The Ecology of Dental Enamel Hypoplasias Among Seven Cameroonian Groups

John Maunders, Alan Goodman and Alain Froment[1]
Hampshire College, Amherst, MA 01002 U.S.A.
1. O.R.S.T.O.M, BP 1857, Yaounde, Cameroon

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ABSTRACT The prevalence of dental enamel hypoplasias (DEH) was clinically assessed for individuals (n = 863) from seven Cameroonian groups residing in different ecological zones and varying in access to nutrition and health resources and stressors. Our dual purpose was to evaluate whether enamel hypoplasia prevalences were sensitive to persistent group-level differences in nutrition and disease, and to explore the potential of this rapid methodology for suggesting other possible group-level differences in nutrition and disease during enamel formation.

Individuals from a high socioeconomic status urban high school (Lycee LeClerc) displayed a low prevalence of paired linear hypoplastic defects (8.3%) compared to individuals from six rural groups (overall 34.6%; $\chi^2 = 12.22$; $P < .001$). Additionally, the Duupa displayed a significantly greater prevalence of DEH (48.1-51.5%) than the other rural groups (Massa, Yassa, Mvae', and Bakola; 24.5 - 28.8%), and rural males more often displayed a DEH than rural females (27.6% to 39.2%; $\chi^2 = 8.26$; $P = .004$). The higher prevalence of DEH in the rural groups suggests that it is a sensitive indicator of differences in nutrition and health status. The differences among the rural groups, and between rural males and females, are potentially related to more subtle and yet to be explored differences in dietary diversity and quality.

INTRODUCTION

Severe malnutrition and its sequelae results in over ten million deaths per year (Latham, 1987). While this is sufficient cause for alarm, it is just the tip of the "malnutrition iceberg." Over a billion children hidden below the surface concurrently suffer from milder forms of malnutrition (Latham, 1987). These children, who remain largely invisible to us, are likely to experience delayed mental development and growth (Jelliffe, 1968), lowered work capacity (Allen, 1984; Ferro-Luzzi, 1984) and depressed immune responses, leading to high levels of morbidity (Blaxter, 1984). Furthermore, if mild malnutrition is chronic then it is likely to develop into more severe forms. If unattended to, some of the children with mild Needs to be spelled out in tust are protein-energy malnutrition protein-energy malnutrition (PEM) will move to the tip of the iceberg. That is, they will develop more severe forms of malnutrition and will be at greatly increased risk of severe morbidity and death.

Although estimates, such as those cited above, are available on types and degrees of undernutrition currently affecting many populations, the geographical and social distribution of undernutrition, especially the less severe but more common forms, is generally not well known. This is due in part to limitations of current methods of nutrition and health assessment. Broadly speaking, biochemical measures of malnutrition are impractical in most settings and clinical signs are only evident in extremely severe forms (Zerfas et al., 1985). Anthropometric measures, the third main means for assessing undernutrition, are generally applicable and sensitive, but lack a great deal of precision and specificity (Sutphen, 1985; Zerfas et al., 1985). For example, only rough estimates can be made about the time in life of undernutrition from current height-for-age, weight-for-age, arm circumference and other common anthropometric measures of nutritional status.

Dental enamel hypoplasia (DEH), a deficiency in enamel thickness resulting from a temporary cessation in ameloblastic (enamel secretion) activity (Goodman and Rose, 1990;

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Sarnat and Schour, 1941), is one under-researched measure of nutritional status, here defined as "...the state resulting from the balance between supply of nutrients on the one hand and expenditure of the organism on the other" (McLaren, 1976:3). Because enamel forms in a regular and ring-like fashion and once developed it can not remodel, these developmental abnormalities may provide a permanent and indelible record of periods of systemic stress suffered during tooth development. On a population level, the prevalence of DEH may provide an estimate of nutritional status early in life (Goodman and Armelagos, 1988).

In this study, part of Operation Nutritional Anthropology (ONA), a multidisiplinary and interregional study of nutritional ecology in Cameroon (Hladik et al., eds., 1989), we explore the potential use of DEH as a measure of childhood nutritional status. Observations were made of the permanent dentition of 863 individuals from seven distinct groups located within the diverse confines of the United Republic of Cameroon. These groups vary along an urban to rural gradient and differ in access to medical care and a diversity of dietary resources. The purpose of this study is to explore whether the prevalence of DEH is sensitive to group level variations in nutrition and disease stressors, and to variations in access to medical and dietary resources

MATERIALS AND METHODS

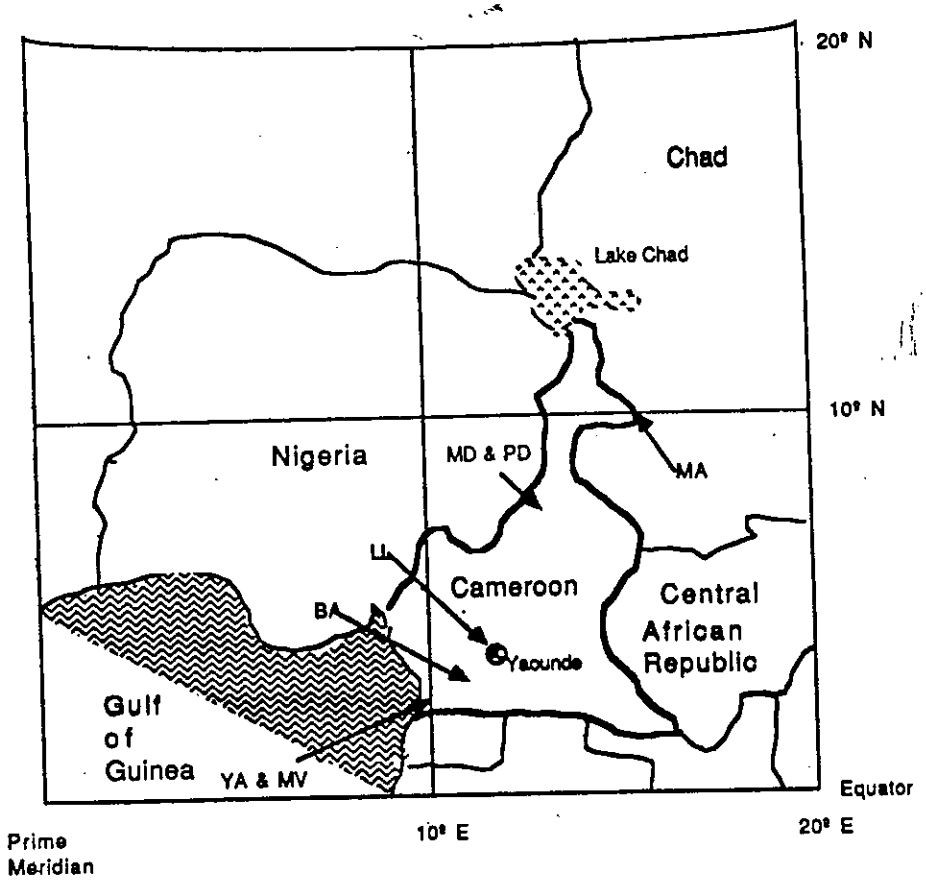
Population and Environments

The Republic of Cameroon provides a microcosm of tropical climates and terrains representative of much of the African continent. In the arid north, bordering Chad, the flat sudano-sahelian terrain is transversed by a few rivers which annually drain the flood plains (Fig.1) Toward the western border of the northern provinces, contiguous with Nigeria, the savanna gives way to the rocky, dry Mandara and Atlantika moun-ain ranges (Seignebos, 1982a). Moving southward into the more densely settled western provinces, the climate and environment changes dramatically to high, humid grassland and mountains of fertile volcanic soils. Dense forest prevails in the central eastern provinces bordering the Central African Republic and the Congo to the east, and Gabon and Equatiorial Guinea to the south. Finally, the Littioral and Ocean provinces have the warm and provident Gulf of Guinea as their southern and western borders, supplying fisherfolk the length of the coast with a livelihood, and the city of Douala with international port trade (Fig. 1).

About 200 distinct languages exist within Cameroon, spoken by an equal number of ethnic groups (Nelson et al., 1974). Some of these groups have held steady in their customs and choice of environment since at least colonial times (or as long as is recalled in oral histories), while other groups have migrated or evolved new lifestyles (Seignebos, 1982b). Some of these people freely intermarry with many other groups, while others maintain a closed society or one with limited social alliances with one or two other groups.

This study includes DEH prevalence figures for seven of these groups. Six of these are located in rural areas and have in common relatively little material wealth. However, they are all distinct in cultural identity, diet and a number of other significant characteristics. These groups form a collective contrast with the seventh group, which consists of secondary school children from a private school in Yaounde, the country's capital (Fig.1).

The *Massa* and *Duupa* are rural northerners who inhabit a sudano-sahelian environment, characterized by a two-season weather pattern- a long dry season followed by heavy rains. The Massa of the extreme north have adapted to the challenges of their environment through agriculture, fishing, and cattle herding (de Garine, 1978). They are tall and "healthy-looking," yet consume an average of only 37g of animal protein per day per person (de Garine and



Southerners Northerners

MA Massa ethnic group (n=98): subsistence farmers, herders, fisherfolk.

MD Duupa ethnic group, mountain dwelling (n=103): subsistence farmers.

PD Duupa ethnic group, plains dwelling (n=108): subsistence farmers.

YA Yassa ethnic group (n=104): fisherfolk, subsistence farmers.

MV Mvaé ethnic group (n=102): subsistence farmers, hunters.

BA Bakola ethnic group (n=106): hunter-gatherers, subsistence farmers.

LL Lycée LeClerc group (n=242): privileged students in Yaoundé, the capital.

Groups boxed together frequently intermarry.

Fig. 1. Location and description of the groups studied. The groups that are boxed together frequently intermarry.

Pagezy, 1989). Observation of strict feeding practices suggest also that the early childhood period may be particularly stressful among the Massa (Mebenga et al., 1988).

The Duupa, in contrast to the Massa, are of small stature. Preliminary inspection of data from health questionnaires indicates that the Duupa have a low fertiliy/fecundity rate and a high prevalence of goiter (M. Matze, personal communication). The Mountain Duupa and the Plains Duupa represent a single ethnic group living on a limited diet (largely millet, corn, and legumes), but living in dissimilar physical environments. The rocky and isolated 1,000 to 1,500 meter highlands near Mt. Batondji pose differing constrainst and stressors as compared to the plains below. The plains are hotter but agriculture is easier in the lower areas because of the high fertility of the plain's soils.

The *Yassa, Mvae'*, and *Bakola* live in the forest-covered south. The Yassa of the southern coast traditionally procure their food from the sea and the nearby forest, mainly through tuber cultivation. The Mvae', living right beside the Yassa, do not fish, but instead hunt game, cultivate tubers and other crops, and gather foods from the forest. Of the roughly 200g of animal protein estimated to be consumed daily by the Mvae', half comes from game and half from fish obtained through trade with the Yassa. The Yassa similarly consume an estimated 246g of animal/fish protein per day: 220g from fish and 26g from forest game (Koppert and Hladick, 1989). Yassa and Mvae' subsistence patterns are thus distinct from one another despite their physical proximity and high degree of interchange.

Deeper in the humid, dense forest of the south, the Bakola (commonly referred to as Pygmies) maintain their hunter-gatherer lifestyle to a considerable extent, enjoying a varied diet high in protein (288g per person, per day from game alone and an additinal 19g from fish) (Koppert and Hladick, 1989). Virtually all of the Bakola who participated in this study supplement their living with tuber cultivation and diverse foods obtained through trade for wild game. Like the Duppa in the North, the Bakola are small in stature. But through their all-night dances and legendary feats of endurance when hunting, the Bakola are reputed to be fit and energetic.

Lycee LeClerc ("General LeClerc High School") in Yaounde was chosen as another examination site to provide a reference population within Cameroon of individuals raised under conditions of less resource stress and greater access to medical resources. To attend this large "public" instiution, a substantial fee must be paid each year. By Cameroonian standards, this is a barrier that prevents the entry of all but the children of the affluent of Yaounde. The nurtition and health care available to this group are among the best available in the country.

Because the seven groups participating in ONA have different food habits and, in most cases, different environments, one would expect the children from these groups to differ from each other in the prevalence of undernutrition and DEH. The clearest expectation based on the ecology of these groups is that we should expect a lower prevalence of DEH in the urban versus the rural groups. Among the rural groups, higher rates might be expected in the north, where protein intake is seasonally limited.

Evaluation of DEH

Developmental defects of dental enamel were evaluated clinically by visual and tactile inspection of the buccal tooth surfaces of the maxillary incisors, canines, premolars and first molars. The inspection included a tooth-by-tooth check for surface irregularities, requiring only a disposable wooden probe and plentiful natural lighting. The scoring system used in this study is a modified version of the Federation Dentaire Internationale's DDE Index (FDI, 1982).

A trained observer can reliably differentiate four types of enamel hypoplasias and distinguish them from caries, hypocalcifications, wear, and trauma. Repeat observations identify the same defect types and locations about 85% of the time (Suckling and Pearce, 1984; Goodman et al., 1987). In this study a single observer (J.M.) followed the same field protocol for each group. Impressions of maxillary teeth were made and provided a permanent record of the occurrence of hypoplastic defects.

Calculations were made of the prevalence of individuals with "paired" enamel hypoplasias, defined as the co-occurrence of DEH at similar locations on contralateral teeth, such as the upper right and left central incisors. Non-paired defects are not counted as diagnostically useful DEHs, because they are less likely to be due to systemic stress.

The prevalence of one or more paired DEH was determined for all the groups, and the rural groups are first compared to the urban sample (Lycee LeClerc). The prevalence of defects in males and females is then compared within each group, in the combined rural sample, and in the total sample. Statistical analyses were performed with $SPSS^X$ on a VAX mainframe computer.

RESULTS

Two results immediately hint to two trends. First, the seven groups cluster into three levels of DEH prevalence, with the urban children on the low end and the Duuppa on the high end (Fig.2). Second, the prevalence of DEH among fema-les, especially in the rural groups, is generally lower than that among males (Fig.3).

The six rural groups together yielded a DEH prevalence more than four times as great as that shown by Lycee LeClerc (34.6% for combined rural groups and 8.3% for the control group ; $\chi^2 = 12.22$; $p < .001$). When all groups are examined separately, however, a further significant difference emerges (Fig.2). All rural groups analyzed separately have significantly ($P < .01$) higher prevalences of DEH than the urban group. However, the Bakola, Mvae', Yassa, and Massa have DEH rates ranging from 24.5% to 28.8% that are significantly different ($p < .01$) from the Plains and Mountain Duupa, but not from each other. The Plains Duupa and Mountain Duupa groups, with DEH prevalences of 48.1% and 51.5%, respectively, form a last clu-ster, clearly a step beyond the intermediate groups but quite similar to each other.

The overall prevalence of paired DEH among males (39.2%) is significantly greater than among females (27.6%; $\chi^2 = 8.26$; $p = < .004$). Furthermore, the greater part of the excess prevalence of DEH in males is confined to the rural groups (Fig.3). Massa, Mvae', and Duupa males display a considerably greater DEH prevalence than do females. In the Massa, for example, females have a 14.7% DEH prevalence, compared to 32.8% for males ($\chi^2 = 2.91$; $p = .09$).

DISCUSSION

A number of studies, especially of prehistoric populations, have revealed differences in the prevalence of enamel hypoplasias among groups assumed to differ in nutrition and health status. For example Swärdstedt (1966) has shown that enamel hypoplasias increase dramatically with a decrease in social status at Westerhus, Medieval Sweden. Similarly, studies of contemporary populations of individuals, who are clinically evaluated to have severe malnutrition, have shown that these individuals have a higher prevalence of DEH than controls (Sawyer and Nwoku, 1985; Sweeney et al., 1971). Occupying a middle ground between these types of studies, this project represents a relatively unique effort to evaluate prevalences of DEH in contemporary groups rather than clinical series. Spanning seven groups and with a total sample size of 863, it is the largest such study that we are aware of.

Bearing in mind the connection between

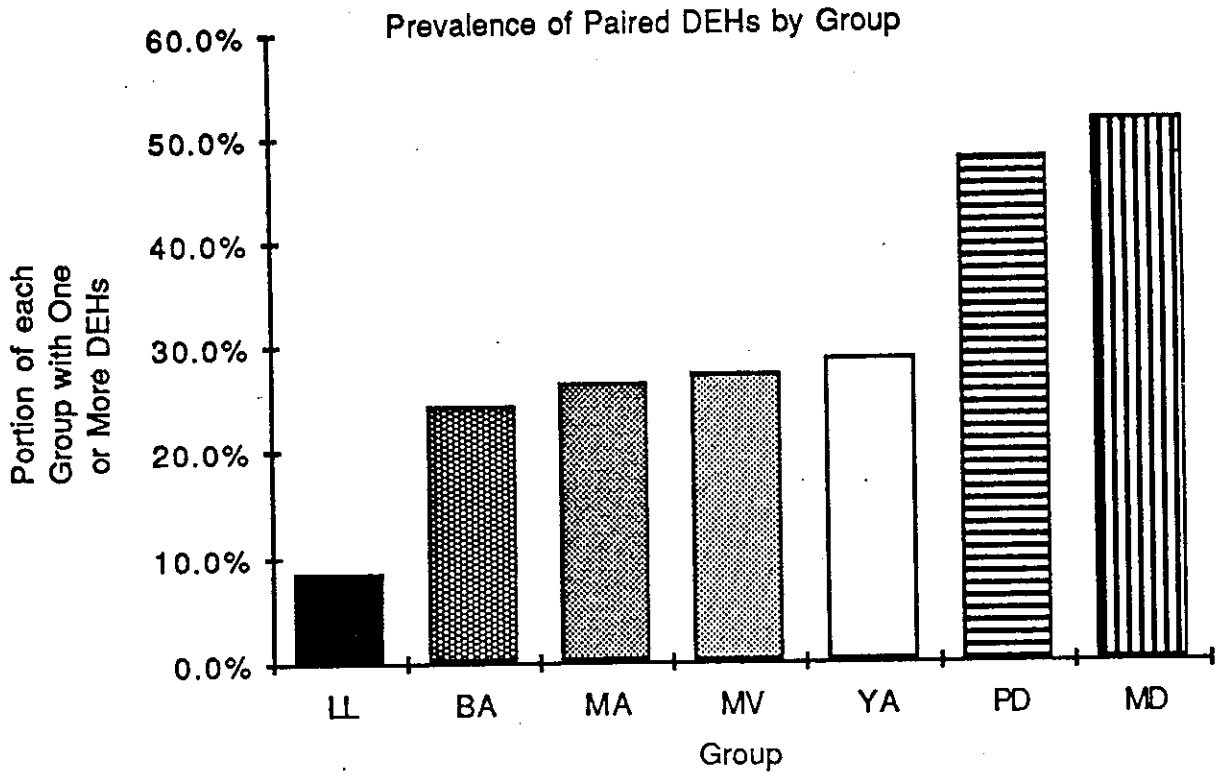


Fig.2. Prevalence of paired DEH the seven Cameroonian groups. Abbreviations of groups names as in Figure 1

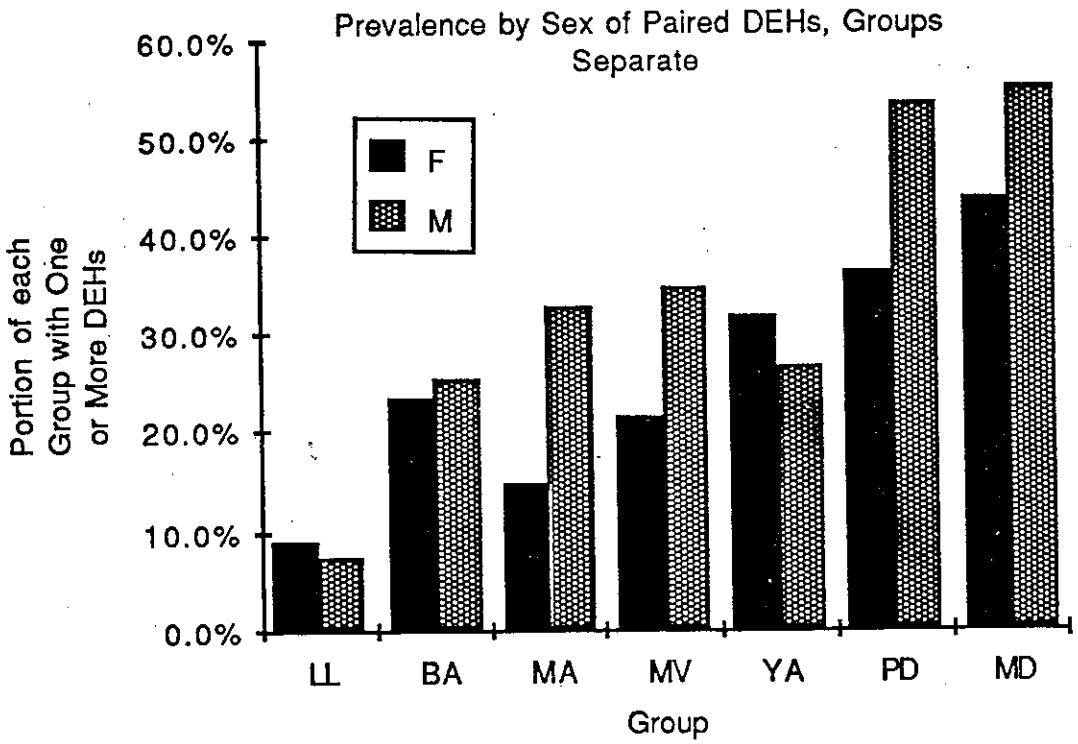


Fig. 3. Prevalence of paired DEH in males (M) and females (F) in the seven Cameroonian groups. Abbreviations of group names as in Figure 1

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