diet of these inmates might have resembled the carbohydrate rich diet of those at the lower end of the social spectrum prior to admittance to a hospital. However we consider that hospitals formed separate social group in their own right. The hospital communities were closed, given that once inmates were admitted they were unlikely to leave during their lifetime. The bequeathal of property or payments of fees, either by the inmates or by a third party, could ensure a place in the hospital for as long as it was required (Rawcliffe, 1984). Therefore, estimation of the diet in hospitals cannot be based solely on what the equivalent social rank would have consumed outside of the institution.

The best sources there are of diet and lifestyle within the hospitals are from the founding charters which dictated the rules by which the hospitals would be run. The hospitals were owned by the Catholic Church, so these rules were based on Christian values, and religion dictated almost every aspect of life inside a hospital. The founding charter from St Giles, Norwich dictates a daily regime of prayer and mass and includes instructions for the priests and brethren who looked after the institutions to also work in the community helping the poor (Rawcliffe, 1999: appendix 1). Detailed in the charter is the order to follow the dietary regulations set down by St. Augustine which dictated a period of fasting and abstinence from meat during holy days (Rawcliffe, 1999: appendix 1). Interestingly, this rule only alludes to the priests and brethren of St Giles, Norwich, and no mention is made of the dietary requirements of the inmates. It can only be speculated that because so much of the way of life in hospitals was dictated by religious rule, that there may have been some expectation for the inmates who benefitted from the institutions' care to lead a religious lifestyle. The inmates relied on the hospital to feed them as well as house them; therefore it is very probable that the diet prescribed to those in the care of the church owned hospitals followed the same rules as the order which governed them.

Past research utilising stable isotope analysis has shown that religious communities consumed a diet rich in fish. For example, Polet and Katzenburg (2003) found evidence that 12th to 15th century monks, lay brethren and children in a Belgian monastery consumed marine fish and possibly also freshwater fish. Furthermore, Mays (1997) found that there was a significant difference between stable isotope measurements of seven groups of monastic and lay individuals from the North of England which was attributed to fasting. It could be argued that the residents of a Medieval hospital would have likely consumed a similar diet because of the connection with the Catholic Church, however, there is a lack of research which utilises stable isotope analysis to investigate this hypothesis.

3. St Giles, Brough and Box Lane, Pontefract

The hospital of St. Giles, Brough in North Yorkshire was recorded as in use from c.1181 AD to 1428 AD (Cardwell, et al., 1995). There is documentary evidence which suggests that the hospital may have been an institution for individuals with leprosy, however as few as three individuals recovered from the associated cemetery displayed skeletal indicators of the disease (Cardwell, et al., 1995). Hospitals in the medieval period served a different function to todays' institutions which focus solely on treating illnesses and disease. Medieval hospitals were open to the sick, but also to the elderly, the poor and to travellers needing temporary respite before moving on (Roffey, 2012). Illness and disease was treated with a combination of prayer and careful adjustments to the diet in order to rebalance the four humours (blood, phlegm, yellow bile and black bile) which was believed to be the cause of sickness if this balance was disturbed (Rawcliffe, 1999: 176). The inmates of a medieval hospital were likely to remain within the institution until their death, and were buried in the hospitals' own associated cemetery.

The cemetery at St. Giles was excavated by English Heritage and North Yorkshire County Council between 1988 and 1990 and 34 skeletal individuals along with a small amount of animal bone are curated by the Biological Anthropology Research Centre (BARC) at the University of Bradford. It was estimated that between 25% and 66% of the individuals from the cemetery were recovered from the site, which is presently a series of earthworks which remain from the original hospital buildings (Cardwell, et al., 1995). The skeletal population was noted in the unpublished skeletal report as having a high prevalence of skeletal pathology (Chundun, 1992). A large range of skeletal pathologies were recorded including leprosy, osteoarthritis, cribra orbitalia, a high prevalence of non-specific inflammation, with osteoarthritis being prevalent in the sample. This is unsurprising, given that the majority of the population were probably long-term inmates of the hospital. Two individuals were identified as priests as indicated by the presence of a chalice and paten in their graves. One of these was notable for having a slipped capital femoral epiphyses and secondary osteoarthritis (Knüsel, et al., 1992; Cardwell, et al., 1995). Priests would have lived at the hospital and been charged with the care of the inmates. The bone preservation throughout the population was variable, and only individuals which were recorded as having 'good' bone preservation were considered for inclusion in the study sample.

Box Lane, Pontefract, West Yorkshire, is located approximately 57 miles away from St. Giles. Pontefract was a rural township in Yorkshire – a county which retained its countryside features long after other areas of England were fully urbanised (Sheeran, 1998, p. 26). This inland and rural location made Box Lane an ideal cultural and environmental match for comparison against the medieval hospital. Both sites share a similar underlying geology, with Brough situated on sandstone, siltstone and mudstone and Pontefract situated on sandstone and dolostone. Box Lane was the site of a medieval priory and the associated lay cemetery, which contained the burials of individual of a range of ages representing both sexes. The cemetery was dated as being in use for at least as long as the priory was active from 1090AD to 1539AD (Roberts & Burgess, 1999), which coincides with the dates at which the hospital at St. Giles was in use.

Figure 1. Map of the UK with the two sample sites investigated within this study indicated.

4. Faunal and plant remains from St Giles and Box Lane

Evidence for dietary habits can be inferred from the remains of animals and plants excavated from an archaeological site. Species and bone elements present, can provide information on the kinds of meat consumed, potential farming practices and can indicate trade practices. The macroscopic analysis of faunal remains from a site can complement the analysis of individual diet by stable isotope analysis by providing evidence of meat consumption of a population as a whole. Caution must be employed when making such dietary inferences using animal remains however, as often such assemblages have been created over an indeterminate amount of time by an unknown number of people.

The evidence for diet inferred by faunal remains was taken from unpublished site reports for St. Giles and Box Lane. At St. Giles, the largest meat contributor to the hospital diet by calculation of meat weight was found to be cattle (79%), followed by sheep (13%) and finally pork (8%) (Cardwell, et al., 1995). A remarkable fact of the St. Giles faunal assemblage is the almost complete lack of fish remains. Given the proximity of the hospital to the River Swale, and the practice of substituting meat for fish on holy fasting days, it would be expected that evidence of fish consumption at the the site would be evident. In fact, very few fish remains were recovered despite sieving being employed as part of the excavation process. The excavator concluded that either very little fish was consumed at St. Giles, or that food waste may have been disposed of away from the hospital (Cardwell, et al., 1995).

At Box Lane, the faunal assemblage revealed interesting details regarding the structure of the community. Typical animals raised for food and clothing such as cattle, sheep or goat and pigs were found alongside higher status prime meat animals such as fallow deer and fowl. Evidence of trade was also discovered in the form of worked goat horn cores (Richardson, 1999). This collection of typical animals consumed by the lower status majority, highly prized high status animals and the remains of a mid-status trade on the site implies that Pontefract was a socially diverse community. Evidence of fish consumption is not confirmed in the faunal assemblage. There is no mention of fish remains in the animal bone report, however sieving is unlikely to have been practiced on the site since the excavation was undertaken with some haste (Boylston, 1991). Is it therefore possible that any fish remains present on the site could have been overlooked.

Interpretation of the dietary implications of seeds and pollen presents issues of accuracy. 'Food weight' models such as those employed to calculate the weight of meat consumed from an individual or assemblage of animals cannot be employed with seeds and pollen due to issues with sample biases caused by preservation, recovery and interpretation of the remains (Reitz & Scarry, 1985). Instead, the general quanification of seed samples can form tentative dietary implications for a site.

Charred seed remains were not recovered from Box Lane, but were recovered at St. Giles. Cereal grains formed 53% of the total sample recovered from St. Giles and of this, 42% of the cereal was wheat, 37% was oats and 14% was rye (Cardwell, et al., 1995). It can be assumed then that these particular grains formed part of the cereal diet at the hospital, and cautiously assumed that wheat and oats were the main cereal contributers to the grain portion of the diet.

5. Materials and Method

Seventeen human individuals and twenty-two herbivores from St Giles were sampled by Müldner and Richards (2005). A further 43 human and eight faunal samples were analysed in this study. The human sample sets were chosen to reflect the age and sex structure of the whole excavated population at St. Giles (n=110), and the samples from Box Lane were selected from the 1987 (samples with prefix BX) and 1988 (samples with prefix BXG) excavations and to broadly match this. This was in order to create comparable sample sets which were representative of the population at the medieval hospital. Ribs, which have a high bone collagen turnover rate (Stenhouse & Baxter, 1976), were chosen for sampling in order to obtain the most recent dietary information for each individual analysed, and representing (as far as possible) the time individuals were more likely to have been inmates at St Giles. Bones displaying pathological lesions were not sampled, in order to preserve these important diagnostic elements. All available animal bones in the Box Lane collection were selected for faunal baseline measurements (N=8). It was not possible to identify whether the different skeletal elements originated from unique individuals and the faunal remains were not assigned a context label. It is therefore possible that multiple elements from the same animal may have been sampled.

Human bone samples (Box Lane: n=30, St. Giles n=13) and faunal baseline samples from Box Lane were prepared using a revised Longin (1971) method developed by Brown et al (1998) for the extraction of collagen from bone for measurement by IRMS. Measurements of human (n=17) and animal bone (four species) from St. Giles reported by Müldner and Richards (2005) were included in the results and discussion. These samples were prepared using the same Longin (1971) pre-treatment method, and were analysed at the University of Bradford.

The prepared samples were measured at the Stable Light Isotope Facility at the University of Bradford (n=23), and at the Bloomsbury Environmental Isotope Facility at University College London (n=16). The two batches measured at the different laboratories were made up of randomly selected samples from both sites. A t-test showed that there was no significant difference ($p>0.05$) between the two batches, indicating that the laboratories produced comparable results. The results were reported in the delta notation (δ), and are expressed in relation to international standards V-PDB for $\delta^{13}C$ and AIR for $\delta^{15}N$. Age and sex data was taken from pre-existing reports (Boylston, 1991; Lee, 1991; Chundun, 1992); these were estimated following a variety of methods (Banks 1934; Stewart 1958; McKern and Stewart 1957; Gilbert and McKern 1973; Prashma 1980; Workshop of European Anthropologists 1980; MacLaughlin and Bruce 1983; Iscan, Loth and Wright 1984; Iscan, Loth and Wright 1985; Lovejoy, et al. 1985; Iscan and Loth 1986; Suchy and Katz 1986).

6. Results

Four human bone samples (BSG1288, BSG1561, BXG2 and BX45) were excluded from further discussion following the application of standard collagen quality indicators (van Klinken, 1999). The percentage yield of prepared collagen sample to the cut bone sample is recommended to be no less than 0.5%, and the C:N ratio in the final sample should be within the range 3.1-3.5. The data discussed here are summarised in table 1 and figure 1.

At St. Giles, the $\delta^{13}C$ values for humans ranged from -21.1‰ to -18.3‰ with a mean value of -19.6‰. The $\delta^{15}N$ values ranged from 10.4‰ to 13.8‰ with a mean value of 12.2‰. At Box Lane the $\delta^{13}C$ values for humans ranged from -21.4‰ to -19.5‰ with a mean value of -20.3‰. The $\delta^{15}N$ values ranged from 8.8‰ to 13.2‰ with a mean value of 11.2‰.

Considering the faunal baselines for each site, at St. Giles, the $\delta^{13}C$ values for herbivores ranged from -23.9‰ to -21.2‰ with a mean value of -21.8‰. The $\delta^{15}N$ values ranged from 4.1‰ to 8.8‰ with a mean value of 5.4‰. At Box Lane the $\delta^{13}C$ values for herbivores ranged from -23.5‰ to -22.1‰ with a mean value of -22.8‰. The $\delta^{15}N$ values ranged from 5.1‰ to 7.6‰ with a mean value of 6.5‰.

Table 1. $\delta^{13}C$ and $\delta^{15}N$ measurements for human and animal bone collagen from St. Giles, Brough and Box Lane, Pontefract.

Age categories: EC = early childhood (c. 1-6), LC = late childhood (c.6-12), A = adolescent (c.13-17), YA = young adult (c.18-25), YMA = young middle adult (c.26-35), OMA = old middle adult (c.36-45), MA = mature adult (c.45+), ? = unknown.

* = measurements produced by Müldner and Richards (2005)

St. Giles, Brough

Identifier	**Species**	**Sex**	**Age**	**$\delta^{13}C$**	**$\delta^{15}N$**	**C/N**	**% coll.**
BSG1229*	Human	F	OMA	-19.2	12.1	3.3	8.5
BSG1253*	Human	F?	OMA	-20.1	10.9	3.4	6.6
BSG1268*	Human	M?	MA	-19.8	12.2	3.4	5.2
BSG1271*	Human	M	MA	-18.8	13.1	3.3	7.5
BSG1272*	Human	M	?	-18.9	12.4	3.3	5.2
BSG1276*	Human	M	?	-19.0	12.2	3.5	5.5
BSG1280*	Human	?	?	-19.3	13.0	3.3	7.1
BSG1283	Human	F	MA	-21.0	10.8	3.6	0.8
BSG1288	Human	M?	YMA	Failed pretreatment – collagen yield			
BSG1291	Human	M?	?	-20.8	10.4	3.3	1.2
BSG1401*	Human	F?	OMA	-18.3	13.0	3.3	9.3
BSG1407*	Human	M	MA	-18.7	13.0	3.4	6.6
BSG1420	Human	?	LC	-20.2	11.5	3.2	2.1

BSG1423*	Human	M?	?	-18.5	13.4	3.3	10.4
BSG1426	Human	M?	YMA	-20.4	11.3	3.3	1.8
BSG1449*	Human	M?	?	-19.0	12.5	3.4	9.3
BSG1459	Human	?	EC	-20.7	12.1	3.2	1.3
BSG1476	Human	F	?	-20.8	10.6	3.3	1.4
BSG1483*	Human	M	?	-18.7	13.8	3.2	6.6
BSG1506	Human	?	EC	-20.3	13.3	3.4	1.6
BSG1523*	Human	M?	?	-18.7	13.2	3.4	2.1
BSG1531	Human	F?	YA	-19.7	12.4	3.2	1
BSG1536*	Human	?	?	-19.9	12.1	3.4	8.2
BSG1542*	Human	M?	?	-19.6	11.2	3.3	5.8
BSG1561	Human	F	YA	Failed pretreatment – collagen yield			
BSG1646	Human	?	EC	-20.3	10.8	3.3	0.5
BSG1649	Human	F	?	-20.3	12.7	3.3	1.6
BSG1656	Human	M	?	-20.6	11.6	3.2	1.4
BSG1659*	Human	M	?	-18.8	13.0	3.3	7.8
BSG1710*	Human	F	YMA	-19.7	11.9	3.3	12.5
BSG-A2*	Cattle			-21.9	6.0	3.4	4.3
BSG-A4*	Cattle			-21.9	5.4	3.2	2.8
BSG-A9*	Cattle			-21.2	4.5	3.4	12.4
BSG-A10*	Cattle			-21.4	4.1	3.4	4.7
BSG-A15*	Cattle			-21.7	5.8	3.2	6.1
BSG-A17*	Cattle			-21.6	4.3	3.4	5.9
BSG-A6*	Cattle			-23.9	4.0	3.2	2.5
BSG-A18*	Cattle			-21.3	4.9	3.1	3.5
BSG-A22*	Pig			-21.4	7.2	3.2	14.2
BSG-A8*	Pig			-20.6	8.4	3.2	8.7
BSG-A14*	Pig			-21.1	7.8	3.1	13.6
BSG-A16*	Pig			-21.8	6.2	3.4	3.5
BSG-A1*	Red deer			-22.0	4.0	3.4	5.3
BSG-A3*	Sheep			-22.2	5.8	3.6	2.7
BSG-A5*	Sheep			-21.8	4.9	3.4	7.1
BSG-A7*	Sheep			-21.6	5.5	3.4	5.9
BSG-A11*	Sheep			-21.9	5.8	3.3	13.3
BSG-A12*	Sheep			-21.3	6.4	3.3	8.9
BSG-A13*	Sheep			-21.5	6.4	3.3	8.9
BSG-A19*	Sheep			-21.7	4.5	3.4	5.9
BSG-A20*	Sheep			-21.6	8.8	3.4	1.3
BSG-A21*	Sheep			-21.4	6.4	3.2	9.2

Box Lane, Pontefract							
Identifier	**Species**	**Sex**	**Age**	**δ^{13}C**	**δ^{15}N**	**C/N**	**% coll.**
BX15A	Human	?	EC	-20.2	8.8	3.2	1.9
BX16	Human	M?	MA	-19.9	12.1	3.2	3.3
BX24	Human	M	MA	-19.7	11.9	3.3	1.9
BX26	Human	F?	MA	-20.9	10.4	3.3	0.9
BX32B	Human	M?	YA	-20.5	10.7	3.3	0.5
BX32D	Human	?	EC	-20.1	12.5	3.3	2.3
BX35A	Human	F	MA	-19.9	12.1	3.2	1.3
BX40A	Human	F	YA	-21.0	9.7	3.3	0.8
BX40B	Human	?	EC	-19.9	12.9	3.2	1.0
BX44A	Human	F	OMA	-21.4	9.9	3.3	0.9
BX45	Human	F	YA	Failed pretreatment – collagen yield			
BX46	Human	M	YA	-19.5	13.2	3.3	1.4
BX47	Human	M?	A	-20.5	10.5	3.3	0.6
BX48	Human	M	MA	-20.0	10.7	3.3	2.5
BX52	Human	?	EC	-20.9	10.4	3.2	2.1
BX53	Human	M	OMA	-20.0	11.7	3.4	0.7
BX55A	Human	M	MA	-20.0	11.5	3.2	2.3
BX60A	Human	F	YMA	-20.8	12.1	3.2	4.2
BX63	Human	M	OMA	-21.1	10.3	3.4	0.9
BX65	Human	F	MA	-20.5	11.2	3.3	0.7
BX67	Human	M	MA	-20.6	10.8	3.3	0.6
BX68	Human	F	YA	-20.6	10.3	3.2	2.0
BX70B	Human	?	LC	-20.5	10.7	3.3	0.5
BX71	Human	M	YMA	-20.4	10.3	3.3	1.2
BX73	Human	F	YMA	-20.4	12.6	3.3	1.8
BXG2	Human	M?	MA	Failed pretreatment – collagen yield			
BXG2B	Human	M	MA	-19.9	12.5	3.3	0.9
BXG4	Human	M	YA	-19.9	10.5	3.2	1.5
BXG7A	Human	M	MA	-20.1	10.7	3.3	1.0
BXG9B	Human	M?	A	-20.0	12.3	3.3	1.9
BXcatast	Cattle			-22.5	7.6	3.6	0.5
BXcatrad	Cattle			-22.1	6.6	3.3	3.5
BXshepha	Sheep			-23.0	5.5	3.4	1.6
BXshehum	Sheep			-23.5	6.9	3.4	7.6
BXsheman	Sheep			-23.4	7.4	3.3	24.6
BXshetib	Sheep			-22.4	5.1	3.3	2.2
BXpigmet	Pig			-20.7	9.2	3.3	0.7
BXfishver	Fish			-12.2	16.4	3.3	0.6

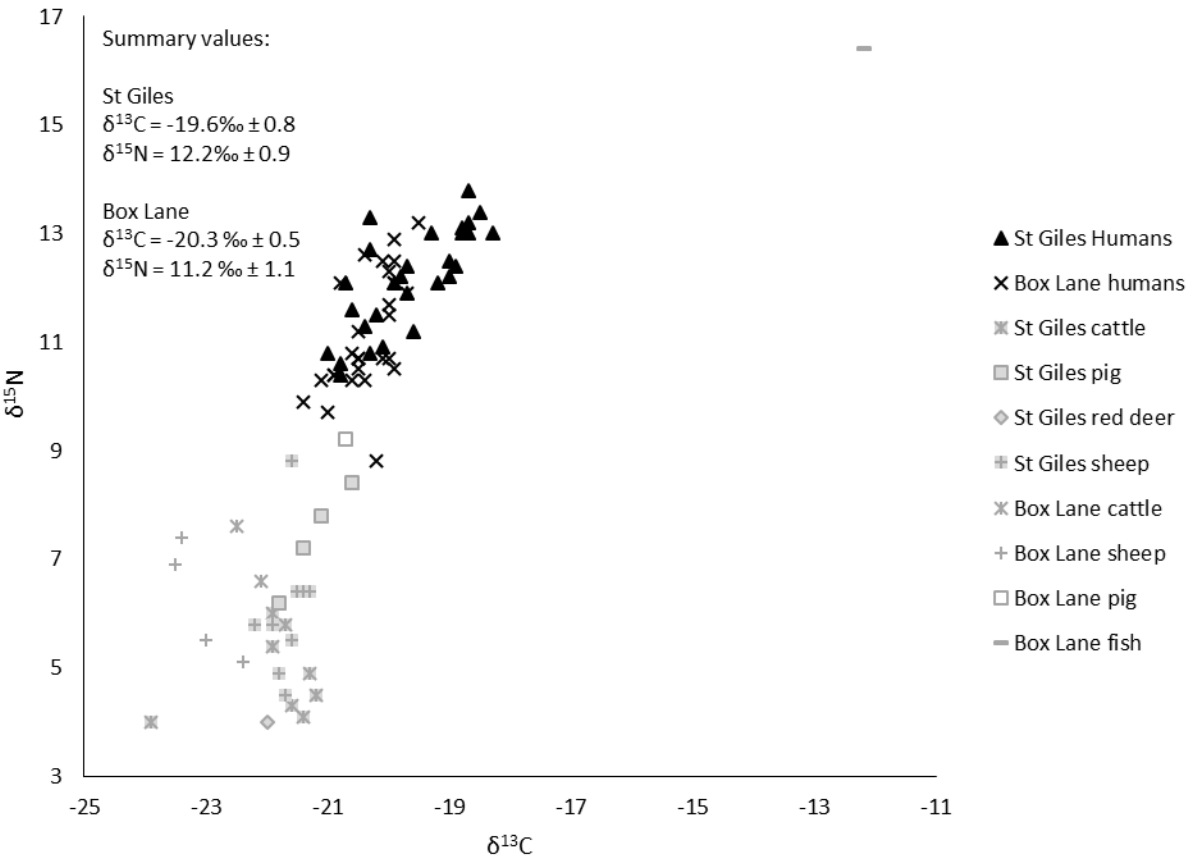

Figure 2. Summary of carbon and nitrogen isotope ratios for humans and animals at St. Giles and Box Lane

7. Discussion

7.1 Inter-population Comparisons

Certain assumptions about diet at St. Giles and Box Lane can be made based on the stable isotope measurements, however caution must be exercised when comparing potential dietary differences between the two sites because of differences observed between the faunal baselines. Some of the human δ^{13}C and δ^{15}N measurements from St. Giles are more enriched in comparison to the majority of human measurements at Box Lane (fig 2); this is often interpreted as a difference in diet between two populations. However, there are also differences in the isotope measurements of the herbivore baselines at each site (fig 3).

The small number of faunal samples that were present in the Box Lane collection resulted in a less than ideally sized faunal baseline and caution was exercised when interpreting the isotope data. A truly representative faunal baseline should include multiple examples of species from each case site, however, this is not always possible, for example, at the site of Berinsfield, Oxford, where diet was investigated through the analysis of 93 human samples along with a baseline which comprised six samples of fauna consumed by the investigated individuals (Privat, et al., 2002), and at Giecz, Poland, where the faunal baseline totalled eight samples (Reitsema, et al., 2010).

The $\delta^{13}C$ values of the herbivores at St. Giles are on average 1‰ enriched compared to the herbivores at Box Lane and he average $\delta^{15}N$ values of the herbivores at Box Lane are approximately 1‰ enriched compared to the herbivores at St. Giles. The differences between the two faunal baselines are apparent in Figures 2 and 3. Where disparities are found between the faunal baselines of two or more sites, it can be inferred that there are natural or human induced differences in soil isotope ratios. It has been previously shown that $\delta^{13}C$ values of herbivore bone collagen can indicate changes in the types of plants available to fauna over time and $\delta^{15}N$ values of may also vary according to the nitrogen signatures in the soil (e.g. Drucker, et al., 2003; Richards & Hedges, 2003). It could be argued that both of these environmental factors have influenced our faunal baselines in this study, rendering them incomparable.

Despite efforts to match the sample sites based on environmental conditions (closely located and inland) and underlying geology (both sites located predominately on sandstone), unique local environmental isotope signatures have been passed up the food chain to animals and humans at St. Giles and Box Lane. These findings reflect previous research that has demonstrated that there may be large differences between isotope faunal baselines between closely located sites in the UK (Britton, et al., 2008), which may be the result of climate variation, different land use practices, or transhumance of animals. Several studies have emphasised that the inclusion of a baseline in human dietary studies is essential for robust and accurate interpretations of data (Jay & Richards, 2007; Mulville, et al., 2009; Casey & Post, 2011). The finding in this particular instance strengthens the weight of this argument, particularly when stable isotope values of two distinct human populations are to be compared.

Despite the significant differences in both $\delta^{13}C$ and $\delta^{15}N$ values of the humans at St. Giles and Box Lane shown by a t-test. $P<0.001$ for both carbon $t(54)=3.842$ and nitrogen $t(53)=-3.557$ results), these differences cannot necessarily be attributed to differences in dietary habit. In this case, the faunal baseline is crucial for determining whether direct inter-population comparisons of isotope data are possible. While we have shown that it is not, it can be cautiously asserted that there is at least some difference in the variability of the diet at the two sites. The $\delta^{13}C$ results for Box Lane shows a terrestrial C3 influenced diet which was typical in the medieval period. The range of $\delta^{13}C$ results is very small, with the data having a standard deviation of 0.47, indicating little variation in the plant protein consumed and very little or no marine input. This is surprising, given that although fish remains were not recovered, the archaeozoological evidence from the site suggests that the individuals living near Box Lane ate a diverse diet and were probably a socially or geographically diverse population. At St. Giles the range of $\delta^{13}C$ results is higher, with a standard deviation in the data of 0.81, indicating that diets at the hospital were more isotopically diverse, possibly reflecting diverse social backgrounds, or different durations of confinement at the hospital. This could indicate that social distinctions between individuals were implied through the quality of the diet. Given that we already know that the plant protein input in a medieval diet was quite limited in variety, we argue this larger range is due to varying levels of dietary fish input.

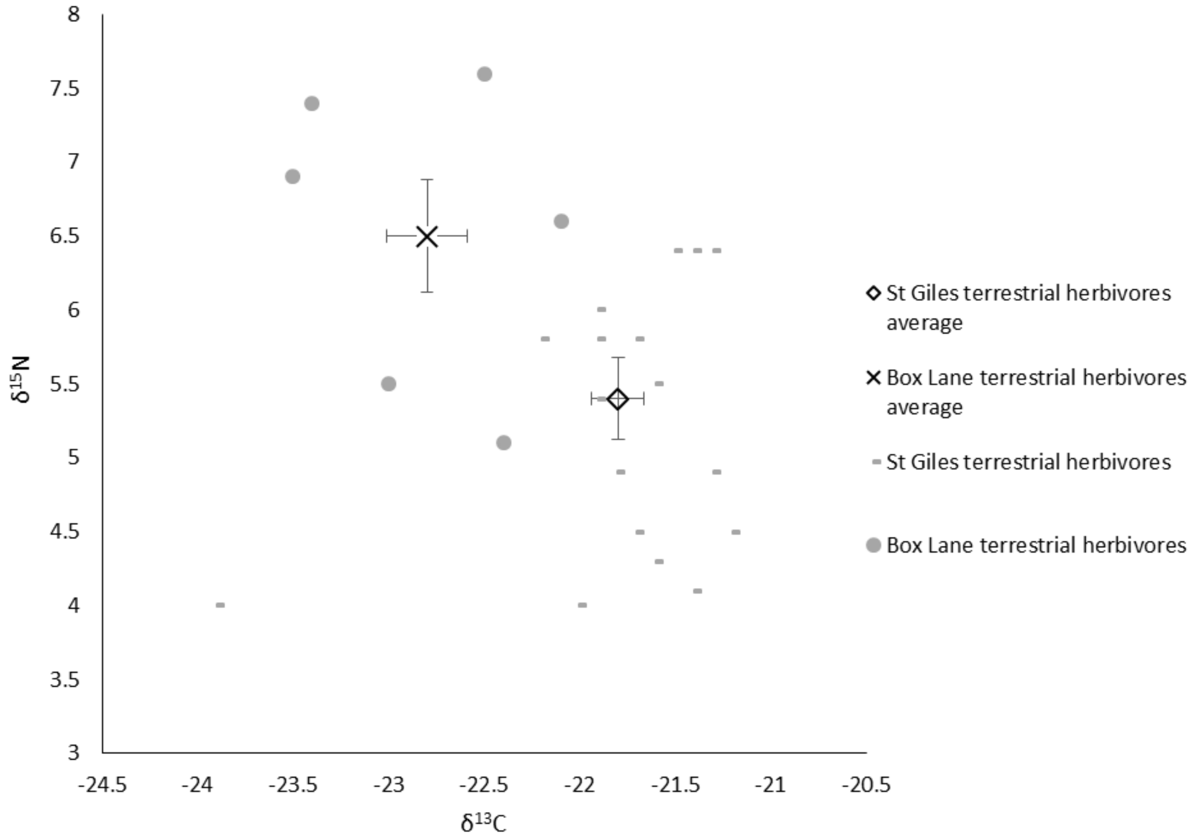

Figure 3. Individual and population average carbon and nitrogen isotope ratio results for faunal baselines at St. Giles and Box Lane. Error = 1 S.D.

9.2 The Priests and Patron at St. Giles

Two individuals in the St. Giles collection (1280 and 1423) were identified as priests by the chalice and patern which each were buried with, and one individual was identified as potentially being the patron of the hospital from his significant burial location in the chapel (Chundun, 1992). The isotope results (shown in fig 4) from these three individuals show an enriched level of ^{15}N and ^{13}C in comparison to many (but not all) of the individuals in the sample at St. Giles, suggesting they may have consumed more animal and fish derived protein than the majority of the sample. Alternatively, the priests and patron may have eaten a diet rich in fish to the same degree as that of the inmates, but for a longer period of time, as rib bone turnover represents average data for approximately the last 3-5 years of life.

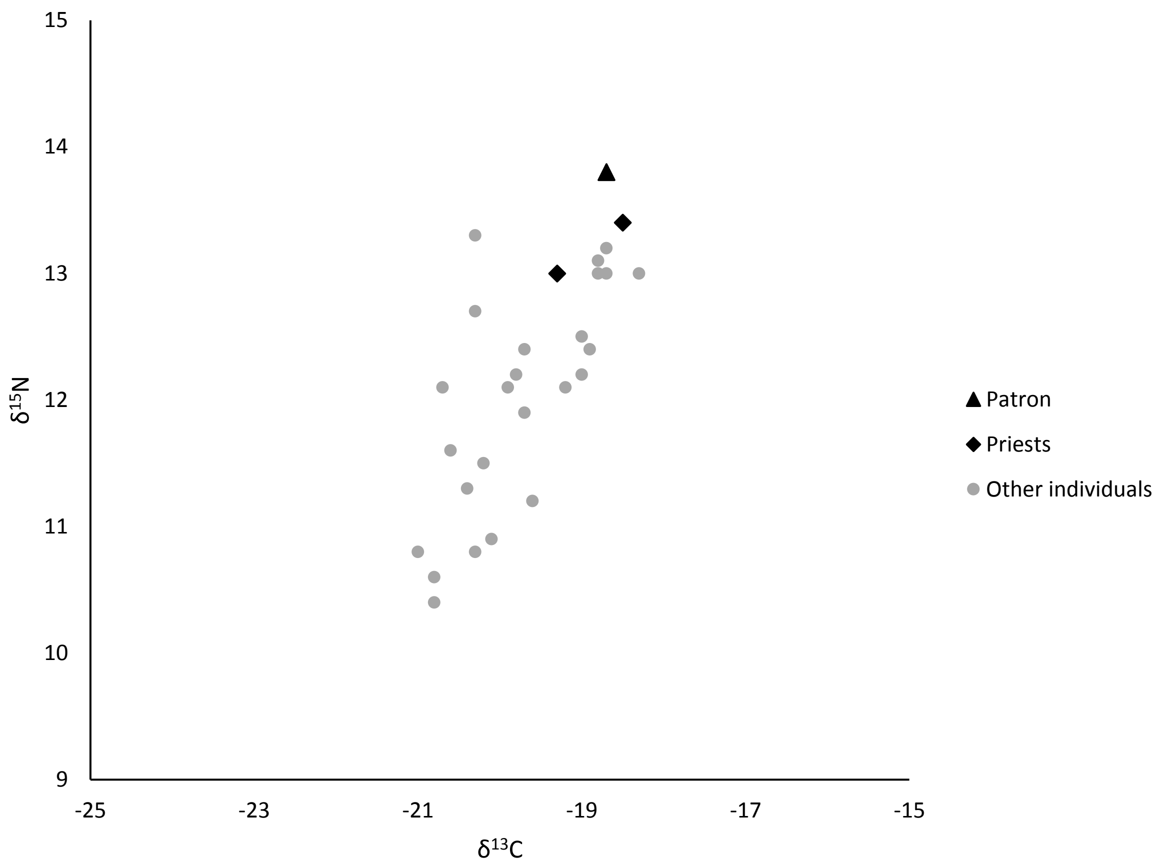

Figure 4. Individuals identified as the patron and priests, compared against the rest of the St Giles population

8. Conclusion

The fundamental outcome of this research is that even where isotope faunal baselines have been carefully considered, there may be isotopic differences between two sites which prevents a confident conclusion about human diet. Even when criteria such as the distance between sites, the geology of the sites and the environment in which fauna resides are considered (as was the case for St. Giles and Box Lane) the baselines may not appropriately complement each other. We would, therefore, recommend that caution is exercised when comparing the bone collagen stable isotope values of humans from distinct populations.

While it was not possible to fulfil part of one of the aims of this research, as we were unable to directly compare the two human diets, several positive findings stemmed from the study. The $\delta^{13}C$ and $\delta^{15}N$ values of humans from Box Lane reflect a diet typical for the period, with some meat and possibly very small amounts of fish eaten regularly. A large range in the $\delta^{13}C$ values of the residents of the hospital shows variation in fish consumption between individuals, possibly reflecting status differences within the hospital community. It would be interesting to investigate whether this pattern also exists in the isotope values of other Medieval English hospital populations. Investigating diet at other Medieval hospitals would add to our relatively limited knowledge of life in these institutions and expand our understanding of the types of food consumed in minority social groups at this time.

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