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Isotopic evidence for migration in Medieval England: the potential for tracking the introduction of disease

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Introduction

Isotopic analysis of individuals excavated from cemeteries has the potential to determine whether they spent their childhood locally, and if not, to indicate possible areas of origin. We have been exploiting these techniques to investigate large-scale movements of populations. When combined with palaeopathological analysis of the skeletons, there is also the potential to investigate the relation between migration and health, and indeed the origin and evolution of diseases. This brief communication outlines an application to early medieval mobility, and the results of a pilot study on the relation of migration and health.

The link between skeletal composition and place of residence arises from natural systematic variations in the isotopes of particular elements between localities. Strontium isotopes have been used to study archaeological residential mobility since the mid-1980s. One isotope, 87Sr, is produced by the radioactive decay of rubidium; an element occurring in many rocks and minerals. The abundance of 87Sr (measured as a ratio to stable 86Sr) therefore depends on the initial Rb/Sr ratio and the age of the rock or mineral in which it is found. Strontium is taken up by organisms, but the proportions of its isotopes are unaltered, so that soil, plant and animal strontium isotope ratios have all been shown to be related to those of the underlying geology (Blum et al. 2000). The characteristic strontium-isotope ratios of particular geographical areas and their persistence in local foods and the tissues of feeding animals (including humans) provides the basis for the reconstruction of the place of residence at the time of the tissue formation.

Oxygen isotopes also vary in the environment in a systematic way, but in this case as a result of differences in climate and geography. Precipitation falling across Great Britain, as elsewhere, is not isotopically uniform, but varies in a systematic way with geographical location (Darling 2004). In antiquity drinking water was drawn from surface waters and near-surface ground-waters collected from precipitation. This provides the basis to link tissue oxygen isotope composition to a person's place of residence when a particular tissue was formed. The oxygen isotope composition of skeletal tissue is directly linked to that of drinking water (Longinelli 1984). Unlike strontium, biological processes alter (or 'fractionate') oxygen isotopes in a systematic way. A number of researchers have developed species-specific calibrations that relate skeletal oxygen isotope ratios to those of drinking water. The calibration developed by Luz et al. (1984) for humans is used here.

Teeth are particularly advantageous for study because of the excellent preservation of enamel, but also because different teeth are formed at particular stages of life. Once formed, the enamel is not remodelled so that its composition is a reliable indicator of childhood dietary composition (Budd et al. 2001, 2004). Although development of the permanent first molar is initiated in *utero*, most of the permanent dentition forms in childhood from 3-4 months after birth until about 12 or more years of age. This formation period of the teeth makes them a potential archive of isotopic data relating to childhood location of an individual. It is thus possible to identify first generation immigrants in a cemetery population.

Our previous work has focussed on early Anglo-Saxon cemeteries in England. Traditional historical accounts of the arrival of the Anglo-Saxons in Britain, for example, that of Bede, describe waves of Anglo-Saxons from northern Germany and Denmark descending upon Britain around AD 450 and displacing the local Romano-British population. In contrast, archaeological evidence is now most often interpreted as showing that Germanic settlers arrived earlier, and over a prolonged period, in smaller numbers. The transition from Roman to Anglo-Saxon culture is thus interpreted as an acculturation of the indigenous population to Germanic styles, rather than replacement of the population by settlers.

We have studied several early Anglo-Saxon cemeteries to identify first generation migrants and evaluate the alternative hypotheses. To illustrate the potential of the technique, we present data from a cemetery near Eastbourne. This area was not heavily populated during the Roman period, but a Roman fort was situated 8 km north of the cemetery. According to the Anglo-Saxon Chronicle, the Saxons sacked this fort in AD 492. On the basis of the items buried in the graves, the cemetery at Eastbourne was in use broadly AD 450-550. The individuals analysed thus span three to five generations, and at most 25% of them might be expected to be first generation immigrants on the invasion hypothesis.

Figure 1 shows the strontium and oxygen isotope results from the analysis of 19 individuals. The variation in strontium isotopes is substantial, but is encompassed by the range of values found by systematically sampling soils within 10 km of the site. For oxygen, the extent of variation of the population as a whole is much greater that the range of approximately 1‰ found in modern groups with a single drinking water source (Longinelli 1984). The oxygen isotope results therefore suggest that there are at least two childhood drinking water sources represented in this population. There appear to be two groups, which we label A and B, which, although we distinguish them primarily on the basis of their oxygen isotope results, do display differing patterns of strontium isotope variation. On the basis of the mapped drinking water oxygen isotope values of the British Isles (Darling 2004) we conclude that Group A are consistent with

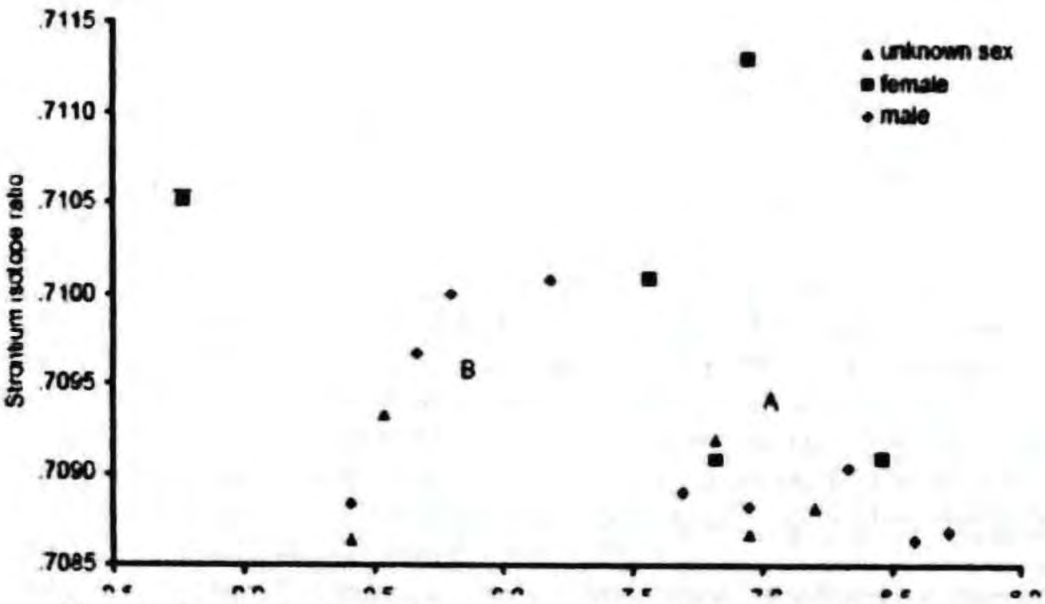

Figure 1: Plot of strontium and drinking water oxygen isotope values from Eastbourne.

local water sources, whilst Group B are consistent with distant water sources, either much further north in Britain or east across the North Sea. One female stands out as having an extremely negative oxygen isotope value and must have an origin somewhere in a broad geographical band across eastern and central Europe. At least 8 of our 19 individuals are therefore immigrants to Eastbourne. Despite the small sample size, we can be confident at the 95% level that at least 19% of the population from which they came were immigrants. This is in line with the predictions of the invasion hypothesis. Although our dating control is poor, there is some evidence that oxygen isotope values correlate with date (Spearman's rho=0.615, p=0.15), again according with the idea that there is a founding generation.

Although at Eastbourne we seem to have good evidence for the arrival of a migrant population, our unpublished analyses of a contemporary cemetery at Berinsfield, Oxfordshire, show no evidence of long-distance migration, and analyses of people from West Heslerton, East Yorkshire, show a migration from the west rather than the east, though a few individuals had migrated from a substantial distance to the east (Budd et al. 2004). Our conclusion is that the pattern of fifth-century Saxon migration was more complicated than either of the simple starting hypotheses.

Disease and migration

Whilst much is written about the impact of movement on infectious disease rates today (Koplan 1988, Wilson 1995), hardly any research has focused attention on the movement of people in the past and its relevance to the origins, evolution and transmission of infectious disease. Populations which move may also bring new diseases to a previously unexposed population which, until the population develops resistance to the new pathogens, can devastate communities. Leprosy, tuberculosis (TB) and treponemal disease (specifically, venereal syphilis) are the three, specific, bacterial infections that have been identified in the skeletal record from cemetery sites in Britain. These diseases, along with other infections, had a great biological and social impact on past populations in the British Isles.

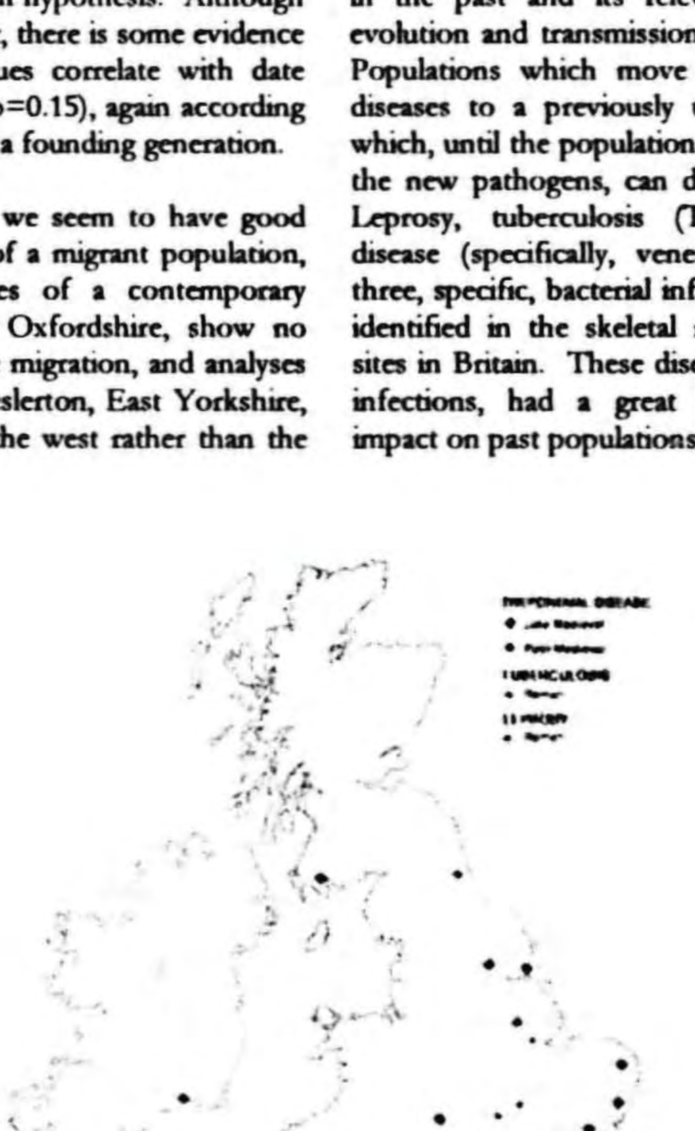

Figure 2: Distribution of earliest cases of leprosy, tuberculosis and treponemal disease in the British Isles

Leprosy is spread primarily by droplet infection, and affects the bones of the face, hands and feet (Möller-Christensen 1961). Tuberculosis is spread by droplet infection or by ingestion of infected meat or milk from other mammals; the spine and, less commonly the hip and knee joints, can be affected (Roberts and Manchester 1995). Treponemal disease (or treponematosis) comprises four "syndromes", pinta, yaws, endemic syphilis and venereal syphilis. The latter is transmitted via sexual intercourse and the others by contact with infected skin lesions or infected food and drinking vessels. Apart from pinta, all may affect the lower leg bones, but venereal syphilis also shows characteristic lesions on the frontal bone of the skull (Hackett 1976). Currently, treponemal diseases are geographically restricted (Roberts and Manchester 1995). Assuming that their past geographic distributions were similar, venereal syphilis seems to be the most likely form to be found in Britain. However, migrants from different parts of the world are possible, so people with other treponematoses could potentially be seen.

The earliest evidence for the three diseases in skeletons is: 2nd century AD for leprosy (Egypt), 5800 BC for TB (Italy) and the pre-Columbian Americas for treponemal disease (Roberts and Manchester 1995). In Britain our earliest evidence was, until recently, the 4th century AD for TB and leprosy (now Iron Age for the former: 400-230 BC), and 15th century AD for treponemal disease (archaeologically and/or radiocarbon dated). Recent research has highlighted that the first cases of leprosy and tuberculosis are located in the south and east of England, and for treponemal disease in the south and east, but this latter infection is also seen on major rivers or at port locations (Roberts 1994, 2002, Roberts and Buikstra 2003) (Fig. 2). Current theory suggests that successive Roman armies invading the south of England from the mid-1st century AD were responsible for the introduction of leprosy and TB into Britain (Manchester 1991). This is a strong possibility, although the recent identification of TB from an Iron Age site (400-230 BC), suggests that TB "arrived" earlier. There is evidence for cross-channel trade from as early as the Bronze Age (2600-800 BC). Thus the evidence is that these diseases originated outside Britain, and it is hypothesised that the people with the earliest evidence of treponemal disease also originated in places outside of the British Isles.

Pilot study

A pilot study of individuals with treponemal disease was undertaken utilising oxygen and strontium isotope analyses to determine their origin. The skeletons derived from Rivenhall, Essex (female, 25-50 years of age, one of 250 individuals from a rural churchyard, radiocarbon dated to AD 1295-1445 (Mays et al 2003)) and Blackfriars, Gloucester (young adult female, one of 250 individuals from a monastic context, archaeologically dated to pre-AD 1492 (Roberts 1994)).While the former was isotopically consistent with a local origin (or west/south-west France), the latter had a high probability of a Norwegian origin (Budd et al 2001).

Discussion

The results of this pilot study suggest that a more wide ranging project documenting the earliest cases of infectious disease in Britain is warranted. However, leprosy and tuberculosis become very common diseases in the early, late and post-Medieval periods in Britain and, beyond analysing the earliest cases to attempt to determine whether they derived from elsewhere, it would be more profitable to concentrate on the earliest cases of treponemal disease. They are so few in number that, it is suggested, they may indeed mostly derive from an origin outside of Britain, thus implying that Britain had no major part to play in the origin and spread of treponemal disease in the Old World. However, there may be value in assessing whether the later cases of leprosy and tuberculosis are indigenous or incomers to Britain.

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