How Changes in Subsistence Influenced the Health of the Hohokam Tribe

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ABSTRACT

This paper discusses how the change in subsistence patterns from the Sedentary Period to the Classic Period affected the health of the Hohokam tribes of the North American Southwest. Subsistence analysis along with 163 Hohokam inhumations from the time periods were analyzed and compared to evaluate if there was a correlation between diet and health. Dental pathologies, anemia, enamel hypoplasia, rickets, urolithiasis, and stature were examined to reveal patterns in health during the time. The results found that childhood stress events were that most prevalent health complication but overall the Hohokam maintained a rich and varied diet, despite their heavy reliance on maize agriculture.

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HOW CHANGES IN SUBSISTENCE INFLUENCED THE HEALTH OF THE HOHOKAM TRIBE

From childhood, we are told what foods are healthy and what foods are not, but research is indicating that our idea of healthy food may be more complex than previously thought. Most agricultural populations rely on a limited variety of domesticated crops and have strayed away from the wild resources that were a staple in pre-agricultural diets. The practice of limiting the variety of foods eaten and depending on foods, such as maize, that are high in starch cause an array of health problems. One of the most common health implications associated with the introduction of agricultural maize is dental carries (Reinhard, Johnson, et al 2012).

I am interested in examining how the health of past societies was influenced by their dietary choices. By switching from a high dependence on wild resources supplemented by agriculture to a high dependence on intensive agriculture supplemented with wild resources, health patterns have emerged that previously did not exist within the population. My belief is that this is because of the types of foods being consumed. Similar to modern human populations, previous cultures experienced fluctuations in health problems due to the assortments of foods being consumed.

This paper explores what effect the change from low agricultural subsistence to high agricultural subsistence had on the health of the Hohokam tribes in Southern Arizona. Hohokam subsistence patterns were analyzed and compared to evidence of disease and malnutrition. To show the changes in subsistence patterns my research is looking at mild agricultural subsistence and intensive agricultural subsistence in Hohokam societies, as well as examining the outside

factors influencing their dietary strategies. I then looked at evidence of health problems shown from bone indicators during these periods and examined the possible causes. Examining the correlation between subsistence and health is important because recognizing that food preference had a major influence on the survival and wellbeing of early populations can help us understand the health implications stemming from food in modern populations.

BACKGROUND

Along with Mogollon, Anasazi, and Patayan, the Hohokam tradition was one of four major cultural manifestations that archaeologists recognize in the North American Southwest (Bayman 2001). Hohokam tribal territory was located in the Sonoran Desert in Southern Arizona. Their primary accepted habitation area was in the Phoenix Basin located between the Gila River and Salt River (Fish and Fish 1992). Also, excavations suggest that the Hohokam occupied extensive areas on the periphery of the Phoenix Basin and settled on the streams and perennial rivers in the area, including the Santa Cruz, the San Pedro, the Tonto Basin, the Verde, the Agua Fria, and the Hassayampa River valleys (Bayman 2001).

The Sonoran Desert fluctuates between arid and fertile landscapes depending on the seasons and weather patterns of the year, though it maintains a relatively consistent climate year round. Relatively high temperatures and low rainfall characterize the Sonoran Desert and perennial water is present in the major river valleys. Annual precipitation averages less than fifteen inches and rainfall is seasonal and bimodal with the greatest concentrations falling during summer and winter. The desert overall is a resource-dense area, which offered a wide variety of storable food resources that helped the Hohokam accumulate surplus (Bayman 2001). The warm desert environment and river resources offered an ideal atmosphere for Hohokam irrigation-

based agricultural production as well as providing wild resource harvesting. The temperate climate provided a substantial growing season with the opportunity for two or more growing cycles per year (Rice and Redman 1993). Some of the main subsistence resources in the area include wild ground cherry, spurge, plantain, indian wheat, gob mallow, purslane, tansy mustard, cactus pads and fruit, mesquite pods, deer, and rabbits (Gasser and Kwiatkowski 1991). The Hohokam tribes exploited all wild resources, utilized river resources, and employed different farming techniques throughout their habitation within the area.

Southwestern archaeologists have come to a general consensus that Hohokam culture developed from the indigenous archaic populations that achieved a sedentary to semi-sedentary lifestyle in optimal areas in the region. Early ceramics lacking decoration and bearing significant resemblance to material culture traits of the preceding archaic populations have been identified at Hohokam sites (Wallace, Heidke, and Doelle 1995). Hohokam occupation is thought to have begun prior to A.D. 200 and lasted until at least A.D. 1450 though there is much debate about the exact chronology of the Hohokam sequence. The Hohokam history is generally accepted to be split into five periods: the Pioneer Period, the Colonial Period, the Sedentary Period, the Classic Period, and the Post-Classic Period (Crown 1990), though many archaeologist debate how the phases of the timeline should be split. Table 1 shows the complete chronology that I will be using for this paper of Hohokam occupation as interpreted by Crown, with a division between the two time periods this paper will discuss.

Table 1. Hohokam Timeline (adapted from Crown 1990)

Period	Phase	Dates (all A.D.)
Post-Classic	Polvoron	1350/1400-1450?
Classic	Civano	1300-1350/1400
	Soho	1150-1300
Sedentary	Sacaton	975-1150
Colonial	Santa Cruz	850-975
	Gila Butte	775-850
Pioneer	Snaketown	700-775
	Sweetwater	600-700
	Estrella	500-600
	Vahki	300-500
	Red Mountain	Pre-200-300

Hohokam Culture

In the periods before the Colonial Period, the four regions of the North American Southwest had not been fully established and Hohokam culture included many aspects of the three surrounding cultures. No material culture identifiable as uniquely Hohokam emerged until the start of the Snaketown Phase around A.D. 775 (Wallace, Heidke, and Doelle 1995). Beginning around that time in the Colonial Period, Hohokam culture begins to reflect differences in ceramic technology, architectural forms, and modes of subsistence and settlement, marking the introduction of the primary symbols of Hohokam culture. These four main hallmarks include, red-on-buff pottery, monumental buildings, large-scale canal irrigation agriculture (Bayman 2001), and cremation burial practices (Fink and Merbs 1991). The one characteristic of

Hohokam culture that remained true for their entire existence was farming. Evidence of Hohokam agricultural practices goes as far back as can be seen in the archaeological record (Purdue, Miles, et al 2009). The diverse Hohokam culture covered a wide expanse and included long distance trade covering areas exceeding 73,000 square kilometers (Bayman 2001).

Material Culture

The Colonial Period marks the introduction of the Hohokam tradition as an individual culture in the Sonoran Desert region. Pottery, lithics, baskets, clothes, and shell beads are manufactured with features that become distinctly Hohokam characteristics. Both Hohokam and Mogollon traditions manufactured undecorated brown ware ceramics during early periods. The red-on-buff pottery, indicative of Hohokam culture, did not emerge until around A.D. 775 (Bayman 2001). The original design focused on simple geometric layouts and the use of parallel lines then transitioned into the addition of life forms as ceramic technology was refined (Wallace, Heidke, and Doelle 1995). The Hohokam used a combination of chipped and ground stone tools. Chipped stone tool assemblage includes scrapers, choppers, knives, and projectile points (Curtis and Wright 2012). Dart points, popular in periods before large-scale agriculture, are not seen after the introduction of large-scale agriculture (Bayman 2001). The most common ground stone tools found are grinding slabs used for grain processing (Curtis and Wright 2012). Baskets were made from the fibrous leaves of yucca, cattail, and bear grass for storage and lightweight transportation. Typical clothing worn by the Hohokam includes breechcloths and aprons made from animal skins and plant fibers such as cotton, milkweed, yucca, and agave. Buckskin shirts, and cloth ponchos would have also been warn in winter (Crown 1990). Marine Shell ornament production and circulation was developed around this time, likely for use with ritual and ornamental usage (Bayman 2001).

Ritual and Burial Practices

The Hohokam performed a variety of ritual and burial activities, their most prevalent being the cremation burial practice. Evidence of ritual and religious behavior is shown from caches of fire-clay figurines, marine shell ornaments, quartz crystals, stone pipes, fossils from Pleistocene fauna, painted artiodactyl bones, and nonlocal minerals and stones (Bayman 2001:269). Ball courts, usually located in the central area of the village, were large mud-plastered shallow pits resembling football fields and functioned as community centers for public ceremonies, rites of passage, and ceremonial exchange. Other buildings located in the centers of town also served as communal centers for religious rituals, among other things. Some central buildings were found with small ceramic bowls that researchers believe could have been used for consuming ceremonial beverages (Bayman 2001). Cremations were the main burial method for Hohokam populations, though inhumations are also present to a lesser extent. Elaborate mortuary rituals involved cremating the remains and interring stylized craft goods such as palettes, censers, and carved shell (Wallace, Heidke, and Doelle 1995).

Structures and Settlement Patterns

One of the cultural characteristics the Hohokam are known for are their monumental buildings, many of which are still surviving today. Although wood for fires and housing structures was scarce in the Sonoran Desert, ironwood, paloverde, mesquite, and cottonwood trees were concentrated in areas along river drainage systems. This allowed for building materials for many of the structures associated with Hohokam culture. Hohokam buildings include ball courts, towers, platform mounds, and Great Houses (Bayman 2001). Hohokam society was centered on

sedentary village-based communities along perennial and non-perennial streams and rivers that crosscut the desert valleys of south-central Arizona. Their locality to water sources made it possible to develop highly advanced irrigation systems to support large-scale agricultural production. Sometime after the rise of the Colonial Period, settlements began to surround administrative centers and public monuments such as ball courts, platform mounds, and Great Houses (Bayman 2001). Semi-subterranean pit houses were the most common housing structure used in Hohokam culture. These dwellings were situated around a central ceremonial or administrative center such as a Great House or platform mound (Curtis and Wright 2012).

Mound Building

The Hohokam and other surrounding cultures from about the thirteenth to fifteenth century A.D built platform mounds for various purposes. Platform mounds are artificial, flat-topped hills used mainly for ruling families to build their homes. Each mound was the administrative, ceremonial, and economic center for a small-scale political system, or polity. Approximately one hundred of these small political systems were scattered around the Sonoran Desert at the height of the Classic Period. Ruling families of the day lived on the top of the mound while additional residences and storage areas were built at the base, and a compound wall surrounded the entire complex (Rice and Redman 1993).

Social Structure

While the sociopolitical organization of the Hohokam remains poorly understood, most archaeologists agree that they were not an egalitarian society (Bayman 2001). Excavations at the Tonto Basin support the claim that the Hohokam tribes were an elitist society. The excavations found evidence suggesting that Hohokam exhibited some level of inequality in power and status

and that mound compounds played a role in a highly developed political system. This allowed for specialization of labor for individual families that was combined and distributed by the ruling families between everyone living in the polity. Different areas of the compound had different concentrations of specialized tool kits, though the site as a whole had similar remains. For example, one residence contained a high concentration of agave production tools and another residence had only granaries, but both still contained agave fibers and grain residues, suggesting that a central area was used for distribution of goods while individual areas were used for singular purposes (Rice and Redman 1993). The peoples of the platform mounds had taken the first step toward the kind of organizational complexity that function today through much of our industrial world (Rice and Redman 1993:54).

Hohokam Agriculture

The success of Hohokam agricultural production was one of the triggers for the jump into social complexity, with less stress on sustaining a population the focus on craft specialization could come about, which in turn led to a demand for a more structured society. Due to the abundance of resources in the riverine areas of the Sonoran Desert, it is likely that sedentary villages emerged prior to the emergence of agriculture (Bayman 2001). Once introduced, agriculture became a major part of Hohokam subsistence for as long as researchers can tell (Purdue, Miles, et al 2009). In the early Pioneer Period around A.D. 200, there is evidence that they used combinations of dry farming and floodwater farming as well as small-scale irrigation techniques. Dry farming is a fairly unreliable technique for large-scale agriculture in the desert because of its major dependence on natural rainfall so it was primarily used for small-scale agave cultivation. Floodwater farming also depends on seasonal floods for crop production, so both of these

options were abandoned in preference to irrigation farming, in which the rivers were manipulated to suit farmers' needs (Ackerly 1982).

During the rise of Hohokam prosperity in the Classic Period, irrigation farming became the main strategy for supporting the society, while other previous strategies began to diminish. The earliest Hohokam archaeology took place more than a century ago at sites with large-scale irrigation canals around the confluence of the Gila and Salt River valleys (Bayman 2001). The Hohokam constructed massive canal structures around the rivers in the area used to water their crops. The main crop during this time was maize, along with beans, squash, grain amaranth, little barley grass, and tobacco (Purdue, Miles, et al 2009). Other domesticated plants included to a lesser extent in crop cultivation were cottonseeds and agave. It is likely that some wild plants may have been gardened or tended to as well but never domesticated, these include false purslane, purslane, mustard, cholla cactus, and mesquite (Fink and Merbs 1991). Though large-scale irrigation farming led to a boom in Hohokam affluence, it also helped lead to their collapse when the US government redirected the rivers used for their irrigation (Ackerly 1982).

Paleopathology

In order to understand how Hohokam subsistence patterns influenced their health, the human remains must be analyzed for nutritional indicators. Paleopathology offers a unique view of the consequences of subsistence strategies and can help elucidate how traditional diets interact with infectious disease, intestinal parasites, weaning, and other stressors to induce illness in prehistoric human populations (Fink and Merbs 1991: 294). The paleopathology of Hohokam health is rarely studied due to two main complications: burial practices and preservation conditions. The Hohokam practiced cremation rituals as their primary burial practice, which destroyed large amounts of bone, and while pathologies can be discerned from bone fragments, it

is very difficult and unlikely that many conclusions can be drawn irrefutably. Another issue common to archaeologists is that any inhumations found yield poor bone preservation, which makes studying Hohokam paleopathology nearly impossible. As the bone degrades, it is less obvious which irregularities are caused from natural deterioration and which from disease. In the late 1980's excavations in the Phoenix Basin area provided numerous sets of non-cremated human remains from three different sites that were fairly well preserved. These rare inhumations were some of the first to be studied for Hohokam pathologies (Fink and Merbs 1991).

METHODOLOGY

To examine the changes in health caused by the changes in subsistence strategies between small-scale and large-scale agriculture, I am researching data from public works, including paleopathology reports and subsistence analyses. I am dividing the stages of Hohokam development into two parts, the Sedentary and Pre-sedentary Periods spanning A.D. 200 to A.D. 1100 and the Classic Period and on spanning A.D. 1100 to A.D. 1450 (Crown 1990). During the Early periods, the Hohokam relied on small-scale agriculture and wild resources while post-Classic Periods relied heavily on large-scale canal irrigation farming and minimally on wild resources, so this should give a good representation of change over time. To examine the health changes in Hohokam society I am looking at human remain analysis of 163 individuals found in the Phoenix Basin area to identify cases of malnutrition, dental caries, bone degeneration, and other disease indicators found in the remains. These remains were found at three Hohokam sites, the Grand Canal, Casa Buena, and La Ciudad. The remains found at Grand Canal and Casa Buena, excavated by Soil Systems Inc. as part of the Squaw Peak Parkway data recovery program and funded by the city of Phoenix, date to the Soho and Civano Phases between A.D.

1100 to A.D. 1450. The remains from Grand Canal held eighty-two individuals: thirty-five male, thirty-four female, three unknown, one adolescent, two children, four infants, and three fetal. The Casa Buena remains held fifty-seven individuals: twelve male, twenty-two female, eight unknown, eight children, six infants, and one fetus. The La Ciudad remains date to sometime before A.D. 1100 in the Sedentary Period. The excavations of these remains done by the Department of Anthropology of Arizona State University were funded by the Federal Highway Administration before the construction of the Papago Loop of the I-10 freeway. The remains at La Ciudad include twenty-four individuals: six males, ten females, one adolescent, six children, and one infant (Fink and Merbs 1991). These remains have been analyzed for nutritional markers such as dental caries, wear and calculus formations, ante mortem tooth loss, enamel hypoplasia, porotic hyperostosis (anemia), rickets, urolithiasis (bladder stone disease), and short stature (Fink and Merbs 1991). I am comparing these cases to the subsistence strategies prevalent at the time to see if there is a correlation between the two factors.

RESULTS

The paleopathology study looks at six main skeletal indicators from the 163 inhumations found at the three Phoenix basin sites. The indicators used are dental pathologies, anemia, enamel hypoplasia, rickets, bladder stone disease, and long bone growth. All of these indicators are representative of typical pathologies found in societies with high agricultural dependence. Within the remains found at the Hohokam sites, all of these indicators are present to some extent. This is congruent with the subsistence evidence indicating a high dependence on maize agriculture. Even with the high dependency on maize, the patterns that emerge from analyzing the data seem to indicate that the Hohokam had a relatively nutritious diet overall. The lack of major nutrient

deficiencies shown in the pathologies suggests that the Hohokam must have continued relying on wild desert resources as a vital part of their diet during large-scale agricultural periods. High instances of dental pathologies found in the remains indicate that maize and other carbohydrate-rich foods were a main staple of Hohokam subsistence. The weaning years seem to have caused the most stress on the health of the individuals. Switch from nutrient-rich breast milk to a less nutrient-dense diet is a typical problem for many societies and may have been the cause of the patterns we see in Hohokam culture. The majority of significant pathologies found in the remains show disease patterns emerging during childhood, specifically around the ages of weaning.

Dental Pathologies

Dental pathologies are frequently used for distinguishing hunting and gathering societies from agricultural societies because with an increase in sticky carbohydrate-rich diets comes an increase in plaque, which provides an adhesive medium for oral bacteria (Fink and Merbs 1991). It is widely accepted that there is a strong correlation between agricultural intensification and the amount of pathologies found in prehistoric dentitions. The dental pathologies being assessed include: the degree of wear on teeth, dental caries, ante mortem tooth loss, and calculus formations. The remains from the three Hohokam sites discussed exhibit numerous dental caries, many of which have progressed to the point of crown destruction and eventual tooth loss (Fink and Merbs 1991: 297). Out of the total number of cases of dental remains for Grand Canal females, 27% showed evidence of dental pathologies, while only 19% of males showed evidence of dental pathologies. For Casa Buena, 33% of female remains had dental pathologies, while only 28% of males showed signs. La Ciudad had the largest difference in male to female dental pathologies with 32% of the female dental remains showing pathologies and only 7% of male dental remains showed signs. Figure 1 shows the differing percentiles of overall dental

pathologies for males and females at the three sites. As you can see, females have a higher rate of dental pathologies in each site, with La Ciudad having the greatest difference. When breaking the sites into sections, we can see that while females have higher overall pathologies, males have higher rates of the sockets being completely resorbed as seen in Figures 2, 3, and 4.

The dentitions at Grand Canal, Casa Buena, and La Ciudad have dental wear to such an extent that wear standards usually used to date individuals appear to over-age the remains (Fink and Merbs 1991). Along with over-aging individuals, wear on teeth may have helped to intensify dental caries, which are high in Hohokam remains. The wear patterns can be attributed to sand and grit incorporated into the food, commonly during the grinding process or wind blown materials, insufficiently cooked food requiring extra chewing, and special use wear (Fink and Merbs 1991). Caries and calculus formations play a large part in ante mortem tooth loss, but there is also support for special use wear because of the patterns of tooth loss. The patterns of tooth loss are similar in all three Hohokam sites as well as two others in the area, suggesting the Hohokam used their teeth to perform certain tasks involving running fibrous or abrasive material across and between their teeth (Fink and Merbs 1991).

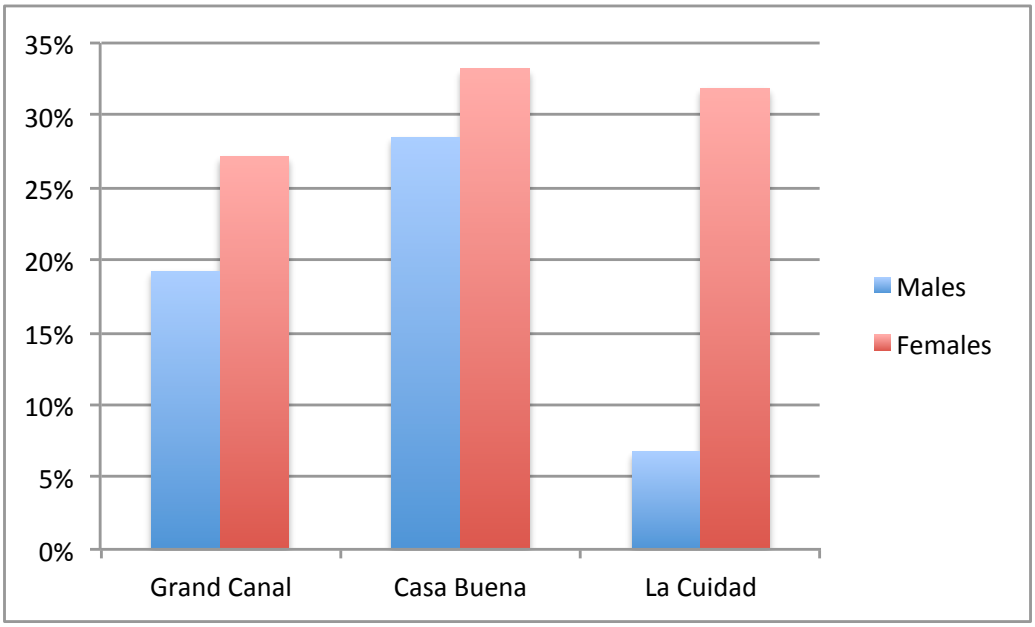


Figure 1. Distribution of Dental Pathologies by Gender (Fink and Merbs 1991).

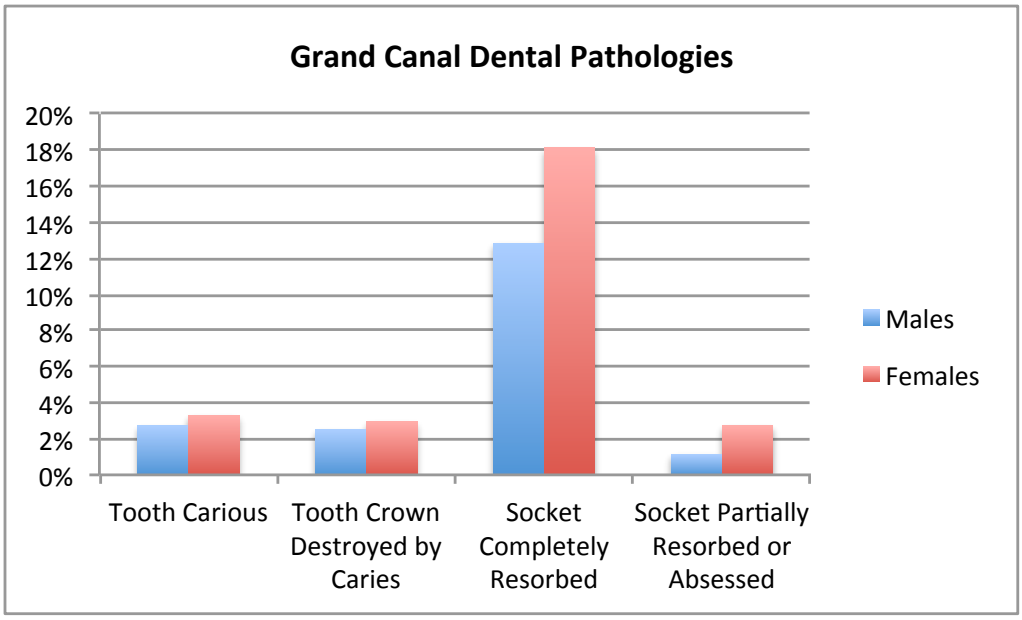


Figure 2. Grand Canal Dental Pathologies by Gender (Fink and Merbs 1991).

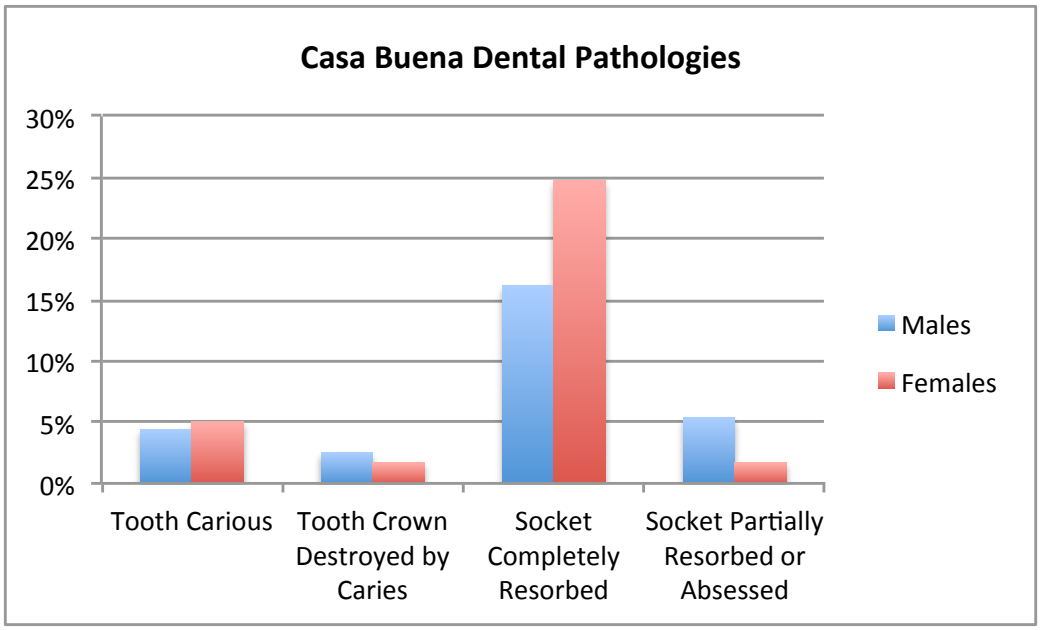


Figure 3. Casa Buena Dental Pathologies by Gender (Fink and Merbs 1991).

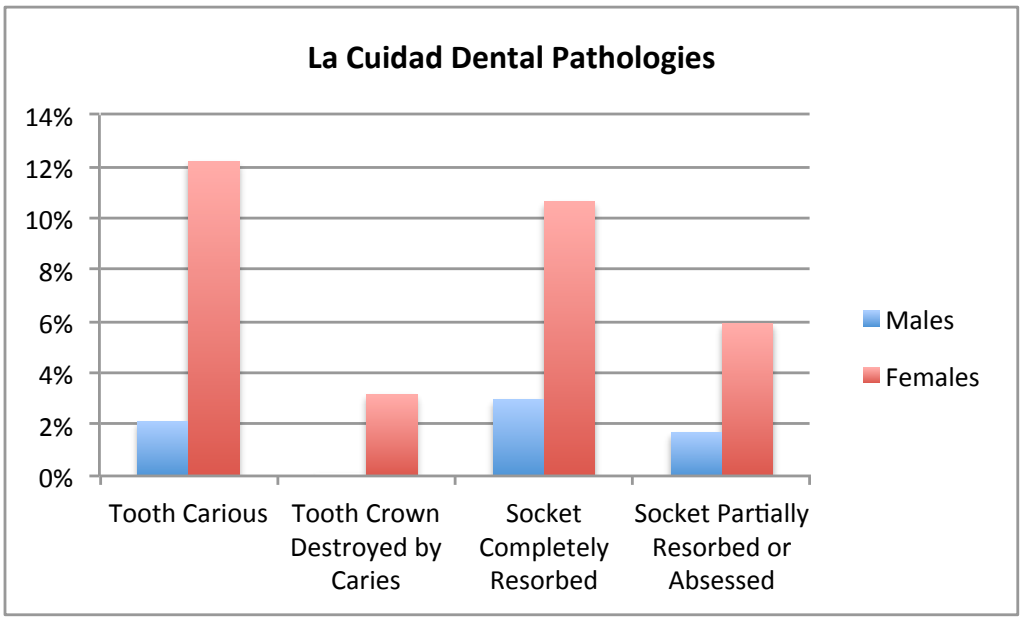


Figure 4. La Ciudad Dental Pathologies by Gender (Fink and Merbs 1991).

Anemia

Anemia can be indicative of agricultural communities with high maize consumption. In the Americas, it is traditionally reflective of an iron-deficiency brought about by a maize-dependent diet. It can also be an indicator of weaning stress, along with parasites or infectious disease. It is probable that a combination of these factors is what causes the high percentages of indicators in Hohokam society. Anemia is shown through porotic hyperostosis, a term used for coral or sieve-like lesions occurring on the cranial vault, including the orbits, which represents a general response to anemia. The lesions may be present in both adult and non-adult individuals and are classified as either active or residual (Fink and Merbs 1991). Residual porotic hyperostosis when seen in adults most likely represents anemia that was active in childhood (Fink and Merbs 1991:308).

Evidence of porotic hyperostosis is prevalent in the Hohokam sites of Grand Canal, Casa Buena, and La Ciudad; 45 individuals showed porotic hyperostosis scarring, 53 showed no scarring, and 35 individuals were indeterminate due to poor preservation of remains. In the Grand Canal series, residual porotic hyperostosis is evident in 43% of the observable adult crania, 50% of the Casa Buena series showed signs, and La Ciudad had the highest percent at 54% of the series showed signs of residual porotic hyperostosis (Fink and Merbs 1991). In these cases it is difficult to say what factors may have lead to these cases of anemia, but it is probable that an inadequate weaning diet, infectious disease, and parasitic infections could have contributed. The assumption of over-dependence on maize is unlikely in this case, because of the wide variety of foods available for consumption (Gasser and Kwiatkowski 1991). Although due to the high wear patterns found on adult teeth, it could be hypothesized that the variety of foods

available to young children was very limited, especially around the weaning age when children's teeth and jaws were underdeveloped for dealing with the tough fibrous foods rich in nutrients, which could have lead to higher occurrences of childhood anemia.

Enamel Hypoplasia

Dental enamel hypoplasia is a deficiency in enamel thickness caused by a disruption of ameliogenesis due to localized trauma, hereditary conditions, or systematic metabolic disorders (Fink and Merbs 1991). Enamel hypoplasia is shown through aligned pits, lines, or striations in tooth enamel in both deciduous and permanent dentitions. When discovered in permanent dentitions, it must be noted that these disturbances occurred in childhood (Fink and Merbs 1991). The top systematic metabolic disorders causing hypoplasia are nutritional deficiencies and infectious disease. The patterns found in Hohokam dentition indicate a common problem among the culture, which leans towards nutritional inadequacies in childhood, especially the weaning years.

Instances of dental hypoplasia were common among the dentitions from the Grand Canal, Casa Buena, and La Ciudad sites. The highest frequency of enamel defects occurred between the ages of 2.5 and 4.0 years, and the second highest frequency found around the ages of 5.0 to 5.5 years and due to a higher frequency of male hypoplasia. Figure 5 shows the distribution of stress episodes by age as seen in the three Hohokam sites. Again, this is pointing back to a lack of adequate nutrient intake for children in their weaning years. Hohokam children seem to be particularly susceptible to nutritional stress, which indicates a poor quality and variety of foods available to them during their growing years.

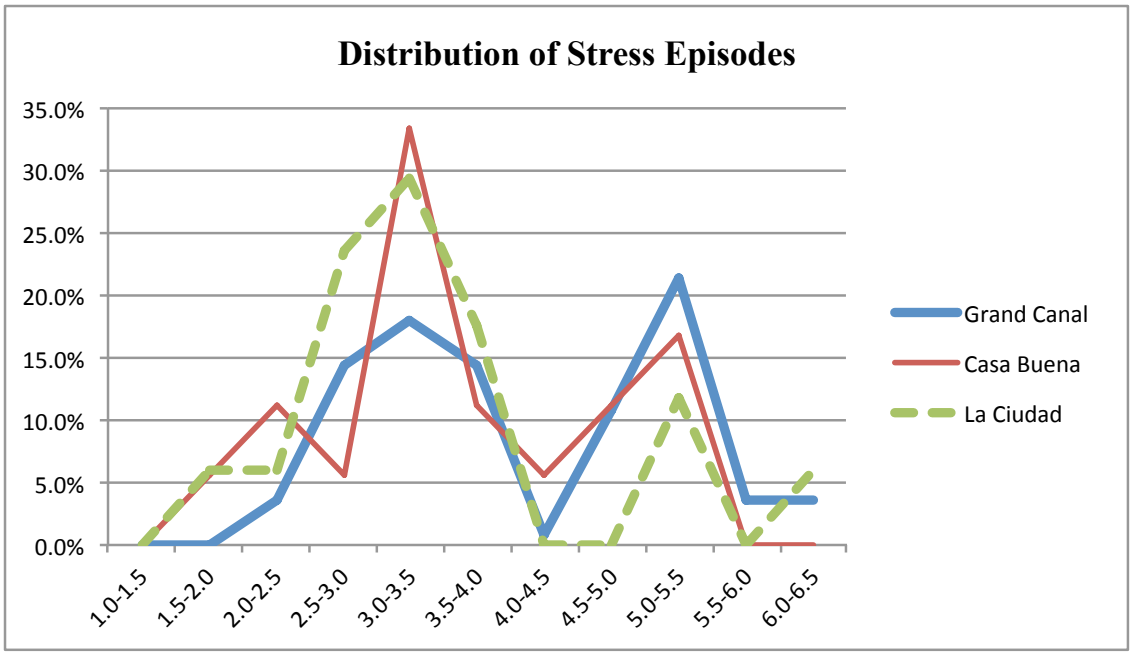


Figure 5. Distribution of Stress Episodes by Age (Fink and Merbs 1991).

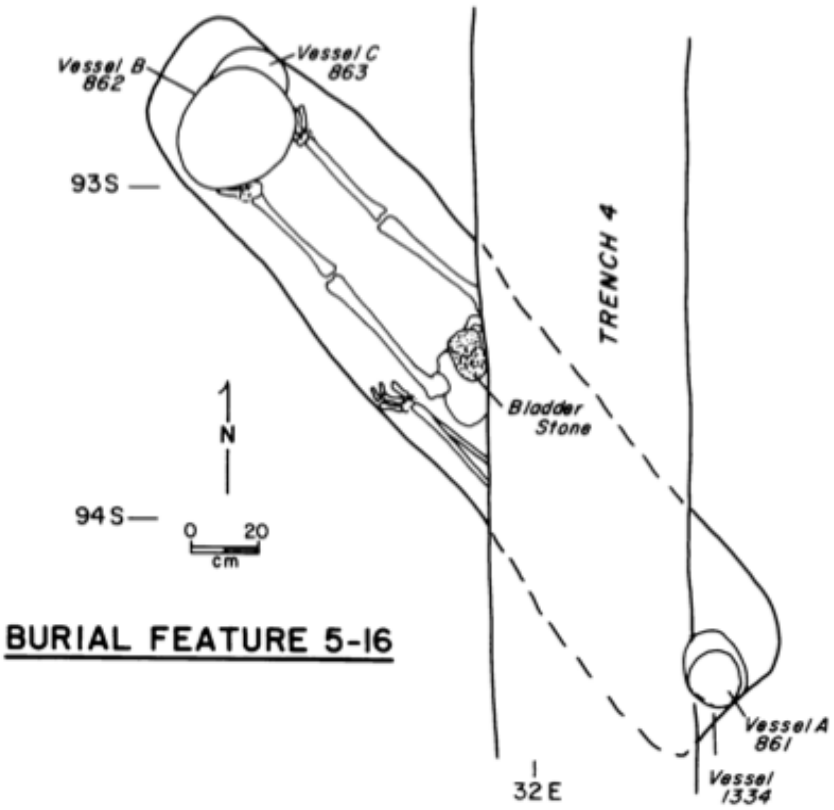
Rickets

Rickets can be caused by several different factors including vitamin D deficiency, calcium deficiency, and renal tubular malfunction (Fink and Merbs 1991). Cases of rickets in the Southwest are thought to be due to a deficiency of calcium in the diet. Only two cases of rickets have ever been discovered within Hohokam remains, one individual of undetermined sex during an 1887 expedition and one adult male from Grand Canal. The low reported instances of rickets being found in Hohokam society could either be due to the low bone preservation or by the availability of calcium-rich desert foods such as cholla cactus buds.

Bladder Stone Disease

Bladder stone disease, or urolithiasis, is frequently observed in societies with a high-carbohydrate intake, not to be confused with kidney stones, which are associated with diets high in refined sugars and animal protein. A predisposition to urolithiasis can be caused by a high grain diet lacking in animal protein during the first two years of life (Fink and Merbs 1991). Hohokam society did not seem to suffer greatly from this ailment, however there were some exceptions.

In the cases of the three Salt River Hohokam sites, one abnormally large bladder stone was observed. The stone, weighing 1,036 grams and 15 x 15 x 12.5cm, was found in the pelvic cavity of a male at Grand Canal. Figure 6 shows burial feature 5-16, which contains the adult male inhumation with the large bladder stone. A stone this large represents an individual with a diet consisting primarily of carbohydrates and very limited animal protein. It also may suggest personal preference to a certain kind of food or a possible underlying physiological problem. Very few other instances were observed at the sites, which could indicate that the population did not suffer from high instances of urolithiasis. However, it is noted in the report that during the excavations of the remains there was no effort to recover bladder stones until the abnormally large stone was found. This could mean that instances were higher than what is shown here, but could also be attributed to their reliance on wild resources (Fink and Merbs 1991).



Feature 6. Male Inhumation Containing Large Bladder Stone (Fink and Merbs 1991).

Long Bone Growth

Short stature is a consequence of children not receiving adequate nutrient intake during their growing years, so their full growth potential is not achieved (Fink and Merbs 1991). Inadequate nutrient intake could be explained through subpar weaning diet, famine during childhood, and sickness during childhood, along with other similar factors affecting children during their growing years. It is impossible to tell the exact cause of the small stature observed in the Hohokam remains found at the three Salt River sites, though it can be assumed that a combination of many different factors influenced the growth of the population. Along with the

previous data, this supports the idea that Hohokam children had a low nutrient diet, whether because of inadequate weaning diet or some other unknown factor.

The three sites show typical dispersals of male and female stature ratios, with the male population being slightly larger than the female population. The interesting thing about the three sites is that the Grand Canal and La Ciudad sites have relatively similar statures, while the Casa Buena site has slightly smaller statures. It would be presumed that the sites from the same time period would have similar statures. Figure 7 shows average female stature and Figure 8 shows average male stature at the three sites. From the figures it is clear that the population from Casa Buena are on average, much smaller than the other two sites. This anomaly could be related to differences in dietary habits at the Casa Buena site, or a period of subsistence stress in the area. The Salt River fluctuated greatly during the time period, and Casa Buena may have been harder hit than the Grand Canal site. The difference could also be explained because of inconsistencies in the measurements used to obtain the average statures. Because of the poor preservation quality of some of the remains, different bones had to be used to determine stature so consistent measurements could not be taken throughout the sites (Fink and Merbs 1991).

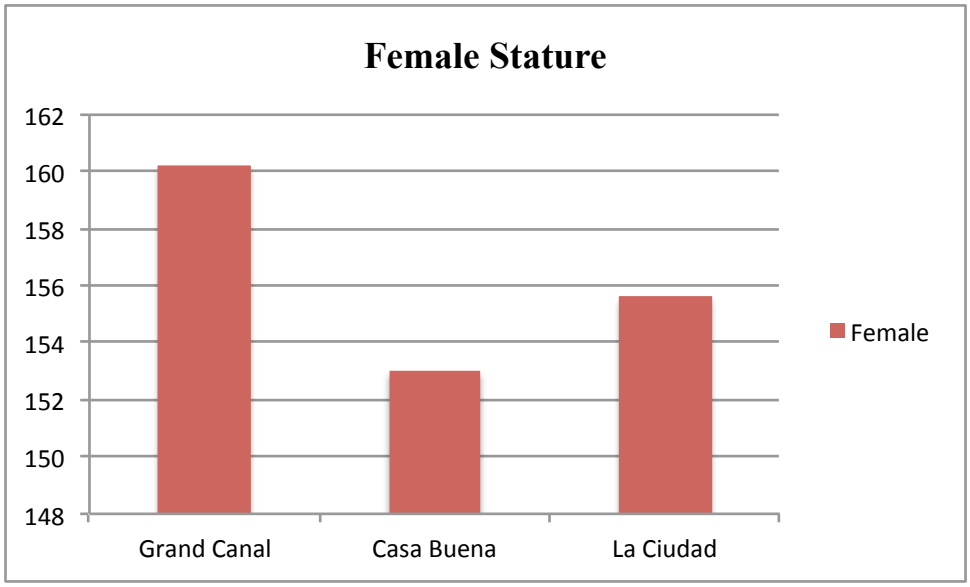


Figure 7. Average Female Stature at the Salt River Hohokam Sites (Fink and Merbs 1991).

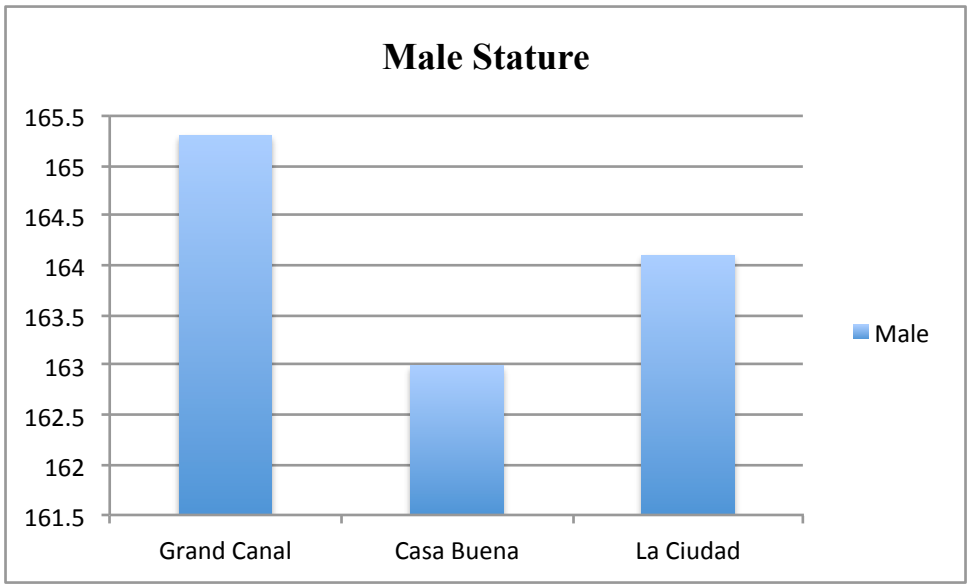


Figure 8. Average Male Stature at the Salt River Hohokam Sites (Fink and Merbs 1991).

Correlation Between Health and Diet

Many outside factors influenced the subsistence of the Hohokam during the periods discussed in this paper. Around A.D. 1197 to A.D. 1355, during the Classic and Post-Classic Periods, water levels in the Salt River fluctuated greatly. At the end of this fluctuation period, there was a 33-year period of low rainfall causing crop failure and low harvest yield. Then between A.D. 1356 and A.D. 1370 there was abnormally heavy rainfall, which led to flooding and destruction of the canal systems, again causing massive crop failure. Some researchers believe that these environmental problems created a major disruption of food production causing malnutrition, iron, protein, calorie, and other nutritional deficiencies (Fink and Merbs 1991).

Though there is evidence of nutritional conditions such as porotic hyperostosis and enamel hypoplasia, there is insufficient evidence to support this claim (Fink and Merbs 1991) It is highly likely that the destruction of the primary source of Hohokam subsistence resources led to a renewed reliance on wild resources for support, which is why we see a relatively low amount of nutritional deficiencies. While the Hohokam did rely heavily on agricultural resources, they lived in an environment with a rich diversity of wild plants that could be relied on in times of stress.

CONCLUSION

My findings indicate that a correlation between diet and health of Hohokam populations does exist. The reason for these findings cannot simply be attributed to their agricultural practices however. Cultural traits, environmental conditions, and outside factors also influence the health and diet of the Hohokam. The characteristics of populations cannot be simply attributed to the

results of statistical analysis or dietary theories, while each analysis brings researchers closer to understanding past cultures, it must be understood that human nature and variability played a role in cultural decisions.

From the 163 sets of inhumations found at the three Salt River Hohokam sites of Grand Canal, Casa Buena, and La Ciudad, we are able to see that the Hohokam had a high amount of wide-ranging dental pathologies. The main pathologies include frequent events of dental caries leading to crown destruction and eventual tooth loss, indicating that there was a higher dependence on foods high in sticky carbohydrates (Fink and Merbs 1991). This hypothesis is supported by macrobotanical and pollen evidence that indicate heavy presence of high carbohydrate foods in sites from the time period (Bohrer, Cutler, and Sauer 1969).

From the remains we can also assume that the weaning age was a major stressor to the population. This evidence is supported by a peak occurrence of enamel hypoplasia around the age of 2.5 to 5 years of age and the frequent occurrence of residual porotic hyperostosis indicating that childhood anemia was an issue. Though it is unclear what the driving factors were behind these occurrences, it can be assumed that a major cause was inadequate nutritional diet during the weaning years. It also could imply that childhood disease was prevalent in these societies or have some sort of cultural significance (Fink and Merbs 1991).

Another hypothesis for the high occurrences of enamel hypoplasia and porotic hyperostosis is that children did not have many foods that they were able to eat. The evidence of high wear levels on adult dentitions supports this assumption. If the high wear patterns were the result of mainly tough fibrous food consumption, then young children would not have the physical ability to ingest those kinds of foods in the same ways as adults. In order for children to consume hard fibrous foods at a young age, the food would need to be made to the consistency

of baby food, which would most likely be done by boiling the food for long periods. During this process, much of the nutrient value of the food is lost; in some cases the remaining food can contain only half of its original nutrient content (Academy of Nutrition and Dietetics 2013). This could explain why Hohokam children suffered from stress episodes at such a high rate during the early years of their lives.

Since instances of both rickets and urolithiasis are relatively rare in Hohokam society, we can assume that they were consuming adequate amounts of calcium-rich foods and animal protein. Overall, the Hohokam seem to have had a rich and varied diet even with their heavy dependence on agricultural maize. The evidence suggests the possibility that while agricultural production was the mainstay of Hohokam subsistence; they still relied heavily on wild resources (Fink and Merbs 1991). This is likely due to the times of rain fluctuations seen in the area at this time causing crop stress, but it is also likely to be caused by cultural preference to traditional foods.

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