



## The Ba/Sr ratio, carious lesions, and dental calculus among the population buried in the church La Concepción (Tenerife, Canary Islands)

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### ABSTRACT

Certain trace elements may accumulate in bone in relation to dietary habits, so some of them are of interest in paleodietary analysis. This is the case with strontium (Sr) and barium (Ba), whose potential value as paleodietary indicators is enhanced by their relatively inert metabolic behaviour. The presence of carious lesions may indicate consumption of sugar and vegetables, whereas the etiology of dental calculus deposition is multifactorial, although some authors consider this as an indicator of protein consumption. Based on these facts we analysed (1) Ba, Sr, and calcium (Ca) content of inner cortical bone obtained from the ramus mandibularis, by atomic absorption spectrophotometry, (2) presence of teeth with carious lesions, and (3) presence of teeth with calculus deposition in 62 mandibles. All samples were obtained from the church La Concepción, an 18th century burial place in Tenerife. Gender was assessed by analysing genetic expression of amelogenin in some cases (14), and by inspection of pelvic bones when available (41 cases). We found (1) Carious lesions in 32 cases, and dental calculus, in 39; no association was observed between sex and presence of dental caries or calculus deposition, nor between the sex and the proportion of carious teeth nor the proportion of teeth with calculus deposition; (2) people buried near the altar (priests and individuals of the highest social class) showed a significantly higher proportion of teeth with dental calculus deposition ( $\chi^2 = 5.36$ ,  $p = 0.021$ ); (3) bone Sr and bone Ba were significantly higher than the values observed in a control group of 10 modern omnivorous individuals; the lowest Sr values were observed among people buried near the altar; and (4) the Ba/Sr ratio was directly related with the proportion of teeth with carious lesions. These data suggest that there were differences in dietary pattern among the individuals belonging to different social classes; overall, consumption of vegetables was widespread, as shown by the high proportion of carious lesions, in relation with raised Ba/Sr ratio, whereas consumption of marine products was scarce.

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### 1. Introduction

Paleodietary inference constitutes an important source of information which may be obtained from detailed analysis of skeletal remains. It may, however, pose a formidable challenge, especially in cases in which skeletal preservation is poor, diagenetic contamination of the bones is especially marked, or only parts of the skeleton are preserved. Several methods are used to infer the dietary pattern of ancient population groups: those derived from analysis of dental pathology (Bonfiglioli et al., 2003; Greene et al., 2005), and those based on bone, teeth or hair composition analysis (Macko et al., 1999). Recording of carious lesions, calculus, and

dental wear is a useful approach in addressing human diets of ancient population groups, although interpretation of the results – especially regarding calculus (Fure et al., 1998) may be difficult. Bone composition analysis is another important procedure in paleodietary research. It is possible to determine the proportion of stable isotopes of carbon, nitrogen and other elements, which reflect different dietary consumption (Schoeninger et al., 1983). Also, some trace elements may accumulate in bone depending on the amount absorbed, which is related to the amount ingested. Marine and terrestrial food may be strikingly different in terms of trace element content. The marine environment is very poor in barium, so the Ba/Sr ratio discriminates between both marine and terrestrial food (Burton and Price, 1990). In addition, consumption of seafood is by far less cariogenic than consumption of terrestrial food (Costa, 1980). Therefore, bone chemical analysis and recording of dental pathology allow an estimation of the

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relative consumption of marine and terrestrial products by ancient people, an issue which is especially important in an island environment, such as the Canary Islands.

The church La Concepción was the major temple of the growing village of Santa Cruz de Tenerife in the centuries following the Spanish conquest at the end of the 15th century. During these centuries, Santa Cruz de Tenerife evolved from a small fishing village to an active city, mainly due to its strategic condition as a port of call on the trade routes linking Europe and South America, South Africa, and even the Far East. This led to a demographic burst and to the progressive development of a wealthy middle social class. La Concepción was not only the main church, but it also served as a cemetery. Indeed, following, the dead were interred under the floor of the church, a practice which persisted until the end of the 18th century (Hernández González, 2004). Due to space problems, especially in times of pandemic or hunger, tombs were re-used several times, so the remains of the previously interred individuals were dug out and deposited in the earth bordering the graves. However, there were some especially preserved places for “important” people, such as priests or those belonging to the highest social class; as in most Western, catholic, countries, they were interred near the altar (Ariès, 2000). Burial place is an important archaeological feature in catholic cemeteries, since it may constitute the only clue to drawing a distinction between individuals belonging to different social classes. In fact, catholic liturgy recommends that even rich individuals should be interred free of any adornment or special shroud.

The location of La Concepción near the seashore has led to relatively poor preservation of the skeletal remains (Figs. 1 and 2). Indeed, few mandibles and/or maxilla have been recovered, but the proportion of individuals with preserved teeth is greater among those interred in the more recent graves. Teeth are the most resistant structures of the skeleton, and, as commented, several pathologic features of teeth, such as calculus deposition or the presence of carious lesions may aid in paleodietary research. Although it is generally assumed that carious lesions may indicate consumption of refined sugar and some vegetables (Larsen et al., 1991), controversy exists regarding the effect of diet on dental calculus deposition (Fure et al., 1998). Calculus deposition is a very complex process in which several calcium phosphate salts interact with organic molecules present in non-mineralized dental plaque (Jin and Yip, 2002). Whereas many authors associate calculus deposition with the amount of carbohydrates ingested (Lieverse, 1999; Bonfiglioli et al., 2003; Greene et al., 2005), others have put it in relation with protein consumption (Gualandi, 1992).

In addition to dental pathologies, there are other approaches which allow dietary inference, and which should be taken into



Fig. 2. Another example of a poorly preserved skeleton interred under the floor of the church.

consideration in paleodietary analysis, especially when the skeletal remains are fragmentary and poorly preserved. As said before, some trace elements, such as Sr and Ba, accumulate in bone in relation to dietary habits, so they are of interest in paleodietary analysis, especially considering that their potential value as paleodietary indicators is enhanced by their relatively inert metabolic behaviour. However, after initial enthusiasm, a great deal of research has more clearly defined the exact significance of these elements in paleodietary research: while knowledge of specific food composition may allow calculation of bone Sr levels, knowledge of bone strontium does not inversely allow us to infer consumption of specific foods (Burton and Wright, 1995). It has been also questioned whether bone Sr/Ca and Ba/Ca ratios truly reflect dietary intake or diagenesis (Fabig and Herrmann, 2002). Nevertheless, some investigators still analyse these elements in search of dietary information (Balter, 2004), although it is important to bear in mind that reduced food intake also leads to increased bone Sr (González-Reimers et al., 2004) and alcohol consumption may also influence bone Sr (González-Reimers et al., 2002). The concentration of barium, but not strontium, is extremely low in marine environments, so the Ba/Sr ratio may serve to differentiate between marine and terrestrial food consumption. Bone calcium content should remain relatively constant (about 27%), so determination of its content in bone may aid as a marker of diagenesis.

Differences in dietary habit or food availability probably existed in the 18th century in the Canary Islands. In addition to dietary differences between men and women, it is possible that some priests and individuals belonging to the highest social class, buried near the altar, consumed a different diet than the common people, interred far from the altar. Probably, some poor coastal fishermen, followers of the primitive traditional economic activity of Santa Cruz de Tenerife, based their diet more on consumption of marine products obtained by themselves, whereas those involved in commercial activities consumed a mixed diet. Considering the poor preservation of most skeletal remains buried in La Concepción, inference of diet from various sources of evidence is a convenient approach, since information derived from dental pathology may be contrasted with that derived from chemical analysis. In this case, differences in the intensity and extension of calculus deposition, in the prevalence of caries, and in the Ba/Sr ratios might exist between individuals buried near the altar and the others. Based on these considerations we performed the present paleodietary study, utilising both bone chemical analysis and dental pathology, to infer dietary pattern from ancient, poorly preserved skeletal remains recovered from La Concepción.



Fig. 1. Poorly preserved skeleton recovered during excavation of La Concepción church's floor.

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