Diet in the Iron Age cemetery population at Wetwang Slack, East Yorkshire, UK: carbon and nitrogen stable isotope evidence

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Abstract

This paper reports $\delta^{13}C$ and $\delta^{15}N$ values for human and animal bone collagen from the middle Iron Age site at Wetwang Slack, East Yorkshire, UK. The data indicate a human diet which was high in animal protein, with no evidence for any significant marine food input. No differences were found between high-status vehicle (or 'chariot') burials and the rest of the population and no other status differentiations are visible according to burial rite, age or sex groupings, although the data obtained for the older males display an unusual trend. No dietary variation is seen between two site phases and no evidence for an early immigrant group is present. The range of isotope values for the adult human group as a whole is small, indicating that the diet is likely to have been consistent over time and across the population, although two individuals stand out as unusual amongst the 62 analysed.

Keywords: Wetwang; stable isotopes; carbon; nitrogen; collagen; diet; chariot

1. Introduction

The middle Iron Age cemetery at Wetwang Slack is located in East Yorkshire, UK (Fig. 1). The extended site is of outstanding interest, having both settlement and burial evidence which date back to the Neolithic and continue into the Romano-British period [19], with the largest sample of late prehistoric structures in East Yorkshire [20]. It is situated in an area on the Yorkshire Wolds which is a rich prehistoric landscape of barrows and linear earthworks [18]. The extensive formal inhumation cemetery, including two-wheeled vehicle (or 'chariot') burials, is exceptional for the British Iron Age and the site (covering both the cemetery and a settlement area) has produced one of the largest animal bone assemblages available for that period.

Carbon and nitrogen stable isotope analysis has been applied to collagen from both human and animal bone samples, the technique facilitating a direct reconstruction of protein levels in the diet over the long-term [2, 27]. This allows exploration of general subsistence patterns for the population. The study was undertaken primarily to characterize the human diet for the Iron Age group at the site and to identify any dietary differences present between status, sex, age and site phase groups.

2. Background

2.1 The site

The site at Wetwang and Garton Slack (SE 945 600) extends across a parish boundary and encompasses a cemetery containing over 450 burials with La Tène-style artefacts, probably dating to the fourth to second centuries BC [19, 32, 50, 51] and in use over several centuries [17]. Given the scarcity of British Iron Age inhumations, this provides a population sample of a size rarely encountered. Excavations by Brewster and Dent took place from the late 1960s through to the 1980s, the area being under threat from gravel extraction as work proceeded [10, 19]. Bone from a range of animal species was available from both the settlement area and the grave inclusions, allowing a herbivore 'baseline' to be produced for the particular environmental conditions of the time and place against which the human diet can be compared. The large human skeletal sample, together with the presence of contemporaneous animal bone, make the site particularly suitable for stable isotope analysis.

The burial tradition seen at the Wetwang Slack cemetery involves barrows surrounded by four-sided ditches (often described as 'square' barrows), with occasional two-wheeled vehicles (or 'chariots') found within the graves. Burials of this type are found concentrated in the Yorkshire Wolds, extending southeast into Holderness, west into the centre of the Vale of York and north across the Vale of Pickering onto the southern edges of the North York Moors [51]. They are often labelled 'Arras culture', the type-site being that of Arras near Market Weighton, where around 100 burials were excavated at the beginning of the nineteenth century [51].

More than half of the Wetwang inhumations are in primary positions beneath barrows within their own enclosures. These are supplemented by secondary barrow inhumations and many flat graves and ditch burials which have been inserted into the space available. Fourteen of the graves excavated by Dent contained animal remains which, along with pottery inclusions, appear to indicate that food offerings were made. In nine of these graves they consisted of single sheep humeri within pots, with three graves including pig front quarters, one containing badly preserved pig fragments and the last grave containing both a complete pig and a complete goat [44]. Other grave goods included brooches, bracelets, beads and pins, with the occasional richer burial including a two-wheeled vehicle or weapons [19]. The vehicle burial discovered locally in 2001 also included pig remains [24, 25].

There are six of the well-known vehicle burials from the Wetwang and Garton Slack location, including that of the 2001 find [24, 11, 25] and a further 'cart-type' burial, where the vehicle itself was not preserved, but Brewster suggested it may have been included [9, 10]. The number found here makes this group of such burials the largest in Britain, with only a further twelve others known, ten of which are from other sites in East and North Yorkshire [9, 51]. The two outside this area are both recent discoveries, one being from West Yorkshire (Ferrybridge [7, 8], which has been analysed as part of this research and which will be published separately) and the other being from Edinburgh (Newbridge, the context containing no preserved bone [13, 14]).

These two-wheeled vehicles and the burial form generally have led to suggestions in the past that the Iron Age populations of the Yorkshire Wolds were originally immigrants, since burials showing similarities to those from northern France have been found in that region [10, 15, 49]. However, current opinion sees variations between the Yorkshire burials and those seen on the Continent as evidence that the immigration of a group is unlikely, although the affinities make it probable that there had been some form of contact [23].

The animal bone from Wetwang and Garton comprises a large and important assemblage. The Brewster and Dent excavations together produced over 23,600 identified fragments, the majority from the Iron Age, but also a significant amount of Roman material [35, 44]. To put this into context, most British Iron Age vertebrate collections have either not been quantified or else have consisted of less than 1,000 identified fragments, notable exceptions being mainly from central southern England [22, 31].

2.2 The technique

Analysis of the carbon and nitrogen stable isotopes in bone collagen has been in use as a technique for reconstructing diet in archaeological material for over 25 years [*e.g.*, 53]. General reviews can be found in [2, 27] and [46]. The theory is based upon the principle that the amino acids from which the collagen is composed are themselves formed from chemical elements which are ingested, mainly in the form of protein. The relationship between the isotopes in food is, therefore, reflected in some recognizable way in the isotope ratios in bone collagen. The technique is quantitative in nature, involving measurement of ratios of the isotopes, and it is also relative, in that geographical and temporal differences in the signals make absolute numbers for an individual human of little utility without localized comparative data from the population and from animals of known trophic level. The isotopic values calculated are given in units ‰ (per mil, or parts per thousand) and reflect the ratio of two stable isotopes (^{13}C and ^{12}C for carbon, ^{15}N and ^{14}N for nitrogen) in a sample as compared to a standard. They are given as $\delta^{13}C$ and $\delta^{15}N$ values.

Isotopic datasets have been used to address hypotheses relating to a wide range of issues such as health and nutrition [*e.g.*, 26], weaning age [*e.g.*, 43], subsistence base [*e.g.*, 40], mobility [*e.g.*, 38, 42, 45] and social status [*e.g.*, 33]. The major distinctions to be made for prehistoric Britain are in terms of levels of animal protein consumed, high proportions in the diet elevating the nitrogen signal, and also in identifying marine foods, which elevate the nitrogen signal at the same time as leading to a less negative carbon value. For British prehistory the distinction between consumption of C_3 and C_4 plants, which can be identified with the $\delta^{13}C$ signal, is not useful. These plant groups have different photosynthetic pathways, leading to different carbon isotope values, but C_4 plants were not widely available during this period in temperate Europe. Millet (a C_4 plant) has, however, been suggested as part of the diet in Iron Age Slovenia and Bohemia [29, 33].

Collagen has a long turnover period in adults, believed to be in the region of 10 to 15 years for long bone cortex, so that the signatures obtained relate to a lifetime's diet, rather than to short-term consumption [30, 52, 54]. The data presented in this paper for humans are primarily from rib and it is generally considered that this will provide a shorter-term signal than seen in long bone [*e.g.,* 45], although the period involved is still likely to consist of a number of years. It is believed that the collagen reflects the protein content of the diet, largely excluding the carbon which has come from ingested carbohydrates and fats [3, 4]. At present, it is not possible to differentiate between the consumption of different types of animal protein, with meat and dairy products producing similar signatures.

3. Methods

Data are presented here for 62 human samples and 68 animals. The Iron Age humans have been selected to include both sexes, a range of ages, subjective status groups and two cemetery site phases. A further 41 infant and child samples are not described in this paper, but will be presented elsewhere.

Collagen was extracted from human and animal bone samples using the standard procedures outlined in Richards and Hedges [39], modified by the use of a Millipore Amicon Ultra-4 centrifugal filter (30,000 NMWL) prior to lyophilization so that molecules over 30 kD were retained [12]. The collagen yields presented in Tables 1 and 2 must be considered in the light of the use of these filters. Tests undertaken on six human samples randomly chosen from those analysed here indicate that the yield is reduced to approximately 40% of the yield which would have been produced for this material without this stage, this being dependent upon the preservation of the collagen in individual samples. All samples listed in the Tables have yields in excess of 1%. For the few below 1.8% (this being considered indicative of poor quality collagen when these filters are not used [1]) the data are considered acceptable on the basis of the expected yield reduction combined with the C:N ratios and element percentages obtained.

The bone element sampled for humans was rib in all cases except WWH 155 and the Iron Age fragment which was not from a burial, these being from long bone cortex. The samples were all taken by the first author directly from the boxed human skeletons and, other than for those burials which included quite specific animal remains as grave goods (see above), there was little likelihood of animal bone being present in these. It is not considered likely that misidentified animal bone was confused during the sampling process. Animal samples were from various bone elements, depending on the material identified to species (see Table 2). The collagen was combusted to CO_2 and

N_2 and analysed using either a Thermo Finnigan DELTAplus XL continuous helium flow gas isotope ratio mass spectrometer coupled with a Flash EA 1112 elemental analyser or an Europa Scientific Geo 20/20 isotope ratio mass spectrometer coupled to a Roboprep elemental analyser, both at the University of Bradford. The analytical σ, averaged from standards run with the samples, amounted to ± 0.2‰ for both $\delta^{13}C$ and $\delta^{15}N$. The isotope values presented are averaged from two replicates, analysed in separate batches, except where one replicate was discarded due to analytical problems or a C:N ratio outside of the range 2.9 to 3.6 [16].

4. Results

4.1 The group as a whole

The human data are presented in Table 1. Averages for adolescent and adult humans (defined here as age 12 and over), together with those for mature sheep, pigs and dogs and for young pigs are shown on the chart in Figure 2. The human $\delta^{13}C$ values for 61 of the 62 individuals (excluding WWH 14) range from -21.2‰ to -19.9‰ (average -20.5‰; σ ± 0.3‰) with $\delta^{15}N$ values from 8.6‰ to 11.2‰ (average 9.6‰; σ ± 0.5‰). Data for the animals are presented in Table 2. The average carbon and nitrogen values for the sheep (n = 15) are -21.7‰ (σ ± 0.5‰) and 5.0‰ (σ ± 1.0‰) respectively, excluding the immature animal, and for cattle (n = 10) they are -21.5‰ (σ ± 0.4‰) and 4.6‰ (σ ± 1.1‰). The adult human averages are around 1‰ less negative for carbon and 5‰ more positive for nitrogen than these herbivores.

4.2 Status and outliers

Figure 3 shows the adult and adolescent human values divided into six subjective ‘status groups’: (1) vehicle burials; (2) those with other grave goods buried beneath barrows; (3) those beneath barrows without grave goods; (4) those which are not barrow burials, but do have grave goods; (5) those without barrows or grave goods; (6) one human bone fragment which was not from a formal burial, but found with animal bone within an enclosure ditch. There are no distinctive patterns present in the data for these groups.

Two individual points of interest are WWH 14 and WWH 431, both marked on Figure 3. These have elevated $\delta^{15}N$ values at 12.3‰ and 11.2‰ respectively. The value for WWH 14 is 0.8‰ higher than 3σ from the mean, even when σ is calculated to include this individual. It is considered to be an outlier. WWH 431 is closer to the mean being just within 3σ, but it is still an extreme point given the clustering of this data-set and it is 0.7‰ higher than the nearest lower value.

WWH 431 is a female from a burial without a barrow or grave goods, probably in the middle adult age group [Dawes, unpublished data; 34]. The original record for this burial describes skeletal preservation as “very good, very hard bone” [Dawes, unpublished record card], but the most interesting factor relates to the quantity of the collagen extracted. This had a yield of over 16% of original bone mass, the highest for any of the Wetwang samples (average human yield was 5.8%, σ ± 2.8%). Comparison of collagen yields with nitrogen isotopic signals for the whole adult human population did not reveal any correlation between the two factors. Indeed, this would be unexpected since there is no indication that the collagen isotope ratios are affected by preservation factors where the C:N ratio is within the range generally considered to indicate the presence of acceptable quality collagen [16]. Since the burial is unphased, a possible explanation for the coexistence of a high nitrogen value and collagen yield might be that it was an intrusive burial. However, this individual was included among 19 skeletons from this cemetery which have been recently radiocarbon dated (dates to be published elsewhere) and it belongs to the middle Iron Age period. A review of the position of this individual within the cemetery reveals that it is in close proximity to two other individuals with particularly high collagen yields, one of which was buried with an Iron Age brooch. It is likely that collagen degradation in this area of the cemetery was moderated by particularly good preservation conditions and that the high nitrogen value for burial 431 is coincidental.

WWH 14 is a male over 45 years of age from a secondary interment in a barrow and without any grave goods. Collagen yield is normal, relative to the rest of the data-set.

4.3 Sex and age

There is an unusual trend to be seen amongst the older males when they are separated from the group as a whole. It can be seen from Figure 3 that a trend is discernible in the overall data from individuals with high nitrogen and more negative carbon values, down to those with lower nitrogen values and less negative $\delta^{13}C$. If a trend line is plotted for all adult data-points, the r^2 value is relatively low, at 0.24 (with the two extreme individuals excluded). However, if the sexes are plotted separately, the r^2 value for the female trend line remains low at 0.15, with the male value much higher at 0.51. The trend becomes even clearer if the males are separated according to age and Figure 4 displays negative correlation between $\delta^{13}C$ and $\delta^{15}N$ for males categorised as over the age of 35 years, showing the r^2 value at 0.60. The correlation is significant at the 99% confidence level for this group of 16 individuals, whilst that for women in the same age group is not significant (n = 10). It is not considered to be a coincidental pattern since an extra 6 male samples were processed from the appropriate age range in order to check that they conformed to the trend, which they did.

Adolescent males in the age group 12 to 20 years do show a similar trend, although sample size is too limited to allow conclusions to be drawn (n = 4). The r^2 value for the males in the age group 20 to 35 is much lower at 0.23 and it is again not significant (n = 10).

The trend outlined above is difficult to interpret. Whilst most carbon and nitrogen stable isotopic data show a positive correlation in line with increasing levels of animal or marine protein in the diet, this is a negative correlation. With that in mind, the trend must be particularly strong to overcome the usual pattern. It is also a trend which is seen *within* the closely clustered data-set for the population, such that even the analytical precision, when considered to 2σ, encompasses a large part of it. It is apparently unaffected by other considered factors such as status or site phase. Perhaps it is the close clustering of the data for this population sample, together with the fact that all of the samples have been taken from one skeletal element (rib), that has allowed the pattern to be clearly defined.

No similar trends are known from published data, which would suggest that it is not the result of a physiological phenomenon restricted to mature males. This unusual correlation requires further research in order that a better understanding of its derivation can be obtained.

4.4 Site phase

Isotopic values are plotted by site phase in Figure 5. No distinction between these cohorts is visible. This is important in the discussion of the possibility of immigrants forming the initial population at the site. The lack of phase distinction is reinforced by the fact that the correlation discussed above is apparent across both phases in similar ranges of both carbon and nitrogen isotopic values and also by the close clustering of the values for the group. If a number of these individuals had come from a different area of Europe, there are likely to have been differences seen in the patterning across the phases and a greater range of values might have been expected. This, of course, is based on that part of the population which has been analysed. Although the samples have been taken from across the site, to represent all parts of the cemetery and all burial types, it is possible that a small immigrant group has eluded the sampling procedure.

5. Discussion

5.1 Adult Iron Age humans

The small shift of 1‰ on the carbon scale and the much larger increase in the average nitrogen value of around 5‰ between the averages of the herbivores and those of the adult humans are consistent with a diet high in animal protein (either meat or dairy products) with no suggestion of a significant level of marine foods; the latter would cause a much less negative carbon value and a more elevated nitrogen signal. It is usually expected that the trophic level effect will produce ^{15}N enrichment between diet and consumer collagen resulting in a spacing of 2 to 4‰ [6, 41]. In this case, the 5‰ elevation is higher than might be expected. Recent research suggests that a possible explanation may relate to particularly high levels of protein consumption [47, 48]. In this case, some consumption of very young pigs (or other species) might also contribute to an elevated nitrogen signal (see below). The conclusion that marine foods were absent from the diet is supported by the fact that no fish bone was recovered from the site and by the location being approximately 25 km from the coast. This is also consistent with suggestions that the lack of fish bone from British Iron Age sites generally is supportive of a situation in which fish are not often exploited during this period (*e.g.*, 21).

One of the possibilities suggested for social distinction within the East Yorkshire burial tradition relates to the inclusion of animal remains as grave goods, some with pig and some with sheep [36]. The sampling programme used for this research encompassed two of the human burials with sheep inclusions, three with pig and one with both pig and goat (see Table 1). Although it might be possible to extend this sampling at some future time to include all such burials, initial findings suggest that there are no significant differences to be found between individuals buried with the different species.

The small range of values (1.3‰ for carbon; 2.2‰ for nitrogen if WWH 4A, 14 and 431 are excluded) for 60 individuals, together with the fact that no distinctions can be made between different cohorts (other than the negative correlation particularly apparent in mature males), suggests a diet which was unusually consistent during the lives of these people and which also did not vary significantly across the population or over the period of use of the cemetery. It is necessary to be aware, however, that a diet which is consistent in terms of protein intake is not necessarily physically identical. It is not possible, for instance, to distinguish between individuals of different status eating different cuts of meat or obtaining their protein from different mammal species. Again, if the protein intake was similar, a distinction might not be seen if one group was consuming dairy produce and another meat.

The lack of a distinction between Early and Late site phase data may be a useful contribution to the discussion of the possibility of immigration from France or elsewhere [15, 49]. Whilst carbon and nitrogen isotopic analysis is not a technique specifically useful in the consideration of mobility, it should be noted that different environments produce varying signals, which is the reason for comparing the animal data with that for humans for any particular location or time period. With this in mind, early immigrants to the Wetwang site might be expected to look at least marginally different from those appearing in the Late phase. WWH 14 and, perhaps, 431 are suggestive of such differences. However, it might be expected that an early immigrant group would have formed the basis for the regional burial rite (enclosed barrows, particular grave goods, perhaps the vehicle burials themselves) and neither of these two individuals are from primary barrow burials, nor did they have grave goods.

Given that the $\delta^{15}N$ value for WWH 14 is around 7.5‰ higher than the average herbivores for the site, it is possible that this is a mobile individual from another location. A diet including a large proportion of freshwater aquatic resources might be considered, but this is unlikely given that access to local surface water at this site is restricted, the nearest source being 5 km away and the local streams being dry for much of the time, only flowing after heavy rainfall [5, 19]. This situation is thought to have been the case during later prehistory in much the same way as it is today.

It must be borne in mind that this East Yorkshire cemetery was probably in use for between 200 and 400 years [17], so that the analysed samples may not have included many (or, indeed, any) of a small, original immigrant group.

The possibility that the individuals with unusual isotopic values were intrusive to the middle Iron Age phase of the site has been considered and rejected, now that direct AMS radiocarbon dates are available for these samples (dates to be published elsewhere).

5.2 Iron Age pigs and dogs

The herbivorous nature of the adult pigs is clear from the proximity of their values to those of the sheep in Figure 2. It would appear that these animals were not being fed human refuse in the form of animal-derived protein, but were reliant on plant protein. Of the five young pigs plotted separately, two are known to be less than or around 6 months old, one less than a year old and the other two generally described as immature [44]. These plot higher on the nitrogen scale, as would be expected for unweaned or recently weaned animals. This is because such animals are one trophic level above their mothers, effectively ‘carnivores’ consuming milk produced by their mothers’ bodies. However, even at 6 months, these animals might be considered too old to continue reflecting this signal. In that case it is possible that these young animals were being fed animal protein of some form after weaning, this being either dairy or meat, such dietary supplements perhaps ceasing if the animal was allowed to live past a certain age. Alternatively, since animals under less intensive husbandry regimes may continue to suckle for longer periods, it is possible that this was the case here (Dobney, pers. comm.).

Of the pigs analysed, 3 of the immature samples had been included as grave goods in different burials. Two of these animals were identified as being less than or around 6 months old [44]. There was a further Iron Age burial from Brewster's area of excavation which included two suckling pigs [10]. Their inclusion in the graves may indicate that young pig was an identifiable part of the diet, given that there is a burial tradition in this area for grave goods to include what are apparently food items (see above). Unlike other domesticated animals, pigs are not generally useful for secondary products. Reynolds has suggested that they can provide 'pig labour', by keeping them in a field to be cultivated and allowing them to prepare and manure the ground, obviating the necessity of using an ard [37]. However, their main utility is that they can convert less valuable food waste into meat and they may have been an obvious resource for preservation of supplies for periods of shortage. They produce high numbers of young and it is possible that suckling pig was an attractive food option. Bones of very young pigs found at the Iron Age site of Staple Howe (East Yorkshire) were suggested as being indicative of the consumption of piglets [28], the charring of snout and legs visible on the remains of the young pig from the 2001 vehicle burial discovery may be indicative of spit-roasting and the remains of very young animals in the enclosure ditch may even be from the consumption of a complete litter (Mackey, pers. comm.). If these, or other very young animals (*e.g*. young sheep) were regularly included in the diet, it would help to explain the particularly high $\delta^{15}N$ spacing between humans and herbivores seen at this site.

The dogs plot high on the nitrogen scale and less negative on the carbon scale, indicating an omnivorous diet, with perhaps a lower proportion of animal protein in their diets than the humans. This suggestion is debatable, however, since experimental studies suggest that different species may exhibit varying levels of ^{15}N enrichment over their diets [47, 48].

6. Conclusions

Bone collagen $\delta^{13}C$ and $\delta^{15}N$ values for humans and animals from the middle Iron Age at Wetwang and Garton Slack, East Yorkshire, show that the humans had a diet over the period of use of the cemetery which did not change significantly over time and which was substantially the same for all individuals, regardless of sex, age or status. This diet can be characterized as one which was high in animal protein and did not contain significant levels of marine foods. Young pigs (or other young animals) may have made an important dietary contribution. The tight range of values, particularly when considered across site phases, appears indicative of a local population rather than one which contains adults who have been geographically mobile.

There are two human outliers in the data and there is an unusual trend in the isotopic data from older males which requires further consideration.

The data presented here are the first for the British pre-Roman Iron Age, and this is one of the few isotope palaeodiet studies where the interpretation of human isotopic data is supported by a large number of contemporaneous animal isotope values from the same site. The relative uniformity of diets is particularly interesting, especially in what is believed to be a complex and socially stratified society where the differential provision of grave goods is present, although there are many ethnographic examples of societies in which different status groups share the same diet. Further studies of Iron Age humans from other sites in the UK and in continental Europe will help determine if this uniformity of diet is a local or more general Iron Age phenomenon.

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Table 1
Data for human samples from Wetwang Slack, East Yorkshire

Sample	Age[1]	Sex[2]	Burial information[3]	Site Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N	Collagen Yield (%)	%C	%N
WWH 1	2	2	5	E	-20.5	8.8	3.3	5.2	42	15
WWH 11	3	1	5	E	-20.3	9.8	3.3	5.6	42	15
WWH 13	1	1	3	E	-20.1	9.0	3.3	5.4	44	16
WWH 14	3	1	5	E	-20.7	12.3	3.3	4.8	44	15
WWH 19	2	2	3	E	-20.8	9.4	3.4	5.0	42	15
WWH 27	2	2	5	E	-20.9	9.1	3.4	6.0	43	15
WWH 43	3	1	5	L	-20.3	9.6	3.3	5.2	43	15
WWH 59	2	2	4	L	-20.5	9.5	3.4	7.5	43	15
WWH 76	1	2	5	L	-21.0	9.5	3.3	2.5	44	15
WWH 93	2	2	5	L	-21.1	10.1	3.3	7.5	43	15
WWH 94	2	2	4	L	-21.0	9.9	3.3	6.2	42	15
WWH 105	2	1	5	L	-20.4	10.0	3.4	4.3	42	15
WWH 117	3	1	2 (pig)	L	-20.9	10.3	3.4	4.2	43	15
WWH 121	1	1	2	L	-20.5	9.8	3.3	3.8	45	16
WWH 122	3	1	2	L	-20.2	8.9	3.3	6.8	45	16
WWH 124	2	2	2	L	-20.2	9.2	3.3	6.3	45	15
WWH 129	2	1	2	E	-20.4	9.4	3.2	6.5	45	16
WWH 131	4	3	3	L	-20.1	9.8	3.3	4.6	42	15
WWH 132	3	2	4	L	-19.9	9.1	3.3	6.3	42	15
WWH 155	3	2	2	E	-21.1	9.9	3.4	3.4	45	15
WWH 161	3	1	2 (sheep)	L	-20.5	9.3	3.3	2.7	44	15
WWH 173	2	2	3	L	-20.0	9.4	3.3	6.4	42	15
WWH 178	2	1	5	L	-20.7	10.5	3.3	1.3	41	15
WWH 186	3	1	2 (pig & goat)	E	-20.5	9.8	3.3	2.6	41	14
WWH 193	3	2	2	L	-20.7	9.3	3.4	3.5	45	15
WWH 224	1	1	5	E	-19.9	8.6	3.3	5.4	42	15
WWH 253	2	1	5	N/K	-20.4	9.6	3.4	8.1	43	15
WWH 273	3	2	4	L	-20.5	10.1	3.4	7.0	42	15
WWH 275	4	2	2	L	-20.7	9.8	3.2	9.8	46	16
WWH 280	3	1	5	L	-20.4	9.9	3.3	4.1	41	14
WWH 283	3	1	5	N/K	-20.4	10.0	3.3	5.2	44	16
WWH 294	2	2	3	L	-20.2	9.3	3.3	8.9	43	15
WWH 299	2	1	5	E	-20.5	9.1	3.4	5.2	42	15
WWH 301	2	2	5	E	-21.1	9.7	3.4	3.4	44	15
WWH 305	2	2	3	E	-20.6	9.1	3.3	4.7	40	14
WWH 306	3	1	5	E	-20.7	10.1	3.4	5.2	43	15
WWH 308	1	2	5	E	-20.3	9.3	3.3	3.9	42	15
WWH 309	3	2	2	L	-20.9	9.9	3.3	5.8	43	15
WWH 313	3	2	5	L	-20.5	9.7	3.3	6.7	43	15
WWH 327	3	1	2	E	-21.1	10.3	3.3	5.4	43	15
WWH 342	2	2	5	E	-21.1	9.6	3.4	5.4	43	15
WWH 348	3	2	3	L	-20.4	9.8	3.4	9.1	42	15
WWH 350	3	1	3	E	-20.4	9.7	3.4	6.2	43	15
WWH 377	2	3	5	E	-21.2	10.4	3.3	4.4	43	15
WWH 384	3	1	3	E	-20.8	10.5	3.4	4.3	42	15
WWH 388	2	1	3	E	-20.9	9.4	3.4	4.2	43	15
WWH 400	3	2	2	E	-20.7	10.0	3.4	4.4	42	15
WWH 413	3	3	5	N/K	-20.7	9.9	3.4	4.8	44	15
WWH 415	3	2	5	E	-20.9	9.1	3.4	4.6	42	15
WWH 416	2	1	5	N/K	-20.2	9.1	3.2	11.8	43	15
WWH 418	3	2	5	N/K	-20.5	9.2	3.3	5.9	43	15
WWH 425	3	1	3	N/K	-20.6	10.2	3.4	5.5	42	15
WWH 426	1	3	5	N/K	-20.6	9.7	3.4	2.6	44	15
WWH 431	2	2	5	N/K	-20.6	11.2	3.3	16.5	43	16
WWH 435	3	1	2 (sheep)	N/K	-20.5	10.0	3.3	3.5	44	15
WWH 438	3	1	2	L	-20.2	9.0	3.2	13.6	42	15
WWH 453	2	1	1 (pig)	E	-20.0	9.7	3.2	13.9	43	16
WWH 454	2	2	1 (pig)	E	-20.6	10.0	3.4	9.6	43	15
WWH 455	2	1	1	E	-20.3	9.6	3.4	2.2	42	15
WWH 3A	4	4	6	E	-20.4	8.8	3.2	3.8	42	15
WWH PRIN	3	2	1	E	-20.3	8.9	3.3	4.4	45	15
GSH 1	2	1	1	N/K	-20.6	10.1	3.3	4.7	43	15

[1] **Age codes:**

Adolescent, 12 to <20	1
Young adult, 20 to <35	2
Middle adult, 35 to 50	3
Adult, unable to refine	4

[2] **Sex codes:**

Male	1
Female	2
Probably male	3
Unsexed	4

[3] **Burial information codes:**

Chariot burial (faunal remains marked)	1
Primary in barrow and grave goods (faunal remains marked)	2
Primary in barrow, without grave goods	3
Without barrow or non-primary, with grave goods	4
Without barrow or non primary, without grave goods	5
Not a burial, Iron Age animal bone context	6

Details of Iron Age burials can be found in [17]. The sample numbers include the Burial Number within that thesis, following the WWH code.

Table 2
Data for faunal samples from Wetwang Slack, East Yorkshire

Sample	Species (skeletal element) & other detail (see Notes 1-4)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N	Collagen Yield (%)	%C	%N
WWA 24	Cattle (tibia)	-21.6	7.1	3.3	3.9	42	15
WWA 25	Cattle (tibia) (young) R-B	-22.2	5.0	3.4	1.9	42	15
WWA 26	Cattle (rib)	-22.0	4.6	3.3	4.5	41	15
WWA 27	Cattle (long bone)	-20.8	4.4	3.3	4.2	41	15
WWA 38	Cattle (rib)	-21.5	4.1	3.3	1.3	41	15
WWA 41	Cattle (humerus)	-21.6	5.5	3.3	2.1	41	15
WWA 45	Cattle (rib)	-21.2	5.1	3.3	2.1	40	14
WWA 5	Cattle (rib) R-B	-21.4	3.8	3.3	2.4	40	14
WWA 51	Cattle (humerus)	-21.1	3.5	3.4	1.2	41	14
WWA 62	Cattle (humerus)	-22.3	4.2	3.3	2.0	42	15
WWA 9	Cattle (rib) R-B	-21.7	3.3	3.3	2.6	42	15
WWA 11	Crow (femur) R-B	-20.1	10.3	3.3	6.0	42	15
WWA 28	Dog (rib)	-20.8	8.3	3.3	5.6	42	15
WWA 49	Dog (long bone)	-20.5	8.8	3.3	4.0	42	15
WWA 64	Dog (long bone)	-20.0	8.1	3.3	7.3	43	15
WWA 68	Dog (mandible)	-21.8	5.3	3.4	1.3	28	10
WWA 69	Dog (metacarpus)	-20.6	7.6	3.4	2.6	44	15
WWA 70	Dog (mandible)	-20.9	8.0	3.4	1.7	44	15
WWA 37	Fox (mandible)	-21.2	6.8	3.4	2.9	41	14
WWA 34	Goat (young) (long bone)	-20.3	4.0	3.3	4.1	42	15
WWA 7	Goat (femur) (grave goods from Burial 186)	-20.8	4.5	3.3	1.7	41	14
WWA 1	Horse (femur)	-22.0	3.6	3.2	1.2	37	13
WWA 2	Horse (tibia)	-21.8	5.1	3.4	3.2	35	12
WWA 29	Horse (rib)	-22.6	3.1	3.2	4.6	42	15
WWA 30	Horse (long bone)	-21.1	3.8	3.3	3.6	42	15
WWA 31	Horse (tibia)	-22.6	4.9	3.3	2.8	42	15
WWA 32	Horse (humerus)	-21.2	3.1	3.4	3.4	42	15
WWA 33	Horse (long bone) R-B	-21.3	6.2	3.3	3.4	42	15
WWA 40	Horse (humerus) R-B	-22.4	3.4	3.3	2.6	42	15
WWA 42	Horse (rib)	-22.9	5.8	3.3	3.7	42	15
WWA 47	Horse (tibia) R-B	-21.5	4.0	3.3	3.7	40	14
WWA 48	Horse (radius)	-22.2	5.0	3.3	5.5	42	16
WWA 54	Horse (humerus) R-B	-22.5	2.2	3.2	5.3	42	15
WWA 55	Horse (femur)	-22.6	2.8	3.2	2.6	41	15
WWA 59	Horse (long bone) R-B	-21.8	5.5	3.3	2.3	42	15
WWA 60	Horse (femur)	-21.2	4.7	3.3	4.0	42	15
WWA 8	Horse (femur)	-22.4	3.6	3.3	8.0	41	15
WWA 13	Pig (humerus)	-21.7	5.8	3.2	4.9	42	15
WWA 17	Pig (long bone)	-21.4	5.8	3.3	1.2	41	15
WWA 18	Pig (long bone) R-B	-21.9	5.7	3.4	2.9	42	15
WWA 19	Pig (≤ 6 mths*) (rib) (grave goods from Burial 117)	-22.4	8.5	3.3	3.8	42	15
WWA 22	Pig (< 6 mths*) (rib) (grave goods from Burial 239)	-21.0	8.6	3.3	5.6	42	15
WWA 23	Pig (long bone)	-20.4	5.1	3.4	2.7	41	15
WWA 43	Pig (< 1 yr) (rib) (grave goods from Burial 53)	-21.9	6.7	3.3	5.0	43	15
WWA 52	Pig (young) (long bone)	-21.9	7.0	3.3	2.6	42	15
WWA 56	Pig (long bone)	-22.3	5.4	3.3	3.6	42	15
WWA 6	Pig (< 1 yr*) (tibia) R-B	-21.6	8.1	3.3	4.1	42	14
WWA 61	Pig (rib) R-B	-21.6	3.9	3.3	7.0	42	15
WWA 12	Red deer (mandible) R-B	-20.9	4.7	3.4	3.2	42	15
WWA 39	Red deer (tibia) R-B	-21.6	6.4	3.3	6.5	42	15
WWA 63	Red deer (mandible) R-B	-20.9	6.1	3.3	4.1	42	15
WWA 10	Sheep (humerus) (grave goods from Burial 277)	-21.0	4.6	3.3	5.9	42	15
WWA 14	Sheep (femur) R-B	-21.5	3.9	3.3	3.5	42	15
WWA 15	Sheep (rib) R-B	-21.8	4.8	3.3	5.2	43	15
WWA 16	Sheep (femur)	-22.1	5.8	3.2	5.9	42	15
WWA 21	Sheep (long bone)	-21.9	4.2	3.3	3.4	42	15
WWA 3	Sheep (tibia)	-21.8	5.3	3.3	3.6	41	14
WWA 35	Sheep (tibia) R-B	-21.6	6.6	3.3	2.4	42	15
WWA 36	Sheep (humerus) (grave goods from Burial 295)	-21.7	4.5	3.3	3.9	42	15
WWA 4	Sheep (tibia) R-B	-21.4	4.3	3.2	3.8	41	14
WWA 44	Sheep (radius)	-21.9	5.3	3.3	2.8	42	15
WWA 46	Sheep (femur)	-20.9	3.5	3.3	2.7	41	15
WWA 50	Sheep (tibia)	-21.8	4.1	3.2	3.9	41	15
WWA 57	Sheep (rib)	-22.8	5.5	3.3	5.3	42	15
WWA 58	Sheep (young) (femur)	-22.3	7.3	3.3	12.6	43	15
WWA 65	Sheep (femur) R-B	-21.5	5.1	3.3	3.4	42	15
WWA 66	Sheep (long bone)	-22.0	6.8	3.4	3.5	41	15
WWA 53	Water vole (humeri)	-22.0	6.5	3.3	8.7	42	15

Notes:

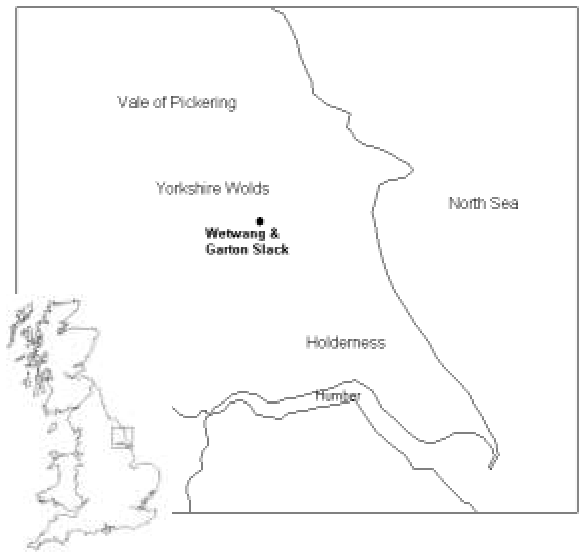
[1] Species identification is mainly by Sally Scott, the zooarchaeologist who worked on the material from John Dent's period of excavation. A limited number of specimens have been identified by Mandy Jay in consultation with Julie Bond at the University of Bradford.

[2] Skeletal element identification is mainly by Mandy Jay.

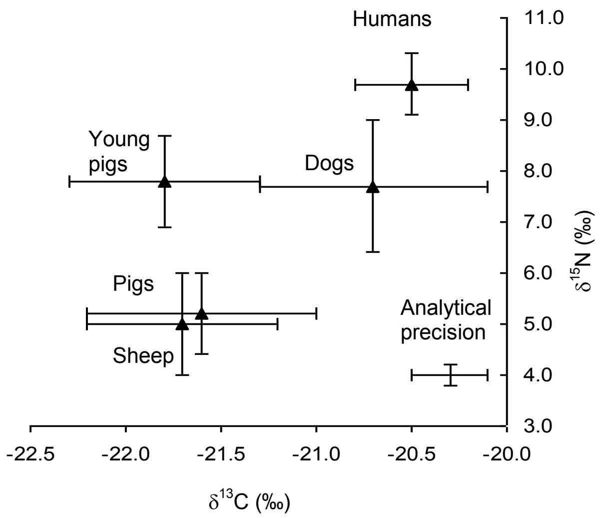
[3] Where "R-B" is shown, the bone is from a context which may be later than the Iron Age burials, either late Iron Age or Romano-British. It is not expected that the data for these animals will have been affected by any significant environmental differences over this time period.

[4] Where information is given relating to age, those marked with an asterisk (*) were aged by Sally Scott. Those unmarked in this way were noted as being young by Mandy Jay on the basis of a combination of unfused epiphyses, obviously low level dental attrition and animal size.

Figure 1



Vale of Pickering
Yorkshire Wolds
North Sea
Wetwang &
Garton Slack
Holderness
Humber


Humans
Young pigs
Dogs
Pigs
Sheep
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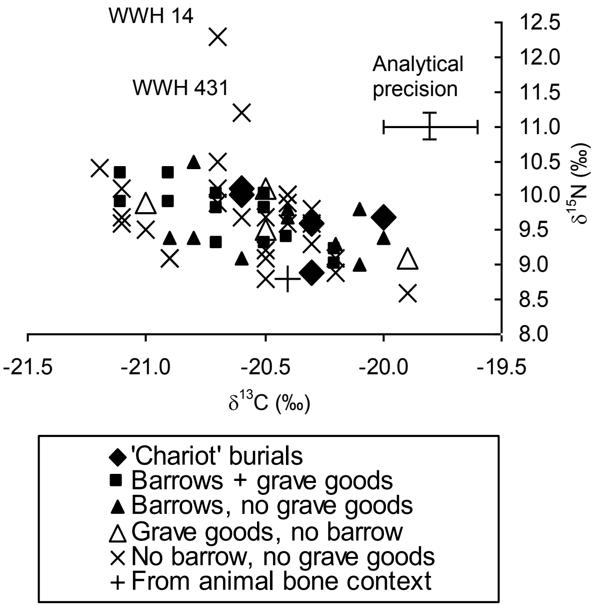
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
-22.5
-22.0
-21.5
-21.0
-20.5
-20.0
$\delta^{13}C$ (‰)
$\delta^{15}N$ (‰)

Figure 2

Figure 3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WWH 431
Analytical precision
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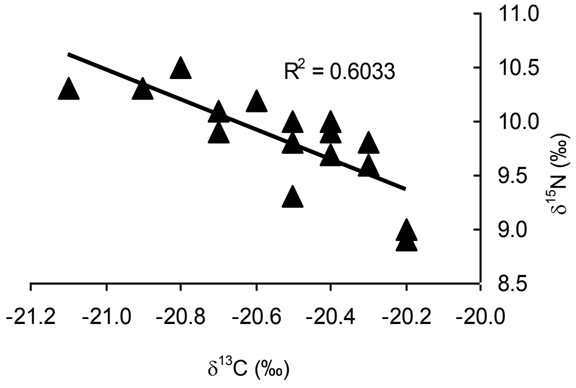
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
δ15N (‰)
-21.5
-21.0
-20.5
-20.0
-19.5
δ13C (‰)
'Chariot' burials
Barrows + grave goods
Barrows, no grave goods
Grave goods, no barrow
No barrow, no grave goods
From animal bone context

Figure 4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9.5
9.0
8.5
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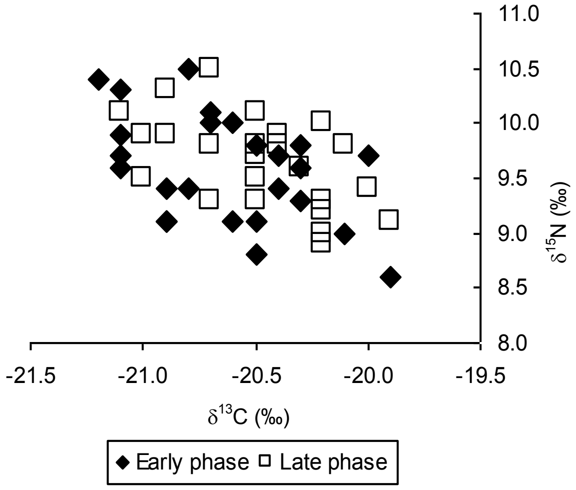
-20.8
-20.6
-20.4
-20.2
-20.0
δ13C (‰)

Figure 5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9.5
9.0
8.5
8.0
δ15N (‰)
-21.5
-21.0
-20.5
-20.0
-19.5
δ13C (‰)
Early phase
Late phase

Fig. 1. Site location

Fig. 2. Carbon and nitrogen stable isotope values for Wetwang adolescent and adult humans, aged 12 and over (n = 62), together with young pigs (n = 5), mature pigs (n = 6), sheep (n = 15) and dogs (n = 6) from the site. Error bars are 1 standard deviation.

Fig. 3. Adolescent and adult humans plotted according to subjective status category. Error bars are 1 standard deviation.

Fig. 4. Mature males, over the age of 35 years.

Fig. 5. Isotopic values plotted according to site phase.