Population health effects of Maize-dependent agriculture: One size does not fit all

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Abstract

This article examines the population health implications related to maize dependent agriculture, specifically as it pertains to bioarchaeological research in the Andean region. It addresses three health problems seen in maize dependent populations: iron deficiency anemia, pellagra, and dental disease. Skeletal evidence of disease and population health interpretations are presented and discussed in the context of the biocultural impact of the rise of agriculture. The evidence demonstrates that population health responses to maize-dependent agriculture are not uniform, even within the Andean region. It is, therefore, important for researchers to utilize meticulous techniques for gathering and analyzing data. They must also consider contextual information in their interpretation.

Key words: maize, anemia, pellagra, periostitis, andean

Resumen

El presente artículo examina las implicaciones de salud de la población relacionadas con la agricultura dependen del maíz, específicamente en lo que respecta a la investigación bioarqueológicos en la región andina. Se dirige a tres problemas de salud vistos en las poblaciones que dependen del maíz: la anemia por deficiencia de hierro, la pelagra, y las enfermedades dentales. Evidencia ósea de la enfermedad y las interpretaciones salud de la población se presentan y discuten en el contexto del impacto biocultural de la aparición de la agricultura. Las pruebas demuestran que las respuestas de salud de la población con la agricultura que dependen del maíz no son uniformes, incluso dentro de la región andina. Es, por tanto, importante que los investigadores utilizan técnicas meticulosas para recuperar y analizar datos. También debe tener en cuenta la información contextual en su interpretación.

Palabras clave: maíz, anemia, pellagra, periostitis, andes

Introduction

Bioarchaeological research in the area of subsistence transitions in various human populations is a thriving field of interest. Numerous projects have focused specifically on the transition to agriculture from a foraging strategy. Several researchers have documented population health problems that often accompany such a change, including anemia, a decrease in stature, and various vitamin deficiencies (Allison, 1984; Cohen and Armelagos 1984; Cohen 1989; Benfer, 1990; Ubelaker, 1992; Verano, 1992; Holland and O'Brien 1997; Eaton and Eaton 1999; Strassman and Dunbar 1999; Tung, 2003; Farnum, 2002).

As the methodological technology has changed, researchers are now able to ask and answer more focused questions regarding population health. Stable isotope analysis has allowed researchers to more specifically identify dietary patterns as they attempt to analyze the impact of dietary change on health (Schwarcz and Schoeninger 1991).

In the Andean region, maize dependent agriculture became the mainstay for numerous populations. A re-analysis of the health effects of this subsistence strategy demonstrates more variability than what had been presumed previously.

This paper will examine the research that has been done regarding three specific health problems (anemia, pellagra, and dental disease) which have been identified in maize-dependent agricultural populations, and discuss the implications for research in the Andean region.

Anemia and Maize consumption

Anemia is defined as a reduction in the concentration of hemoglobin and/or red blood cells. Iron is a necessary element for the development of hemoglobin, which is the component of red blood cells that allow the cells to carry oxygen, i.e., their main function. An anemic person has red blood cells that become pale and small, and have a much shorter lifespan than normal red blood cells. Aside from helping with the formation of hemoglobin, iron is also necessary for the transmission of nerve impulses for collagen synthesis and it aides in strengthening the immune system.

Thus, a deficiency of iron can result in a number of health problems including anemia. Iron is found in high quantities in red meat, legumes, and shellfish, but iron from plants is harder to absorb. This is particularly true for the two staples of domestication, wheat and maize, because both of these plants contain substances called phytates, which actually serve to inhibit the absorption of iron in the intestines.

Additionally, these cereal crops are poor sources of iron. Thus, a maize dependent diet could lead to iron deficiency anemia (Roberts and Manchester 1997). It is necessary to point out, however, that a number of other causes can lead to anemia, including parasitic infections, cancer, and infectious disease, the latter of which Stuart-Macadam (1992) pointed to as a major etiological factor in anemia associated with iron deficiency. Thus, diet is but one of a number of possible contributions to the development of anemia. Larsen and Sering (2000), for example, found that although the population of the late prehistoric Georgia Bight was dependent upon maize agriculture as a subsistence strategy, there was no increase in evidence for iron deficiency anemia.

The authors attribute this to an equally strong dependence on marine resources which may have increased the bioavailability of iron. In the Andean region, numerous researchers have documented the high frequency of anemia as evidenced by the skeletal indicators of porotic hyperostosis and cribra orbitalia in the coastal regions of Peru (Allison, 1984; Benfer, 1990; Ubelaker, 1992; Verano, 1992; Tung, 2003; Farnum, 2002). The factors implicated in the condition, however, are more difficult to pinpoint. Maize was often a prominent dietary staple for the populations in these studies; however, marine resources were also readily available (Blom et al. 2005).

In their study of anemia in coastal Peru, Blom et al. (2005) found that unlike the population of the Georgia Bight, a mixed maize and marine dependent diet was likely to be more predictive of anemia in childhood. That contradicts expectations indicated by the Georgia Bight study (Larsen and Sering 2000). The authors concluded that dietary practices were not the likely explanation for the patterns seen; rather environmental stressors such as parasites were more likely the culprit. They found that less arid environments resulted in higher levels of anemia, and this regardless of whether those environments were the result of landscapes manipulated by irrigation or natural variation. Environments with more water are associated with higher parasite loads and more water-borne pathogens (Blom et al. 2005). Thus, while maize has been implicated as a contributing factor for anemia in many populations (numerous authors in Cohen and Armelagos 1984; Holland and O'Brien 1997), the picture appears more complicated in the Andean region.

Pellagra and Maize consumption

Pellagra is a niacin/tryptophan deficiency disease. Niacin is also known as water soluble vitamin B_3 and a deficiency in niacin disrupts the maintenance of cellular processes. Tryptophan is an amino acid that can be converted to niacin if dietary protein intake is adequate; however, if other factors inhibit this conversion or the bioavailability of both is limited, the disease pellagra is the result. This can occur in populations overly dependent on maize agriculture with limited protein intake. Maize contributes to the problem because of the tendency for essential minerals to bind with the phytates in maize (Lynch, 1997; Reddy, 1989) and form insoluble complexes that make them biologically unavailable to the consumer.

The symptoms associated with pellagra include dermatitis, diarrhea, dementia, and eventually death. An analysis of known pellagrins from a population in South Africa by Brenton and Paine (2007) demonstrates high frequencies of periostitis (71%), dental caries (35.7%), and cribra orbitalia and/or porotic hyperostosis (28.5%). These are many of the same symptoms that are labeled as non-specific indicators of stress which are generally interpreted as indicating overall poor health, and while the authors of this study could not identify pathognomic lesions for this disease, they suggest it needs to be added to the list of dietary problems associated with populations undergoing subsistence transition. They note that it can also seasonally affect populations where winter months may both further reduce protein intake and increase reliance on stored maize; another factor which must be considered by bioarchaeologists and paleonutritionists as they strive to interpret their findings.

The significance of this study suggests that aside from simply analyzing maize consumption, it should be considered in conjunction with protein intake. This has implications for all researchers in the field of paleonutrition including those in the Andean region, where high levels of periostitis, dental caries, cribra orbitalia and/or porotic hyperostosis have also been identified, particularly in coastal areas (Allison, 1984; Benfer, 1990; Ubelaker, 1992; Verano, 1992; Tung, 2003; Farnum, 2002).

Dental disease and Maize consumption

Another main argument for a decline in health with the rise of agriculture is in the area of dental health. Many researchers have noted an increase in dental disease, specifically dental caries, with the transition to plants with high levels of sucrose, such as maize, as dietary staples (Roberts and Manchester 1997). Recent research, however, has questioned the validity of this broad claim. Temple and Larsen (2007) found that people of the Yayoi period in Japan, the earliest point of agricultural dependence (ca. 2500 BP) did not have significantly different carious tooth frequencies than Jomon period foragers.

Wet rice was the primary food source for these early agriculturalists, and while their study indicates that it is a cariogenic food, they found that it was not more cariogenic than foods consumed by the foragers. Thus, there was no significant difference in frequency between the two groups. There are, of course, a number of studies that have demonstrated an increase in the frequency of carious lesions with the transition to agriculture (Lukacs, 1996; Larsen, 1997; Hillson, 1996, 2001).

General figures developed by Turner (1978, 1979) and Schollmeyer and Turner (2004) indicate carious frequencies of 0% - 5.3% in foraging groups, .44% - 10.3% in groups with a mixed economy, and anywhere from 2.2% - 26.9% in agricultural groups. Clearly, there is significant overlap in these numbers, but there is also a general increase in frequency as groups transitioned into agriculture. Still, the numbers are not incontrovertible, and a number of factors come into play when considering the research.

Lanfanco and Eggers (2010) found no significant increase in the frequency of dental caries between populations living in the coastal desert of Peru who merely experimented with maize agriculture and those from a later time period when agriculture in the region was at its apogee and the society was highly stratified. They did note, however, that there was a statistically significant increase in the depth of carious lesions and there was a change in the location of the caries from occlusal to extra-occlusal sites. They concluded that when this information is taken into consideration with an evaluation of dental wear, it could be used to reconstruct subsistence strategies in ancient populations.

Discussion

This paper is not meant to be an exhaustive discussion of the research that has taken place in the field of paleodiet reconstruction and paleonutrition, nor even of the discussion of the bioarchaeological research into cultures dependent upon maize as their main dietary staple. It examines three areas where there have been claims of a correlation between health problems and agriculture, particularly maize-dependent agriculture. What is clear from this short discussion, however, is that one size does not fit all. While there are reasons why human health may have declined in some areas with the advent of agriculture, such a decline can in no way be assumed to have occurred with the rise of agriculture in any given population and there is significant evidence that on the whole, the transition to agriculture has been a positive event in human history.

Gage (2005) notes that an analysis of mortality and life expectations in ancient populations demonstrates a trend of a decline in total mortality correlated with a decline in infectious diseases and degenerative diseases as a whole. He also points out that the argument by people in the field of evolutionary medicine, among others, that novel environmental conditions, such as would be created with the advent of agriculture, should be detrimental to human health is not a foregone conclusion. He argues that positive effects are noted in the case of ‘genotype by environment correlation’ whereby particular genotypes seek out, or in the case of humans build, environments to which they are best suited. Thus, future research in this field should not rely on assumptions, but should gather meticulous data using isotopic studies as well as contextual information that includes environmental factors in order to assess the particular situation of any given population.

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