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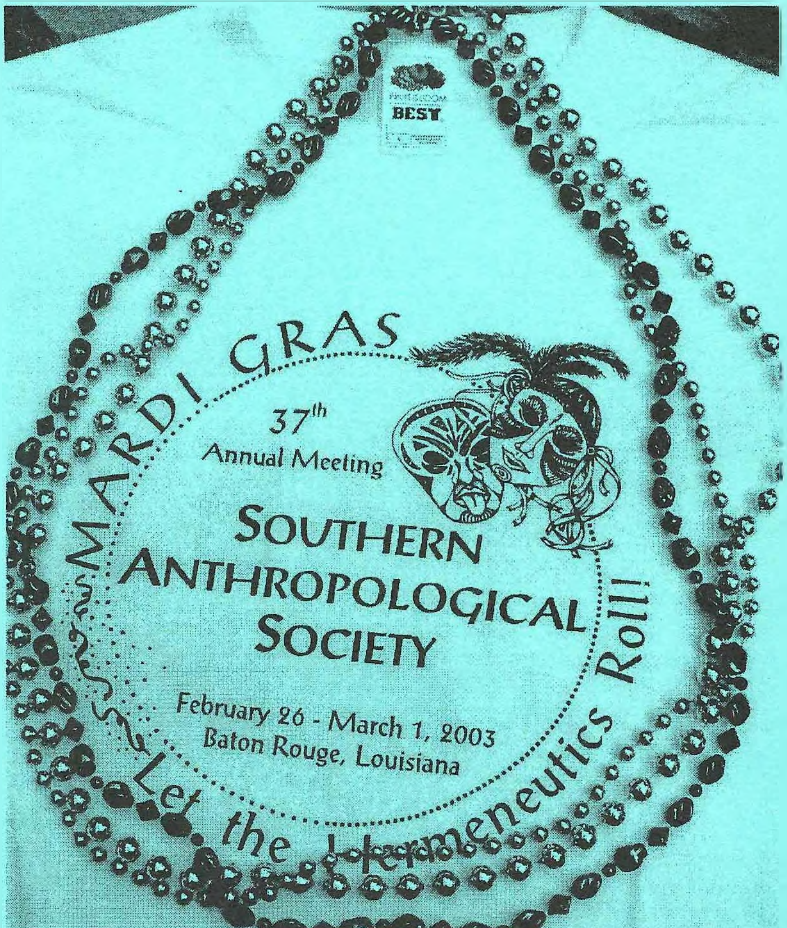

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Southern Anthropologist

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Southern Anthropologist

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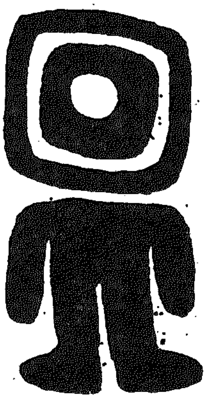
"Gigabyte" Johnson

Editor's Corner

The New World!

Welcome to the Spring/Summer issue of the Southern Anthropologist! (OK, it was originally the Spring edition, but you know…)

Anyway, our focus is on New World native populations, which is perhaps fitting for an issue whose cover picture is from the Annual Festivities in Baton Rouge, Louisiana, and its Mardi Gras parade theme of '200 years of the Louisiana Purchase!' (According to a number of the floats at the parade, what has been purchased since Lewis and Clark has been largely Louisiana politicians!)



Our Mooney prize book review is of Sam Cook's Monacans and Miners: Native American and Coal Mining Communities in Appalachia, about the coal fields of Appalachia, and covers contemporary groups in the eastern part of North America. There is both a review of the book and a thoughtful letter from Sam Cook himself.

One of the Student Prize winning papers from this spring's competiton is Kristin Marie Stoeppler's paper on anemia among Native Americans. She examines paleopathological data on several Native American populations to assess risk factors for anemia among these groups. This gives us a window into the life experiences of some groups of Native Americans during historic times.

The other prize paper is Rhonda Fair's analysis of the detailed data collected and presented by Villa Rojas in his study of Quintana Roo, Mexico, in the 1940's. She applies the theory of the Domestic Mode of Production, formulated by Marshall Sahlins, to the data, and concludes with some important criticisms of the theory. (I will not give the details here, in order to keep the reader in suspense!)

In short, we have three Native American groups covered, with a variety of places and times! If that doesn't get your excitement up, what will it take?

On a different note, this is my last issue as Editor of the Southern Anthropologist. I have enjoyed myself a lot over the past several years, and enjoyed supporting the students and others who have kindly shared with me their work, but have decided that it is time to let someone else take over the reins. I plan to continue my involvement with the Southern Anthropological Society, but in some other capacity (how does "Editor in Chief Emeritus" sound? I hear the retirement pay is terrific!)

I am turning the editorship over to the dynamic duo of Celeste Ray and Eric Luke Lassiter, who have lots of good ideas for new directions for the SA, so I welcome them to this spot for the Fall of 2003!

President's Column

Dan Ingersoll
Saint Mary's College of Maryland

It has been a very good year!

The spring semester has drawn to a close and finally I have a moment to catch my breath and write this column, which has been past-due for n weeks to David Johnson. Speaking of David, the first thing I want to say is a million thanks for nearly ten years of dedicated editorship. It was sometime during the last century—1994 to be exact—that David began as "Interim Editor" for volume 21, number 2 of Southern Anthropologist. He ascended to Chief Editor for the next volume, and the rest is history—our SAS history. Gigabyte did it all: took photographs (can you remember a time when David wasn't pointing that Leica for illustrating SA, editor or not?) to remind us what a great time we had at the meetings, sketched cartoons to make us laugh, printed challenging articles to keep us thinking, and published our students' prize-winning essays. As if being editor were not enough, in 1998 and 1999 he served as President-Elect and President, respectively. We owe him big time. David is retiring from the editorship but not from the SAS, so I'm sure he'll be there to help in all of the transitions. The editorship of SA will continue on in the capable hands of Celeste Ray and Eric Lassiter.

Congratulations to John Studstill for piloting us through another productive SAS year as our president. He kept us rolling and happy and now continues to advise us as Past President. Question: What professional anthropological society has the best meetings and the most fun parties? Answer: We do. Thanks to Past Presidents John Studstill and Barbara Hendry, Secretary/Treasurer Margaret Bender (she's the one who gets you to send in your dues and registrations) and many others, our Baton Rouge meeting was a great success. Helen Regis (Program Chair), Mandy Dickerson (Program Coordinator), Miles Richardson (Local Arrangements), and Program Committee members David Beriss, Jeffrey Ehrenreich, and Antoinette Jackson did it up big for us. How about that fabulous Cajun group, The Magnolia Sisters? And the lively Spanish Town Mardi Gras? Fine tonic for creeping Calvinism and the Protestant work ethic. And way to go with the good timing for the SAS meetings, you folks at LSU! As usual, the Keynote Address and Keynote Symposia were excellent. Important features of the meeting were the Student Paper Award (Kate Meatyard, Chair, Lindsey King, and Hector Qirko evaluated all those papers and made the tough choices) and the Mooney Award (Hester Davis, Chair, Daryl White, and Carrie Douglas devoured a pile of books). LSU's Department of Geography and Anthropology and Mary Lee Eggert, and Michelle Ashton supplied resources and logistic support. Thanks, all of you: I know you worked very hard behind the scenes to prepare for and orchestrate this memorable annual meeting. By the way, Miles: all your planning and worrying really paid off.

In the works: the first five years of SAS Proceedings will be reprinted, due to the creative energies of incoming Proceedings Editor, Chris Toumey, and Judith Knight (she's the one who has generously run the book exhibits at our meetings over the past few years) of the University of Alabama Press. Chris is also hard at work editing the next new volumes to appear. We have had extraordinary good luck in our SAS editors— before Chris, Michael Angrosino did a beautiful job of editing countless volumes of the Proceedings. Like David, Michael has been one of the selfless powerhouses keeping SAS strong, vibrant, and self-reflective. Michael serves as a major repository for SAS corporate memory, so we should remember Michael for his contribution as he has remembered us.

As your current president, I'm pronouncing the state of the SAS union sound and solid. It has been a very good year. We have great plans for the future, and I invite you to join in on those plans for programs, meetings, and publications—more on those plans in the next column. But for now, I will just assure you that we will continue holding the best meetings and the best parties, all the while supplying you with thought-provoking publications.

SAS Endowment Campaign for Education and Outreach in the South

The Endowment is now in its seventh year of fund-raising towards a $30,000 goal.

The purpose of the endowment is to:

- support student participation in the meetings and the student prize competition,
- expand the knowledge of anthropology in and of the South and to smaller colleges and universities which do not yet offer courses in anthropology,
- bring the message of our discipline to minority institutions through a dynamic speakers bureau,
- encourage minority participation in the field and at our meetings, and
- reward outstanding scholarship in the anthropology of the South with the annual presentation of an enhanced James Mooney prize.

At present the Endowment is about one-third of the way to the goal, so your contributions are needed!

Please take time to make a campaign pledge or donation and send it to:

Dr Max E White
Department of Sociology and Anthropology
Piedmont College
PO Box 10
Demorest, GA 30535
email: <mwhite@piedmont.edu>; Tel: (706) 778-3000 ext 261; Fax: (706) 776-2811

SAS Annual Meeting Announcement

The annual meetings will be held March 18-21, 2004, at the Holiday Inn Select Atlanta/Decatur, Decatur, Georgia.
Due dates for papers and abstract will be announced later.

Meeting Organizers:
George Armelagos (Emory University) and Daryl White (Spelman College)

We invite your help in any aspect of the meetings.
Contact: Daryl White: dwhite@spelman.edu

SAS Key Symposium 2004:
Globalization and the Evolution of Emerging Disease

Abstract: The concept of epidemiological transition provides a means of understanding the changing relationship between humans, pathogens and other disease insults. The adaptation of hominid populations in the Paleolithic created a disease ecology that minimized the impact of infectious disease. The shift to primary food production about 10,000 years ago resulted in the first epidemiological transition marked by the emergence of infectious and nutritional diseases that continues to the present. The origin and rise of social inequalities that are a feature of the post-Neolithic society play a major role in the emerging disease pattern. Within the last century, some populations underwent the second epidemiological transition in which public health measures, improved nutrition and medicine resulted in declines in infectious disease and a rise in non-infectious, chronic and degenerative diseases. On the eve of the antibiotic era, we are entering the third epidemiological transition in which there is both a re-emergence of infectious diseases previously thought to be under control and the emergence of novel diseases. Many of the emerging and re-emerging pathogens are antibiotic resistant and some are multi-antibiotic resistant, having the potential to be spread globally and affecting both populations that experienced and those that never experienced the second epidemiological transition. The symposium will examine these subjects from both biological and cultural perspectives.

The Southern Anthropological Society

Requests Nominations For

THE 2003 JAMES MOONEY AWARD

A juried prize to be awarded for the best book written on the South or Southerners from an anthropological perspective and published in the years 2001 and 2002.

The James Mooney Award: The purpose of the James Mooney Award is to recognize and thereby encourage distinguished anthropological scholarship on the South and Southerners. Presented annually, the award includes a $500 cash prize and certificate of recognition to be presented to the winning author at an awards ceremony. In addition, an Honorable Mention Award includes a $250 cash prize and certificate of recognition. The winning presses will also receive a certificate of recognition and will be granted free exhibit space at the Society's annual meeting and, for one year, free advertising space for the winning books in the ***Southern Anthropologist.***

Eligibility Criteria: To be considered for the 2003 James Mooney Award, a book must have been published between the years of 2001 and 2002. The judges welcome works on the South or Southerners from any subfield of anthropology or from other disciplines so long as the primary perspective of the work is anthropological. Co-authored books may be nominated, but edited volumes may not. The nomination must clearly be for a single book, even if it builds on prior work by the author or others.

Nomination Procedures: Nominations for the 2003 James Mooney Award may be submitted by any individual, author, or press. The nomination should include a letter describing briefly the subject and significance of the work and giving the name, address, and telephone number of the author. The letter of nomination should be accompanied by at least one copy of the book and preferably by three copies, one for each member of the selection committee.

Nominations for the 2003 award must be received by July 15, 2003 and should be sent to the Chair of the Awards committee, from whom additional information can be obtained:

Dr. Daryl White; Department of Sociology & Anthropology
Spelman College; Campus Box 375
350 Spelman Lane, SW
Atlanta, GA 30314

Books will be judged by a committee of anthropologists from different subfields in the discipline. The winner will be announced in March of 2004.

Mooney Award Committee Report

The report of the Mooney Award Committee for 2002, By Hester Davis, Chair for 2002

The Mooney Award Committee (Daryl White, Carrie Douglas, and Hester Davis), received nine books from various presses for review. Three of these were ones which had been submitted for the award last year, but these were dutifully reviewed by this committee and again did not win. The Committee's decision was unanimous in choosing Dr. Samuel Cook's ***Monacans and Miners: Native American and Coal Mining Communities in Appalachia*** **(Lincoln: University of Nebraska Press. 2000)** for the 2002 Mooney Award. Because Carrie was not able to review ALL the books, we agreed that this year there would be no "Honorable Mention" (created two or three years ago and carrying a $250 award with no invitation to the meeting).

We had some good books this year and a good response from the presses. I think the Mooney Award is doing very well and I've seen presses noting the Award in their advertizements. I have always thought that the Mooney Award was one of the most important things that the SAS does. I hope that the Board will continue to try and find a way to increase the prize money to $1000.

(Comment from Daryl White)

The Mooney Award Committee considered over ten books this year and easily agreed that Samuel R. Cook's ***Monacans and Miners*** deserves this year's Mooney Award for its substantial contribution to the anthropological understanding of the U.S. South. ***Monacans and Miners*** admirably epitomizes many qualities of anthropological scholarship—qualities that allow anthropologists to contribute both to understanding contemporary conditions and to promoting positive social change. The book is comparative, conceptually focused, methodologically diverse, deeply sympathetic, and written very well indeed. As his subtitle, ***Native American and Coal Mining Communities in Appalachia***, suggests, Cook performs a comparative analysis of two communities and a region: The Monacans of Amherst County, Virginia, who have survived centuries of economic exploitation and political subjugation; a coal community of Wyoming County, West Virginia, that has undergone dramatic population shifts resulting from the development of the coal industry; and Appalachia, a region characterized by high degrees of local impoverishment, absentee landownership, and remote control. The communities differ significantly, yet share important commonalities, and Cook explores these principally by using two related concepts—dependency theory and internal colonialism—to develop ten broad questions that guide the research. There is nothing heavy handed in the ways these analytical tools are used; he is not out to prove something, but to explore and understand political efficacy through a controlled comparison. In his introduction, Cook writes:

> At the bottom line, this is a study of power relations. It is not merely an examination of material inequalities but of differential cultural configurations within a set space. It is also a study of how power relations can *change*, and how human agency at *all* levels of the power structure can alter the entire configuration. I represent the Monacans and the residents of Wyoming County only as a concerned—albeit well-informed—outsider, and not as a definitive authority. At the same time, I hope to open the canon to an understanding of two underrepresented communities consisting of people whose stories should be told. Their stories are in some ways remarkably similar and other ways profoundly different (2000:22, italics in original).

The stories are well researched and well told. The book is both historical and ethnographic, in equal proportion.

Cook employs a wide range of research methods: archives, quantitative measures, participant observation, in-depth interviews and oral histories. There is a welcome sense of collaboration. To empower the reader, he includes long passages in the words of his informants. And the interviews, by providing informants with the opportunity to reflect in a new way on their history, helped shape new understandings on both sides of the interview conversation. Monacans and Miners is well-suited for use in a wide range of undergraduate and graduate anthropology courses, including Introduction to Anthropology to other courses focused on region, development, identity, and change. Cook describes his analytical concepts, research questions, and methodological choices in language that is clear, concise, and interesting. For me, the simple dedication at the beginning of the book signals the depth of Cook's connection to the subject of his book: "For the mountains of the Virginias. The most forgiving landscape I know."

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(Letter from Sam Cook to the SAS upon receipt of the Award)

First, let me express my deepest regrets for not being able to attend the SAS meetings to receive this award in person. I have heard so many good things about this organization from close colleagues, and I was looking forward to this event marking my possible transition into the fold. I was also looking forward to escaping one of the harshest winters in the recorded history of the New River Valley. Then again, I live for irony.

I am humbled, to say the least, to have been selected to receive this high honor. For me, it has a particular significance because I have always admired James Mooney. Not only did he pioneer anthropological work among Virginia Indians, he also produced the first comprehensive monograph on Siouan peoples of the East, which monograph remains a foundational ethnohistorical document for those of us who work with groups such as the Monacans, Catawbas, and Occaneechis. James Mooney, I believe, played a significant role in developing the MODERN profession of anthropology. Like all of his contemporaries in the Bureau of American Ethnology, he was versed in cultural evolutionary theory, Lewis Henry Morgan-style. However, once he actually entered the field and came to know the people he worked with as HUMAN, the theoretical veneer became problematic, and Mooney realized how complex human groups truly are—too complex to be reduced to simple typologies.

Mooney, in fact, was a staunch advocate of the political rights of Virginia Indians at a time when even acknowledging that these groups were "Indian" was grounds for virtual banishment. He later distinguished himself, much to his disfavor, as an advocate for American Indian land rights and religious freedom, ultimately resulting in his banishment from Indian Country by federal authorities. In the long run, then, Mooney realized—at least to the same extent as Boas—that anthropologists had to move beyond the façade of scientism because the pursuits of our profession, by nature, carry certain ethical and moral mandates.

I would like to believe that my work is guided by the same ethical and moral principles. In no way can I liken myself to Mooney, but I can certainly exalt him as a model for ethical conduct in anthropological pursuits.

That being said, I am compelled to offer my humble thanks to many people, including my dissertation committee chair David E. Wilkins, who not only taught me the true meaning of critical thinking, but also introduced me to the Monacan community. I must also thank my other dissertation committee members, Nancy Parezo and Tom Holm, for imparting a great deal of practical and professional wisdom in me. I am indebted to Gary Dunham, editor of the University of Nebraska Press, for his expressing such enthusiasm for my book project from the first moment that he looked at my prospectus. There are many people in the Monacan community who deserve special thanks, including George Whitewolf, Diane Johns-Shields, Karenne Wood, Phyllis Hicks, Lucian Branham, and Buddy Johns, among so many others. I also, need to express my deepest love and thanks to those in my West Virginia homeland who helped to facilitate my research, including Wanda Lester, Paige Cline, Sarge McGhee, Jack and Sarahh Lou Frank, and Thurman and Josephine Lester. Finally, I must honor my late parents, Tom and Mary Cook, who would be proud beyond words on this occasion, even though it is but a pittance in remembering them.

Most of all, I cannot reiterate enough how thankful I am to the Southern Anthropological Society for selecting my book for this high honor. You not only honor me, but all of those in the Monacan community in Wyoming County, West Virginia, whose lives and experiences are at the heart of this book.

All My Best,
Sam Cook

Winning Entry 2003 SAS Student Paper Competition: Undergraduate

A Critical Evaluation of the Frequency of Anemia in Native American Populations

by Kristina Marie Stoeppler
Appalachian State University

Analyzing anemia in paleopathological studies facilitates the understanding of past life-ways by clarifying the effects of disease and diet on human populations. By determining disease states that were frequent in particular populations, hypotheses can be developed as to why certain populations were more vulnerable to stress than others. The presence of anemia, in particular, can give insight into the adequacy of a population's diet as well as their susceptibility to particular diseases.

Anemia, literally meaning "no blood," is a condition characterized by a depressed concentration of hemoglobin or packed cell volume (Stuart-Macadam and Kent 1992). Red blood cells in anemic individuals are therefore not as efficient in carrying oxygen throughout the body. There is a wide range of symptoms associated with anemia, including; pallor, fatigue, poor appetite, gastrointestinal problems, depression of neurological function, menstrual disturbances, poor physical growth, lowered immunity, higher maternal morbidity, and child mortality during pregnancy (Ramakrishnan 2001; Underwood 2001).

In this study I examined a 16th century, North American skeletal collection from the Sully site in South Dakota. I illustrate the population's general health status by comparing the frequency of dietary anemia to available diet and to potential anemia producing pathogens. In addition, this study aims to gain a better understanding of the Sully data through comparisons of two contemporaneous populations: Libben and Mouse Creek. The purpose of these comparisons is to better understand the biological variability among these three cultures. In doing so, this study provides critical information for understanding the effects of anemia by examining the adequacy of the population's diet, sanitation practices, and association with parasites and pathogens.

PALEOPATHOLOGICAL DIAGNOSIS OF ANEMIA

A paleopathological diagnosis of anemia is established through the observation of porotic hyperostosis and/or cribra orbitalia. Mann and Murphy (1990) define porotic hyperostosis as 0.5 to 2.0 mm sieve-like holes affecting the outer table of

Acknowledgments

I would like to acknowledge the contribution of my readers to this paper. I am most grateful to Dr. Kathy Jack who challenged and encouraged me throughout the course of this project. Likewise, I thank Dr. Harvard Ayers, Dr. Richard Henson, Dr. Larry Kimball, and Dr. Susan Keefe for reviewing my work and offering me constructive criticism and support.

I would also like to acknowledge the Smithsonian Institution, in particular Dr. David Hunt, for allowing me to use the materials necessary for this study, and for consultation in the development of the research format.

My special thanks to the Holmes and Maguire families for giving me a warm place to sleep and food to eat while conducting research in Knoxville and Washington. I couldn't have done it without you.

the cranium and the diploe (space between the two bone layers of the cranium), accompanied by increased vault thickness (resembling a porous orange peel). Cribra orbitalia is defined as porosity and/or expansion of the superior orbital plates during childhood (Mann and Murphy 1990). This condition is usually bilateral and appears as small to large holes in the upper surface of the orbits. Both of these cranial lesions (porotic hyperostosis and cribra orbitalia) occur when red blood cells are inadequately functioning. To compensate for the inadequacy of the red blood cells to carry oxygen, the body generates more of them. Consequently, the bone marrow cavity in the cranium (the diploe) will expand in order to allow for production of additional red blood cells (Boyd 1984). As the diploic space expands, it is thought to wear through the outer table of the cranium forming lesions (Larson 1997). This process begins in the eye orbits and, as the condition becomes more severe, proceeds back towards the lambda (the point were the sagittal suture meets the lambdoidal suture). Therefore, the presence of cribra orbitalia alone indicates a milder case of anemia than if porotic hyperostosis were also manifested (Stoeppler, unpublished data).

This expansion process occurs before pubescence, when the bone is more supple and malleable. However, different stages of remodeled lesions (porotic hyperostosis and cribra orbitalia) can be observed in adult crania. The lesions will heal with the presences of an adequate hemoglobin concentration, or they will remain active if the individual continues to live with depressed iron stores (Todd 1994). The time frame in which adequate iron stores must be consumed before healing takes place is yet to be determined. In addition, menstruating females are less likely to be able to heal the cranial lesions because of their increased demand for iron, and therefore can cause an iron deficiency bias within the data. For these reasons, the analysis of prepubescent populations (when there is a large enough sample) is preferable.

CAUSES OF ANEMIA

When considering epidemiological studies, it is necessary to recognize that a correlation between two factors does not necessarily imply cause and effect. The body is a complex system, in which many factors synergistically affect the development of diseases. Global scenarios (such as anemia frequencies in current Sub-Saharan Africa) create innumerable variables that can all lead to the development of anemia. Therefore, the following research is specifically addressing anemia in the North American pre-contact context.

Anemia is most commonly thought to be the result of parasitization, bacterial, fungal, viral infections, inadequate intakes of iron, B12, and folate, as well as the presence of dietary factors that limit the absorption of the aforementioned minerals. (Factors such as sickle cell anemia, toxin exposure, and renal disorders of the elderly, which are well-known causes of anemia in some populations, are not included in this study, because they did not affect Native American pre-contact populations.)

Dietary stress:

Pernicious anemia results from vitamin insufficiencies that prohibit the methylation of DNA in the red blood cells preventing proper development. This, in turn, precipitates a shortage of hemoglobin and thereby leads to an anemic state. Vitamins B12, B6 and folate are responsible for DNA methylation in the red blood cells, and these vitamins are obtained through animal products (such as fish, eggs, beef and milk) and green plant foods (Sizer and Whitney, 2000).

While pernicious anemia seems to permeate strict vegan lifestyles, few cases are reported in the general population. However, iron deficiency anemia (IDA), which is anemia resulting from inadequate hemoglobin function due to insufficient iron intake, is the number one nutrient deficiency in the world (Sizer and Whitney, 2000). Iron intake recommendations for the United States suggest that men consume

10 milligrams per day of iron, and women should consume 18 milligrams per day (Sizer and Whitney, 2000). Most grains are low in iron, especially corn, wheat, and rice (often below 2 milligrams per serving). Underwood (2001) speculated that populations having excessive dependence on corn, wheat, or rice would show evidence of IDA. Beans and other legumes are somewhat higher in iron, but many servings are required to reach the suggested dosages. Prehistoric foragers would have had higher iron stores because of their heavy utilization of seeds, which typically contain around seven milligrams of iron per serving, as well as their consumption of higher quantities of meat (Underwood 2001).

Unlike the prehistoric foragers described by Underwood (2001), some agrarian populations consumed the majority of their calories in the form of corn, therefore their serum iron levels would tend to be depressed because of the decreased consumption of meat. For example, using cribra orbitlia and porotic hyperostosis as indicators of anemia, Boyd (1984) found that people in the Appalachian summit regions who were still using some hunting and gathering subsistence strategies showed very little evidence of anemia, while the cultures in the Mississippi river valley that had developed a predominately maize agriculture economy showed higher frequencies. Boyd (1984) attributed these differences to discrepancies in the diet between the two populations. In addition, Mensforth, Lovejoy, Lallo, and Armelagos (1978), based on their examination of prehistoric sites from Ohio, concluded that illness and dietary stress are important factors in causing anemia. Also, in a study from the southwestern United States conducted by El-Najjar et al. (1975), where the frequency of anemia was positively associated with dietary factors, it was concluded that anemia due to inadequate iron is the most likely causative factor for the deficiency to develop.

Another factor in determining dietary stress as the cause of anemia is iron absorption by the body. Iron occurs in two forms in foods. Some is bound into heme, which is the iron containing part of hemoglobin and myoglobin, and is found in poultry, fish, and other meats. Other iron is nonheme, such as iron found in plants and the nonheme iron in meats.

...[T]his study provides critical information for understanding the effects of anemia by examining the adequacy of the population's diet, sanitation practices, and association with parasites and pathogens.

The form of the iron affects absorption; heme iron is absorbed much more efficiently, an average of 23%, while only 2-23% of nonheme iron is absorbed. In addition, phytates, tannins, calcium and phosphates in milk, and fiber in whole grain cereals impair absorption (Sizer and Whitney, 2000). Therefore, even if people were eating beans and corn, their body would only be absorbing a small percentage of the iron they were consuming.

Given these relationships, studies cannot simply determine the amount of iron that was eaten. Absorption levels should be based on nutrients and minerals consumed with the iron. For example, Woodruff (1958) studied 272 infants with IDA and noted that the poor diets of several anemic infants were similar to those of a much larger number of infants who did not develop anemia to the same degree of severity. He concluded that factors other than diet are important in the etiology of IDA (cf. Stuart-Macadam 1992). However, Woodruff did not comment on any differences in fiber or calcium and phosphate intake, which theoretically, could cut iron absorption down to 2% (Sizer and Whitney 2001).

This interaction holds true for Native American populations as well. A large number of studies have suggested that the prolonged lactation practiced by Native American cultures, and consequent high intake of calcium, would have significantly deterred iron absorption (Palkovich 1984). They base this conclusion on the presence of an iron-binding protein, lactoferrin, which has the potential to influence the development of IDA in children and infants. However, recent clinical studies are questioning the validity of this claim, as the benefits of extended breast-feeding seem to far out-weigh the risk of anemia. For example, a UNICEF, WHO, US AID project reported that some 2 million children under 1 year of age die every year from diarrhea associated with various forms of infant feeding (diarrhea can intensely affect absorption of nutrients into the blood stream and may therefore lead to IDA). Many researchers suggested that these deaths could be averted if children were exclusively breastfed through 4-6 months of age, thereby reducing their exposure to contamination while also reaping the nutritional immunological protection of breast milk through this period (Dettwyler and Fisherman 1992; Jelliffe and Jelliffe 1978).

Studies of Native American lactation indicate that children were traditionally breastfed until the age of one or longer (Gonzalez 1969), and early accounts of Native Americans also describe lengthy lactation periods (Waselkov and Braud 1984, Madanagd 1986). With extensive lactation periods, children would have had more protection from diarrheal diseases that decrease absorption of nutrients, while receiving adequate supplies of folate and perhaps iron. Gonzalez (1969) conducted extensive interviews and concluded that each of the different ecological zones in the United States adequately supplied the essential nutrients to Native Americans. She further acknowledges that the seasonal variations could have produced a "feast or famine" situation. However, Larson (1997) notes that even a season of nutrient deprivation would not cause chronic anemia unless it exceeded six months or more.

The hypothesis of diet-induced anemia does not have unanimous support. Stuart-Macadam (1985), for example, suggests that except in cases of outright malnutrition, diet plays a minor role, if any, in the development of IDA. She also found that even if iron intake was reduced to nil, which is virtually impossible even with the most frugal diets, it would still take at least two to three years to develop IDA. Likewise, several case studies have shown that iron is recycled continually in the body, making dietary attributed chronic anemia only obtainable after several years of deprivation (Underwood 2001). In addition, iron absorption by anemic individuals increases to over 35%, as opposed to 25% at best in healthy individuals (Stuart-Macadam 1985). Yet people, especially women and children, who rely on corn or other nonheme iron sources to supply their dietary requirements would have a hard time consuming, and absorbing, 18 mg of iron per day even with increased absorption.

Infectious disease:

Other possible causes of anemia in North American pre-Colombian populations are pathogens, specifically bacteria and parasites. Porotic hyperostosis is related to the overall pathogen load of a population; "a heavy pathogen load will increase the incidences of parasitic infections, viral and fungal diseases, which have the effect of reducing iron status of individuals" (Stuart-Macadem 1985; p. 4). With the development of agricultural complexes in North America, urbanization and human contact increased, causing a significant decrease in sanitation. Today, most of the world's populations live under these same conditions and the World Health Organization reported in 1975 that most people in the world lose one to four milligrams of iron per day due to parasites.

According to a study conducted by Masasme et al (1974), up to 80% of children, young adult women, and pregnant women in the tropics have anemia (cf. Stuart-Macadam 1985). The results of the study showed that patients with anemia have significantly fewer bacterial infections than patients with adequate iron stores. Stuart-Macadam's explanation for this finding was as follows:

> ...prorotic hyperostosis has been referred to as a 'nutritional' stress indicator. Traditionally those groups with a higher incidence of porotic hyperostosis have been considered to be less successful in adapting to their environment or more nutritionally disadvantaged than other groups... there is new appreciation of the adaptability and flexibility of iron metabolism; as a result it has become apparent that diet plays a very minor role in the development of iron deficiency anemia. It is now understood that, rather than being detrimental, hypoferremia [anemia] is actually an adaptation to disease and microorganism invasion. When faced with chronic and or heavy pathogen loads individuals become hypoferremic as part of their defense against these pathogens.. (Stuart-Macadam 1992:1)

Nevertheless, there are many negative effects of anemia making it unlikely for the body to be benefited by an intentional decrease in iron stores. In addition, the immune system would be depressed as a result of IDA, making people more susceptible to infections (Schmidt and Roberts 2000). Stuart-Macadam (1992) argued that the body would develop an iron-deficiency response in order to defend itself from pathogens; therefore iron deficient people benefit by being less attractive to foreign invaders (parasites and pathogens). However, individuals with an iron deficiency are more susceptible to severe infections (Martin et al. 1985). Furthermore, Combes (2001) states that individual nutrition modulates the immune system; a properly balanced diet is one characteristic that most strongly influences the resistance of hosts to pathogens. This is due to the requirement for iron in the incorporation of hydroylysine and hydroxyproline into collagen (Aufderheide and Rodriguez-Martin 1998). Endt and Ortner (1982) examined the content of these amino acids in normal bone and compared them to individuals with porotic hyperostosis and found 5-25% less amino acids in the individuals with porotic hyperostosis. Iron deficiency anemia has also been found to adversely affect immune function and to increase susceptibility to infection under laboratory conditions. This is due to impairment of the T-cells to mitogens and the bactericidal activity of neutrophils (this study was conducted ***in vitro***) (Walter et al. 1997). Furthermore, evidence from recent controlled trials in juveniles indicates that short-term iron supplementation does not increase the incidence of common childhood infections such as diarrhea, respiratory illness, or increased parasite susceptibility (Ramakrishnan 2001). Also, Roberts and Manchester (1995) found an increased mortality in individuals with cribra orbitalia. In summary, anemia makes the body susceptible to infection – the body does not deter infection by becoming anemic.

Pathogens can potentially factor into the development of anemia by directly causing anemia due to decreased absorption of nutrients. Table 1 (located at the end of this article) provides a list of diseases that might have affected iron absorption of Native American Indian populations. These data are presented in terms of probable occurrence in the population, anemic and periosteal complications, and other skeletal markers that are manifested and interpreted by the paleopathologist as "diseased". Only four of the potential diseases possibly afflicting Native Americans lead directly to chronic anemia (anemia is a primary reaction): trauma, syphilis, sporotrichosis, and congenital cyonogalourus. Furthermore, all of these diseases that potentially cause anemia will manifest other osteological markers, such as bone deformations and abnormalities, or periostitis, of the long bones. Those diseases that produce anemia as a secondary response do so after the disease is in a chronic stage in which white blood cells are being produced instead of red blood cells, thereby causing anemia. It is only after the disease has run a significant length of time that signs of anemia might develop (Kaschula 1998). In contrast, the diseases discussed above that directly lead to anemia do so at initial onset (Kaschula 1998).

Parasites:

Parasites can also lead to anemia. Stuart-Macadam and Kent (1992) cite malaria, hookworm, and osteomyelitis as pathogens that could lead to porotic hyperostosis. Larson (1997) argues that the high occurrence of porotic hyperostosis in El-Najjar's (1975) Southwestern population studies, from maize-dependent populations inhabiting canyon bottomlands, are a result of problems arising from poor drainage and contaminated water rather than maize consumption as suggested. Larson (1997) criticizes these studies by stating that they underplay the role of parasitism in IDA, especially in the case of Enterobius vermicularis (pin worm).

Table 2 indicates which parasites may or may not have been affecting Native American populations, the effect they would have on the population, and why they would not be a factor in the etiology of IDA. Although the list of parasites that could have affected Native American populations is quite extensive, tapeworms, Trichuris, and hookworm are the only parasites present on the continent that would have been of any relevance to the study population. In addition, it has been documented that even in the most severe cases of parasitic infestation, a sufficient diet will likely disguise all symptoms, including anemia (Schmidt and Roberts 2001).

Childhood diarrhea:

Another possible cause of chronic anemia is dysentery caused by Giardiasis and weanling diarrhea. These diseases are attributed to poor potable water and sanitation. Therefore, the probability of anemia caused by weanling practices must be made on a case-by-case basis. While these diseases are caused by diet and pathogens, they are recorded separately from dietary and pathogenic etiologies in that they are culturally manifested.

CONCLUSION: CAUSES OF CHRONIC ANEMIA

As noted above, all diseases that precipitate chronic anemia leave behind other skeletal markers in addition to cribra orbitalia and porotic hyperostosis. Therefore, it is possible to distinguish anemia caused by bacteria and viral infections from anemia caused by diet. It is also established that individuals must first be malnourished before they will show signs of chronic anemia from parasitic infections (Schmidt and Roberts 2001). Again, it is anemia that makes the body susceptible to infection – the body does not deter infection by becoming anemic.

While some studies have shown that populations with hyperostosis have consumed as much iron as those without, few studies have considered the absorption of iron in addition to consumption. Yet, high parasite and pathogen loads caused by crowding and poor sanitation can cause anemia as well. These findings illustrate the importance of separating the etiologies of anemia; where individuals displaying anemic lesions alone are classified as having severely deficient diets, and individuals displaying other diseased lesions in addition to anemic lesions are classified as having pathogen-induced anemia.

Much information can be gained from studying the frequency of cribra orbitalia and porotic hyperostosis in archeological settings if they are accurately calculated. I collected my data over a three month period (June through August 2002) at the Smithsonian Institution examining the skeletal remains of 173 juveniles from a pre-contact South Dakota Indian culture for evidence of IDA with the intent of uncovering a new understanding of the population's life-ways and, in particular, their diet. Upon analysis of my data, I have also found it necessary to re-evaluate previous studies in-order to compare my findings with accurate anemia frequencies. The two studies I was able to re-evaluate on the basis of full skeletal analysis, archaeological data, and contemporary medical studies were from the Mouse Creek and Libben sites that were originally evaluated by Boyd (1984) and Mensforth et al. (1978) respectively.

BACKGROUND

Study site

I examined the skeletal remains from the Sully Site, a pre-historic community located 20 miles north of Pierre, South Dakota that was previously part of the Arikara culture of the Upper Missouri River. This skeletal collection, excavated by Bass in 1957, is currently housed in the National Museum of Natural History (Washington DC). Bass directed the excavation of four cemeteries (A, B, C and D), but suggested that Cemetery C, which contained burials in patterns that differed from the other cemeteries, was not associated with Sully and was instead associated with another unnamed village (Bass unpublished document). Consequently, cemetery C was not included in my study.

Jantz et. al. (1971), Lehmer (1971), Key (1983), Rodgers (1990), Johnson (1994), and Bass and Stephenson (unpublished manuscript), have been the main researchers involved in the excavation and interpretation of the site. While many aspects of the village occupation are under debate, there are several accepted facts. First, none of the early historic records of this portion of the Upper Missouri River had any reference to a Native American site in the location of Sully (Stephenson and Bass unpublished data). Although Lewis and Clark extensively described neighboring villages (both occupied and abandoned), they made no mention of the Sully site in October of 1804 (Lewis and Clark 1983). Furthermore, an 1866 military post on the west side of Sully Creek also made no mention of it (Billick 2002). Consequently, Bass and Stephenson (unpublished manuscript), and Rodgers (1990), date the site from 1650-1750. The cemetery population would have thereby avoided the recorded European derived epidemics that began in 1772. Craniometric data from Key (1983) support Bass's findings, but push the date of occupation further into contact periods. However, Key (1983) estimated that the grave contents were even later. While all cemeteries, except C, contain trade goods, trade routes had been established before direct contact would have occurred. Some French fur traders would have made their way to the Arikara, but their viability as disease vectors is not likely because the extensive journey would not have been possible for diseased individuals. Therefore, according to the majority of researchers, the Sully site would have had minimal direct contact with Europeans. Due to this fact, European diseases can be safely eliminated as causative factors in the development of periosteal lesions or anemia exhibited in the study collection.

Arikara Culture

The Arikaras were a settled agricultural group (Dorsey et al.1940, Wetfish 1965) that were thought to have separated from the Pawnee around AD 1400 and settled in the Dakota river valley (Rodgers 1990). The Arikara people eventually became part of the Mandan when they were forced onto reservations in the 19th century. Using historic and archaeological evidence, Rodgers (1990) dates the pre-contact period for the Arikara from approximately the late 1500's until 1680. The earlier date coincides with the first archaeological data that may reasonably be identified as Arikara. The later date is the time of the first direct contact with the village groups on the Upper Missouri. However, diseases introduced by Europeans may have had a significant impact on the Arikara population well before the eighteenth century (Ramenofsky 1987). According to Rodgers (1990), this time frame (1500 – 1680) was most affected by the introduction of diseases, however he notes that the disease vectors responsible for epidemics are tentative. From 1681-1724, there was little direct trade with French explorers as other Native Americans served as intermediaries between the Arikara and the Europeans. At this time, there would have been few chances for the spread of European disease. Soon thereafter serious social stress and a dramatic life-way change ensued (Rodgers 1990). Yet, as noted above, the occupation of the Sully village ceased before this transition.

The other members of the Arikara culture, having existed into the contact period, have provided historical accounts of their life-ways. Particularly valuable to an anemia study are accounts of diet, agriculture, and sanitation. Agriculture and hunting were two primary subsistence activities, although the collection of roots, nuts, berries, and other naturally occurring resources formed an important supplement. Corn was the principal domesticate, although beans, squash, and sunflowers were also grown (Rodgers 1990). This wide variety of nutrients would have supplied a well-balanced diet for the Arikara. While corn was the main staple, there is evidence that hunting (particularly of buffalo) remained an important food source, thereby providing the Arikara with significant iron intake. Furthermore, B12, B6 and folate would have been available to the Arikara, which would have fended off pernicious anemia. Historical records (eg. Abel 1939) mention directly or imply periods of starvation and periods of feast. However, as previously stated, longer periods of nutrient deprivation would be necessary for development of chronic anemia.

Rodgers (1990) claims that no fertilizer was used on the fields and that they were periodically left fallow while others were utilized. It is significant that no human feces were used, making the spread of hookworms and tapeworms less likely. This is especially true in the case of the Sully site because of the locality on the swift Missouri River, which would have moved contaminated feces away. Other than hunting and trading, another source "of buffalo were the carcasses found floating in the Missouri River during the spring thaw...although the animals were often in an advanced state of decay, the Arikaras ate parts of the meat raw" (Rodgers 1990; p 45). While breaches of normal sanitation standards like the one recorded above might have provided sufficient opportunities for parasites to invade the Native Americans, their well balanced diet would have helped to ward off adverse effects from the parasites that they were exposed to during these situations.

Villages were well dispersed and consisted of several earthen lodges and shelters. While population estimates vary dramatically depending on the time period and the researcher, the limited size and dispersal of the villages would have helped to quell parasite infestations and sanitation problems because contact with people would be limited, especially when compared to higher density populations.

Overall, when taking into consideration the historical records of the Arikara life-ways, as well as the archeological data from the study site, the Arikaras at the Sully village had a healthy life-style. Their diets were well-balanced so that what pathogens they were exposed to could be warded off by a well functioning immune system. In addition, the exposure to pathogens was probably kept to a minimum because: (1) there was no direct contact with Europeans so epidemics would not have affected them; (2) the community was located on a moving body of water so improper dispensing of sewage was not as significant a health risk; (3) they did not use human feces as fertilizer so parasites were not as likely to contaminate the soil, and; (4) the villages were well dispersed so human contact would limit pathogen transmission.

MATERIALS AND METHODS

Skeletal material and diagnosis of IDA

The skeletal material excavated from the Sully site is in excellent condition and supplied a large sample population. In addition, there appears to be no time of excessive mortality, but rather the individuals died at a steady rate (Billick 2002). There is a minimum of 500 skeletons from the cemeteries, of which 173 are mostly complete juveniles under the age of 10. This study focuses on juveniles in order to eliminate a possible bias caused by excessive iron loss of menstruating females. Age was assessed according to root and crown development of the dentition (Bass 1995). As noted in the introduction, the indication of other anemia causing diseases is just as important as the identification of anemia. The most common sign of nonspecific infection is periostitis. This bone infection has a characteristic look that is similar to a paper birch tree; the thin flaky layers of bone growth and odd striations are similar to the muscle attachment points in growing children (Hunt, David personal communication 2001). Larson (1997) describes the pathology as osseous plaques that arise from the osteoblastic stimulation caused by infection or trauma. The lesions can be localized or may involve several skeletal elements depending on the etiology of deformity. Because the majority of diseases listed in Table 2 cause chronic anemia after the onset of bone infection, it is very likely that when periosteal lesions occur with porotic hyperostosis the severity of the anemia was induced by infection rather than diet. In this way, it is possible to differentiate between various causes of anemia. If there are only cranial lesions found, then it is possible that they were caused by a deficiency in diet. Conversely, if there are additional postcranial skeletal lesions found with IDA lesions, then the infection was likely the primary cause of the chronic anemia state.

Complete skeletal analysis was not conducted for every juvenile, but the crania were all closely examined. If cribra orbitalia or porotic hyperostosis were observed, they were given a score that corresponded to the severity of the porosity. This decision was made according to the number of pores, size of the pores, and space that was affected by the pores. Those crania that exhibited porotic hyperostosis or cribra orbitalia were also examined for periostitis and other pathological bone changes. The surface area that was affected determined the severity of the bone infection. All scores were based on a scale of 1 to 10, 10 being the most severe.

RESULTS:

In my examination of the Sully juveniles (N=173), 11(6.3%) showed signs of cribra orbitalia (see Table 3). No porotic hyperostosis was conclusively determined, indicating that these were only minor cases of chronic anemia. When these 11 juveniles displaying cribra orbitalia were further investigated for evidence of periostitis, 7 were found to manifest additional postcranial lesions, while 4 (2% of the study population) displayed only cribra orbitalia.

Sully, Libben, and Mouse Creek Comparisons

I compared my findings from the Sully population with those of two contemporaneous studies of the Mouse Creek (Boyd 1984) and Libben (Mensforth 1978) skeletal collections to determine if anemia was occurring at similar rates, and if not, why was there a difference? Both of these studies provided data that separated individuals with only cribra orbitalia and porotic hyperostosis from those with anemic lesions and skeletal lesions. Of the 241 individuals included in the Libben collection, 24 (21%) displayed only cribra orbitalia and/or porotic hyperostosis, while 25 (23%) displayed cribra orbitalia and/or porotic hyperostosis with additional periosteal lesions (See Table 4). The Mouse Creek population contains the highest percent of anemia victims with 28 of 42 (66%) individuals exhibiting cribra orbtialia and/or porotic hyperostosis. None of the 28 individuals displayed additional periosteal lesions.

Figure 1 shows that Sully has the highest proportion of individuals with cribra orbitalia and/or porotic hyperostosis accompanied by periosteal lesions compared to individuals with only cribra orbitalia and/or porotic hyperostosis. Yet, Sully has the lowest percentage of total anemic individuals. Mouse Creek has the highest percent of individuals with only anemic lesions, as well as the lowest number of individuals with periostits. In addition, Libben has the highest percentage of anemia victims with periosteal infections.

Following previous methodologies used to infer anemia in skeletal remains (Boyd 1984, Parham 1992, Todd 1994) the results presented by this study would have been interpreted by diagnosing the 11 (6.3%) individuals with cribra orbitalia as having nutritional deficiencies. However, when those individuals manifesting both cribra orbitalia and periosteal lesions are separated out of the population, even more information can be gained because the presence of infection indicates that the anemia was a secondary response to disease. If we exclude those cases of cribira that are associated with periostitis, then a different picture of the population's diet emerges (i.e. their adaptability to their environment). This is especially true when comparing anemia frequencies of populations in different locations and with different cultural practices.

As previously stated, studies of radiology, parasitology and anthropology (Ubelaker 1992, Shmidt and Roberts 2000, Ortner and Putschar 1981) subscribe to bacterial and viral infection being a primary cause of anemia. In fact, when looking at the levels of circulating serratin in the body, many studies of iron deficiency have shown infection to be a larger contributor to anemia than diet. Therefore, individuals displaying chronic signs of infection (i.e. periostitis) should be eliminated from the data when conducting a dietary profile of past populations.

In this study, I found only four juveniles (2%) who displayed cribra oritalia alone. Bearing in mind that the site had an approximately one hundred-year occupation, this finding indicates an adequate diet. This hypothesis is also supported by the analysis of the archaeological data (Jantz et al. 1971, Lehmer 1971, Key 1983, Rodgers 1990, Johnson 1994). While meat was not a primary nutrient in their diet, and there were times of famine, the wide variety of plant foods would have supplied adequate folate and iron to have prevented chronic anemia from occurring.

In addition, analysis of the descriptions of the Arikara culture (Jantz et. al. 1971, Lehmer 1971, Key 1983, Rodgers 1990, Johnson 1994, and Bass and Stephenson unpublished manuscript) shows that sanitation was relatively good so transmission of parasites would be restricted. They did not use fertilizer on their fields, so the absence of human feces would prevent fecal contamination of foodstuffs. Also, the villages were dispersed along a flowing body of water contributing to positive sanitation practices. These living conditions do not lend themselves to chronic infection of parasites, especially when added to the cold and dry climate of North Dakota. With good sanitation practices and adequate diet, the only etiolology of anemia left to analyze is weanling diarrhea in infants. Considering the small percentage of anemic individuals, the weaning practices of the Arikara communities probably included an extended lactation period that would have bolstered the child's immune system to significant levels, which would support Gonzalez's (1969) suggestion of lengthy lactation periods in early Native American populations that have been discussed previously.

My finding of a 2% rate of chronic anemia caused by dietary stress in the Sully population is more strongly supported by the archaeological and historic records than would the higher rate of 6% that would have been yielded had individuals with periosteal infections not been eliminated. Although much more information can be ascertained about a population's diet by adopting this practice, previous studies (Parham 1992) of IDA have failed to separate cribra orbitalia and porotic hyperostosis from other signs of disease and infection. In these previous studies, skeletons that exhibit cribra orbitalia and or porotic hyperostosis might also have periosteal lesions, thereby artificially inflating the instances of

IDA in a population. Therefore, where the raw data are available, I compare my results with those obtained from other sites.

The Libben site

The Libben Site from the Ohio River valley was occupied a few hundred years before the Arikara moved into the Missouri River valley. Their settlement was one of similar construction to the Sully site, consisting of small lodges placed along the riverbanks, although the Libben population was considerably larger than that of Sully. Floral and faunal analysis indicated a diet rich in animal protein but with little evidence of plant foods (Mensforth et al. 1978).

Mensforth (1978:20-21) and his colleagues analyzed 241 juveniles from the Libben cemeteries. They produced one of the only studies that took into account the manifestation of chronic anemia due to infectious disease because "most nutritional deficiencies are either precipitated by, or aggravated by infectious diseases in individuals with borderline nutrient supplies." Their investigation produced results in which anemia frequencies could be associated with specific causes (see Table 4). Compared with Sully, Libben has a higher number of anemia cases (18% more than Sully when specimens displaying periosteal lesions are removed) even though both populations have a diet rich in meat. There are two possible explanations for this difference: (1) that increased population leads to both crowding and sanitation problems, thereby increasing pathogen loads; (2) a folic acid deficiency (i.e., pernicious anemia). While pernicious anemia is downplayed in current studies, it is possible that red blood cells were less efficient because of a lack of folate, especially considering that Mensforth (1978) found little evidence for plant food staples in the Libben diet. If their diet was lacking in folate, pernicious anemia could have led to an increased susceptibility to diseases, just as IDA would, accounting for the increased periostitis frequency as well. The Libben population was nutritionally disadvantaged compared to Sully because there was a lack of plant food, not meat. Because the Libben peoples were anemic (or borderline anemic) they would have been more susceptible to infection, resulting in the higher amount of periosteal lesions accompanied by the cranial lesions.

Pernicious anemia seems to be the most valid argument for the difference. If an increase in population size led to higher frequencies of anemia, you would expect to see a higher number of periosteal lesions in proportion to the cribra orbitalia. This is because decreased sanitation leads to the increase in bacterial disease, which could eventually manifest symptoms of chronic anemia as a secondary response; the primary response would be other skeletal lesions. Therefore, the increased crowding would have led primarily to more periosteal lesions, and secondarily to anemic lesions. However, only half of the population displayed both anemic lesions and perisotitis. In addition, the population was malnourished enough for 21% of the children to develop chronic anemia without the presence of other diseases. This would indicate that diet is the primary contributor to the development of these anemic lesions. In summary, for bacterial or viral infection to be the main cause of the anemia, periosteal lesions would be found on more of the skeletons with cribra orbtialia and perotic hyperostosis because infection would be the primary cause of the anemia. Yet, the opposite was found to be true with the Libben site because there was a substantial increase (compared to the Sully site) of skeletons with only the cranial lesions.

The Mouse Creek site

The Mouse Creek skeletal collection is from the Appalachian Summit Region in eastern Tennessee. Corn is hypothesized to be a common domesticate among the Mouse Creek population. However, Lewis and Knedberg (1941:7) found "the bones of deer, rabbit, squirrel, wild turkey, turtle and fish were abundant in the refuse of Mouse Creek communities" (cf. Boyd 1984). Although corn was utilized, there is evidence that other (iron supplying) resources were also consumed. Other than times of famine in the winter, which has been established as being customary (Gonzalez 1969), the village had both meat and plant foods available. Yet, the population has 64% more cribra orbitalia then Sully and no cases of periosteal lesions associated with the cranial lesions. Because there are no cases of periosteal lesions associated with cribra orbitalia and or perotic hyperostosis, a nutritional etiology can be deduced as the primary cause of the anemia. However, as noted above, according to the archaeological data the Mouse Creek people probably had sufficient nutrients in their diet. Therefore, anemia must be caused by a nutritional deficiency that occurs for a reason other then diet (such as parasites or weanling diarrhea). Little is known about the cultural practices of the Mouse Creek people, such as the use of human feces as fertilizer and lactation periods. Because we do not know if children were weaned with a corn gruel, or at what age they were weaned, weanling diarrhea could have been a significant contributor to the development of chronic anemia, possibly accounting for the variation in anemia frequencies.

What can be established is that the anemia of the Mouse Creek population is caused by a nutritional deficiency because none of the skeletons that manifested porotic hyperostosis and or cribra orbitalia had any sign of other infection or disease. When compared to Sully, there is a drastic difference in the frequency of anemia. Even though both communities appear to have sufficient food supplies and decent sanitation, Mouse Creek has many more victims of chronic nutritional anemia. Weanling diarrhea is the one factor that cannot be controlled for in this situation other than that, by deduction, we know that Sully children seemed to suffer little from it. Therefore, the probability that it was weanling diarrhea that caused the variation seems likely.

CONCLUSION

The bacterial and viral diseases that eventually cause chronic anemia initially cause other osteological manifestations (ie. periostitis, osteomylitis and pathologic bone deformities). Therefore, skeletons displaying evidence of chronic anemia and chronic infection should be eliminated from a dietary profile because it is probable that the infection led to chronic anemia rather than anemia caused by dietary insufficiency. Overall, when utilizing this method of deduction, 6.3% of the anemia cases are eliminated from the Sully site, from the Libben site 56% of the anemia cases are removed, and none from the Mouse Creek site are removed. Reducing (or sustaining) the number of individuals potentially afflicted by dietary anemia drastically changes the researcher's perspective on resources available to the study populations, as well as the differences in the various populations' life-styles that would have impacted their lives so differently.

A possible variation in life-style might have been exposure to parasites. However, they all were in well-dispersed villages that had a significant supply of running water, and if human feces were used at all, it was limited. These factors would have reduced the prevalence of parasites. Also, it is worth restating that in most cases it is only if diet is insufficient that a victim will display signs of chronic anemia due to a parasite infection.

Weanling diarrhea is probably the most difficult variation to address because there are no definitive ways of knowing the traditional lactation periods. However, this is something that must always be kept in mind when evaluating specific case studies. For example, it is not a significant contributor to the Sully population because there is not a high prevalence of anemia, however, in the case of Mouse Creek, because there are no periosteal lesions, and there is a high number of anemia victims, while diet is considered fairly balanced, weanling diarrhea might have been a large factor in the development of chronic anemia.

Diet is the main etiology of anemia addressed in this paper. Archeological data from all of these sites suggest that everyone had a steady supply of iron, and that Libben was the only population that might have had a folate deficiency. For more information to be attained on the effects of dietary anemia, a differential study such as the one presented here must be used to analyze maize-dependent societies. Researchers like Parham (1998) have already conducted such skeletal analysis, however, the cases where anemia is a secondary response to infection have not been eliminated, that is anemia of chronic disease is included as evidence of dietary stress.

In this study, infectious lesions were included in the differentiation of anemia so that the possibility of infection causing the cribra orbitalia and porotic hyperostosis in the study populations can be eliminated giving a much more accurate estimate of dietary anemia in past populations. From the evidence presented here, I believe the Sully population was healthy as a result of adequate nutrition, while the Libben population was possibly affected by a folate deficiency (i.e. pernicious anemia), and the Mouse Creek population was possibly affected by weanling diarrhea. These conclusions can be drawn because anemia caused by chronic infection was compared to anemia caused by nutritional deficiencies, something that must be taken into consideration when analyzing future dietary profiles of Native American cultures.

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Table 1 Infectious Disease Leading to Anemia of Chronic Disease

Infection	Causes Anemia Primary/Secondary Response	Duration of the Disease long enough to develop bone modifications	Osteological Markers of Disease present (other then those caused by anemia)	Present in North America	Source
Osteomyelitis	Secondary	Yes	Yes	Yes	Kaschula 1995; Larson 1992; Ortner 1992
Trauma (Infected wound)	Can be Primary	No	Yes	Yes	Larson 1992; Ortner 1992
Syphilis	Can be Primary	Yes	Yes	Possibly	Larson 1992; Ortner 1992
Infantile Corticle Hyperostosis	Secondary	Yes	Yes	Possibly	Kaschula 1995
Hyperparathyroidisim resulting from hypocalcemia	Secondary	Yes	Yes	Yes	Kaschula 1995
Toxoplasmosis	Secondary	Yes	Sometimes	Extreme southern regions	Larson 1992; Ortner 1992
Sporotrichosis	Rarely, secondary if it occurs	Yes	Yes	Yes	Kaschula 1995
Coccidoidomycosis	No	Yes	Yes	No	Kaschula 1995
Baceraemia and Septicemia	Secondary	Yes	Yes	Yes	Kaschula 1995
Hypo and Hyperthyroidisim	Primary	Yes	Yes	Yes	Kaschula 1995
Absorbic Acid and Copper deficiency	Secondary	Yes	Yes	Yes	Kaschula 1995
Menningitis	Secondary	Yes	Yes	Yes	Kaschula 1995; Larson 1992; Ortner 1992
Periosteal lesterrosis	No	No	Possibly	Yes	Kaschula 1995
Congenital Cyonogalourus	Primary	Yes	Yes	Yes	Kaschula 1995
Tuberculosis	Secondary	Yes	Yes	Yes	Larson 1992; Ortner 1992

Table 2: Parasites Contributing to the Development of Chronic Anemia

Parasite	Will it contribute to IDA development?	Why/ Why not	Habitation of North America prior to 1700s	Possibly contribute to Native American IDA	Source
Plasmodium (malaria)	Yes	sickle cell, binds to hemoglobin	No, brought by first explorers	No	Larson 1997; Kelton 1998; Smith 1987
Enterobbius vermicularis (pinworm)	No	does not effect blood stream or lumen of the stomach or upper GI tract	Yes	No	Schmidt and Roberts 2000; Reinhard 1992; Larson 1997
Trichuris trichura	Yes	effects hemoglobin directly	Extreme southern regions of the continent – with poor sanitation	Yes, in southern areas	Schmidt and Roberts 2000
Ascaris lumbricoides (tapeworm)	Yes	feeds off of contents of GI tract	Yes	Yes	Stuart-Macadem 1995; Schmidt and Roberts 2000
Stronglyoides	only rarely - effects immunocompromised individuals	Does not effect blood stream	Possibly	Possibly	Larson 1997; Schmidt and Roberts 2000
Shistosoma	Yes	Effects blood stream directly	No – brought to North America with Slave trade	No	Schmidt and Roberts 2000
Necator americanus and Anclyostoma duodenale (Hookworm)	Yes	Feed directly on blood stream	Yes	Yes	Faulkner 1991; Schmidt and Roberts 2000; Allison et al 1974

Table 3 - Results From Sully Site

	Total Cases From Sully	Percent of Individuals Affected
Total Cribra Orbitalia and Porotic Hyperostosis	11	6.3
Only Cribra Orbitalia and Porotic Hyperostosis	4	2
Cribra Orbitalia, Porotic Hyperostosis and Periosteal Lesions	7	4

Table 4 Results from Mouse Creek and Libben Sites

	Total Cases From Libben	Percent Of Individuals Affected	Total Cases From Mouse Creek	Percent Of Individuals Affected
Total Cribra Orbitalia and Porotic Hyperostosis	107	44.4	28	88
Only Cribra Orbitalia and Porotic Hyperostosis	24	21.2	28	66
Cribra Orbitalia, Porotic Hyperostosis and Periosteal Lesions	25	23.2	0	0

Winning Entry 2003 SAS Student Paper Competition: Graduate

The Domestic Mode of Production and Risk Management in Quintana Roo, Mexico

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Introduction

Marshall Sahlins's theory of the domestic mode of production (hereafter, DMP) held great import for the analysis of peasant economic systems. In short, this theory states that "primitive" economies, generally based on domestic groups and kin relations, are inherently underproductive. The net result of the underuse of land and labor is that most households barely eke out a subsistence. Though the DMP describes an idealized situation that Sahlins admitted probably does not exist, many economic anthropologists take the DMP to heart (Brush 1977; Donham 1981; Reyna 1994). Unfortunately, most modern ethnographic research fails to incorporate the type of quantitative data necessary for testing Sahlins's theory. Furthermore, the increasing market integration of once peripheral areas means that many ethnographic field sites violate some of the DMP's basic assumptions. For these reasons, the data presented here are from an older ethnographic source, Alfonso Villa Rojas's study of the Maya of east central Quintana Roo, Mexico (Villa Rojas 1945). Villa Rojas provides data on the agricultural production and demography of 52 households, but gives no in-depth analysis of this data. Since his data on household agricultural practices are of superb quality and this case meets all of the underlying assumptions of the DMP theory, we have before us the ability to quantitatively test Sahlins's model. In doing so, we see that the DMP does not accurately describe the productive activities of the Maya of Quintana Roo. On average, households are overproducing, i.e., producing much more than is necessary to meet their basic subsistence requirements. One explanation for this overproduction is that households overproduce in an attempt to mediate environmental variation. This conclusion points to one of the underlying weaknesses of Sahlins's theory – his failure to adequately include the environment as a factor affecting household production and risk management.

As anthropologists, why should we bother with a critical examination of a theory whose heyday

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has passed and which has already been subject to enormous criticism? Two reasons immediately come to mind. First, the underlying argument of Sahlins's theory of the DMP has been unconsciously, if not sometimes uncritically, absorbed by many economic anthropologists. As a discipline, we should constantly check our premises rather than rely on accepted and oftentimes stale theoretical models. In this way, our theories for explaining cultural behavior become more sophisticated, as do the models that these theories generate. Fortunately, the centennial of American anthropology encourages many anthropologists to take such a critical historical perspective.

Second, while an in-depth discussion of an older theory in light of even older data may seem outdated, to say the very least, the situation described by the DMP model, as well as the circumstances encountered by the Mayan farmers in Quintana Roo in the 1940s, are quite contemporary. At the heart of the DMP model lies strategies for risk management. The peripheral areas which Sahlins hoped to describe with this model still exist and have become even riskier environments due to market integration and the impact of globalization. Now, more than ever, an understanding of risk management strategies is critical, particularly because of the implications this understanding may have for theories of development and our understanding of globalization as a local process.

The Domestic Mode of Production

According to Sahlins (1972), the domestic mode of production characterizes economies that are organized on the basis of domestic groups and kin relations. In such a system, production is geared towards the requirements of a household or family unit, and this production is for the benefit of the producers alone (1972:77). Three interrelated elements make up the DMP. First, the household consists of a small labor force with a division of labor by sex. In this regard, the household appears much like the peasant farm described by Chayanov (1986); the labor force available to the household is constrained by the number of people in the household. Members of the household neither engage in wage labor, nor do they hire wage laborers. Second, the household uses simple technology. The technology must be compatible with the household's organization and must be of a similar dimension or scale (1972:79). For example, a peasant household would not use a combine to harvest its maize nor would a multinational agribusiness use a dibble to till soil and sow crops. Third, these economic systems have finite production objectives and more specifically, are oriented towards subsistence rather than market production. In Sahlins's model of the DMP, as in Chayanov's theory of peasant economy, the household produces for its own consumption and exists outside any developed marketing system.

The implication of these three elements is that the DMP under-uses the available resources, particularly land and labor. Much of Sahlins's quantitative data come from slash and burn agriculturalists and demonstrate that actual production in much less than is possible (1972:42). In more ecological terminology, those groups characterized by the DMP live well under the carrying capacity of their environments. Rather than arguing that the environment is a factor influencing agricultural production, Sahlins claims that sociocultural organization, that is, the domestic organization of production, impedes the development and intensification of productive means.

The Maya of East Central Quintana Roo

Villa Rojas studied the Maya of east central Quintana Roo during 1935 and 1936 as part of Redfield's comparative project on the "folk culture" of the Yucatan (Redfield 1941). Four communities were compared, Merida, Dzitas, Chan Kom, and X-Cacal, each of which represented a different degree of cultural development in Redfield's folk-urban continuum (See Figure 1)[Note: Figures are found at end of article.]. Redfield intended X-Cacal to represent the most "primitive" of the communities. While Redfield's folk-urban continuum no longer survives as a viable model, the ethnographic data generated by his and Villa Rojas's work is impressive. As with much older research, these ethnographies contain a wealth of information, some of which has yet to be fully analyzed.

Villa Rojas describes Quintana Roo as divisible into three zones, the northern, central, and southern, with the central or "native" zone being the focus of his study. Concentrated here are Mayans who "are characterized by seclusiveness, by a hostility toward civilization, and especially by their dislike of the Mexican Government. These traits, together with scarcity of roads and other means of communication, have kept this a marginal region" (Villa Rojas 1945:40). Within this central zone, the X-Cacal sub-tribe is particularly known for its self-imposed isolation and hostility to outside influence. For example, only one community, Chanchen, tolerated the presence of a schoolteacher and this for only a short period of time (Villa Rojas 1945:42). The route to the village is very seldom ever traveled, and very few non-natives are ever seen in the pueblos. Travelers and strangers passing through the territory of X-Cacal are not allowed to sell anything in the pueblos, nor are they allowed to remain in a pueblo for more than one night (Villa Rojas 1945:42). Only two or three known itinerant merchants are tolerated. In many ways, the X-Cacal Maya of the 1930s exemplify a closed corporate peasant community (Wolf 1957).

The X-Cacal sub-tribe is composed of nine settlements, all of which are quite small (see Figures 2 and 3). While Villa Rojas concentrated on Tusik and X-Cacal, the most important villages of the sub-tribe, he collected data on all nine settlements. The residents of these pueblos share a common culture, including a fusion of Catholicism and traditional Mayan religious beliefs, maize agriculture, very little accumulation of wealth, exclusive use of the Mayan language[1], and an emphasis on extended family relations. Marriage is village exogamous, leading people to view the sub-tribe as one very extended family (Villa Rojas 1945:44). Given this marriage pattern, numerous ties exist between communities. But even though close relatives may live in other communities, people only leave their village three or four times a year and only for special occasions (such as births, illnesses, and fiestas) or ceremonies which require their presence in another pueblo (Villa Rojas 1945:44). The distribution of population is fairly stable, and negligible amounts of in-migration and out-migration occur. Only within the 1930s did people from X-Cacal migrate to the commercial centers of Valladolid and Peto, 168 km and 192 km respectively; Villa Rojas claims that this is because the X-Cacal Maya are "somewhat afraid to appear among the Whites." Trips are infrequently made to Valladolid and Peto to purchase knives, machetes, whiskey, salt, pepper, and clothing and to Belize (then British Honduras) to sell pigs (Villa Rojas 1945:45).

Given the basic assumptions of the DMP and their implications, the X-Cacal Maya of east central Quintana Roo are the perfect test case for Sahlins's theory. First, X-Cacal households correspond to family units with a division of labor by sex. This division of labor is symbolized in the ceremony called *hetzmek*, whereby infants are "baptized" and presented with the tools with which they will work for the remainder of their lives. Females, whose lives are to center around the household and the three stones of the hearth, are given weaving implements and cooking utensils. Males, whose lives are to center on the four stones marking the boundaries of their corn field (*milpa*), are presented digging sticks and machetes. As infants grow into productive members of the community, they learn to perform the activities associated with the items they are given during the hetzmek ceremony. Women are responsible for all housework, including the preparation and grinding of maize, cooking, washing, sewing, embroidering blouses (huipiles), and fetching water from the well.

Women also act as midwives, care for domestic animals, raise small gardens near the house, and make cigarettes. Though firewood is cut by men and boys alone, windfall and downed limbs may be gathered by women. Public and religious functions are the responsibility of men, but women may play a secondary role in religious ceremonies. Likewise, men are responsible for the milpa, though women may assist in weeding, sowing, and harvesting. Men do all work requiring the use of a machete or axe; hunt; care for beehives; make candles, hats, and baskets; and extract chicle (Villa Rojas 1945:70).

Second, the slash-and-burn technology used by the X-Cacal Maya is relatively simple. The livelihood of the X-Cacal Maya depends on the milpa: its selection, preparation, maintenance, and harvesting. Once a plot of land is selected, the existing brush is felled with axes and machetes purchased in Valladolid. After the brush is sufficiently dry, it is burned over, and the milpa is ready for planting. A pointed stick (xul) tipped with iron is used for digging holes about a pace apart. After making the hole, the farmer plants five or six maize kernels, plus squash and beans. The seed is carried in a shoulder bag (sabucan). The crop grows, is weeded once or twice, and eventually is harvested and stored (Villa Rojas 1945:56-57). Thus, the main technological requirements of this economic system are axes, machetes, fire, and a pointed stick, all relatively simple.

Third, the X-Cacal sub-tribe exists outside of the marketing areas of any nearby towns (see Figure 2). Villa Rojas describes the entire region as extremely isolated and hostile to outside influence (Villa Rojas 1945:42). Routes of communication here were in bad condition during Villa Rojas's fieldwork, and roads were only useable during the dry season. During this time, November to April, itinerant merchants came through the area, and people were able to make any necessary purchases of knives, axes, clothing, and so forth. Only two or three recognized merchants were allowed to trade in the pueblos. All other travelers "were objects of suspicion, whose every attempt to engage in friendly conversation was evaded" (Villa Rojas 1945:42). Villa Rojas, who remained in Tusik and X-Cacal for some time, was still regarded suspiciously in the other pueblos. Furthermore, as other villages in the central zone were increasingly receptive to outside influences, including the federal government, cooperative organizations, and schoolteachers, the X-Cacal Maya were becoming relatively more isolated.

Given this isolation, the X-Cacal Maya engage in a negligible amount of commercial activity. The primary item of consumption throughout the area is maize, and given the difficulties of transporting it any distance and the X-Cacal's dislike of outsiders, very little of it goes for commercial purposes (Villa Rojas 1945:59). Only rarely is maize sold to muleteers and itinerant merchants for their animals and then only in emergencies. Chicle production is of secondary importance, engaged in very occasionally and undertaken on individual initiative. When presented with the opportunity to develop chicle extraction as a commercial endeavor through the establishment of a government cooperative organization, the X-Cacal Maya flatly rejected the idea (Villa Rojas 1945:40-42). Only one pueblo, Chuncunche, has anything resembling a craft specialization. Straw boxes are made and sold in Chuncunche, but no other village specializes in any industry or product (Villa Rojas 1945:44). The very occasional journeys that people make to Valladolid and Peto generally have no commercial purpose whatsoever. During Villa Rojas's fieldwork, he noted only one such excursion, when a man who owned a horse carried a tin of lard[2] into the city to exchange it for whiskey (Villa Rojas 1945:45-46).

Based on these three characteristics, division of labor by sex, simple technology, and production for consumption, Sahlins predicts that such a group will not fully exploit their available labor and land resources. An examination of available data shows that the X-Cacal Maya fulfill each of these predictions, as much labor time and land are either unused or used for non-economic activities.

First, labor resources are under-used. Villa Rojas (1945:77) provides data on the distribution of time, by days, for an average man of the Tusik pueblo[3] (see Figure 4). Only half of the average man's time, or 186 days, is devoted to labor. Of labor time, only 75% or 141 days was devoted to agriculture, the basis on the X-Cacal economy (Villa Rojas 1945:77). Therefore, the average man has much room to reallocate the distribution of his time in favor of economic activities, yet fulfill his religious obligations and have the occasional diversion. Figures 5 and 6 show the distribution of time between labor, religious obligations, and diversions, as well as the distribution of time among four types of labor activities (agriculture, chicle extraction, hunting, and beekeeping).

Therefore, the labor resources of the average man are not fully exploited, as nearly half of available labor time is spent fulfilling religious obligations, attending fiestas, visiting kin, or sitting idle. Furthermore, Sahlins would argue that the division of labor by sex contributes to the under-use of labor resources (1972:54). Women seldom participate in agricultural activities, and when women do assist their male relatives and husbands, they are restricted to weeding and harvesting. Women are not physically incapable of agricultural work, nor do their household duties consume all of their available time. As a whole, then, the X-Cacal Maya under-use their available labor resources.

As predicted by Sahlins's theory, the X-Cacal Maya also seem to under-exploit the available land resources. According to Villa Rojas's calculations, there must be between 36 and 42 mecate (0.0828 to 0.0966 km^2) of land available per person over the course of a lifetime.[4] This estimate takes in to account the standard of living, the prevailing techniques of maintenance, variations in soil fertility, and necessary fallow time (Villa Rojas 1945:60). The population of the X-Cacal sub-tribe is 720 people distributed in 9 communities. Given this population, there must be between 59.61 and 69.55 km^2 of land available for the sub-tribe as a whole. The total territory of the sub-tribe is 1625 km^2, well over the necessary upper limit of 69.55 km^2. Thus the X-Cacal sub-tribe under-exploits their available land resources.

The DMP's prediction, based on the above information, would be that the X-Cacal Maya have a domestic mode of production. Therefore, their failure to fully exploit the available labor and land resources translates into widespread under-production. Rather than investing more time and energy into agricultural production, people would develop other aspects of their culture, e.g., religious activities, diversions, and social relationships, as seen in Figures 4 and 5. An examination of Villa Rojas' data show that this prediction does not hold true. In fact, the X-Cacal Maya, on average, over-produce.

Household production in Quintana Roo

Villa Rojas provides data on 52 households for the agricultural season of 1935-1936. These data come from five of the nine villages of the X-Cacal sub-tribe and are slightly weighted to the pueblos of X-Cacal and Tusik. Given that these are two of the larger and more accessible settlements, this distribution is not surprising. And given the relative homogeneity of the X-Cacal sub-tribe, this distribution should not significantly impact the data. Villa Rojas' goal was to provide an estimate of the area's total maize production. To this end, he presents data on area planted and amount of maize harvested and breaks this down by type of milpa planted. Farmers in this area recognize three types of milpa.

Chacben: first year plots, when the high brush must be felled,

Zakab: second year plots, when the regrowth must be cleared and burned, and

Hubche: land that is fallow after being planted for several years and will eventually by re-planted.

The land in this area is moderately fertile, but fertility declines yearly as the soil of a particular plot becomes depleted. Morris Steggerda's informants in the northern part of the Yucatan at roughly the same ethnographic period estimated that a plot of land produced half the yield in the second year that it produced in the first. Steggerda's own field experiments demonstrate that this estimate is exaggerated. He found that yield declined by an average of 17% in the second year (Steggerda 1941:119-120). In terms of the types of milpas listed above, "the harvest is satisfactory if the produce amounts in terms of the average mecate to: 1 carga in milpa chacben; 0.6 carga in milpa zakab; and 0.8 carga in milpa hubche" (Villa Rojas 1945:60). Given the variability of the different types of milpas and the extra time and labor needed to prepare the more fertile types, farmers usually prepare two tracts of land a year, one in chacben and the other in either zakab or hubche. A tract is chosen and measured off, and the brush is felled from December until beginning of April. The first rains are believed to fall on St. Mark's Day, the 25th of April, so the burning and preparation of the milpa must be completed in the first two weeks of April but no later than the end of May (Villa Rojas 1945:56-57).

Figure 7 shows the data that Villa Rojas presents for the 52 households he studied. The only modification made is to convert cargas into kilograms (1 carga = 46 kg). More specifically, this table presents data on the type of milpa planted and the amount of maize harvested from each plot.

To arrive at an estimate of household overproduction, we must first determine the amount of maize necessary for each household to subsist. Thus, we must look at the number of people in each household and the amount of maize needed per person. Villa Rojas included data on household demography, and Steggerda's work gives a fairly precise estimate of the amount of maize consumed per day per person. He calculated that the average person consumed 1.43 lb or 0.64 kg of maize per day.[5] Also, he found that households fed an average of 3.5 lb or 1.58 kg of maize per day to their domestic animals, namely swine and poultry, regardless of the number of animals they had (Steggerda 1941). Thus, we can arrive at the amount of maize needed for each household in a year by multiplying the number of people in the household by the amount of maize needed per person per day, adding in the amount of maize fed to domestic animals per day, and multiplying all of this by 365. This calculation represents the minimum needed for that household for one year and is shown for each of the 52 households in Figure 8. Any maize produced over the amount needed to feed the members of that household and their domestic animals is classified as overproduction, while failure to meet this minimum standard is under-production (italicized in Figure 8).

Because subsistence farmers should plan to produce at least this minimum amount of maize, we next calculate their expected harvest. Again, this is a rather straightforward calculation, given that we know the areas for each type of milpa planted for each household and the expected yield[6] for each type of milpa. We can then compare the minimum amount necessary to subsist with the amount expected at harvest time. This figure indicates the planning and management that each household does in order to allocate their land and labor resources. In terms of testing the DMP, the comparison of necessary harvest and expected harvest is crucial. Assuming that each household unit knows how much maize is necessary for their survival (and there is no reason to believe otherwise), the DMP predicts that the household would take this as its goal, i.e., each household will plan to produce just enough to subsist and nothing more.

Figure 8 shows the total amount of maize necessary, expected, and harvested for each of the 52 households. Some households, like #33, come very close to planting exactly what is necessary to subsist. Others, like #30 and #35, do not plant enough to meet their subsistence needs based on expected yields. As it turned out, this agricultural season was slightly better than expected, and these households do manage to plant enough to survive. What is most startling about these calculations is that the majority of the X-Cacal farmers are planning to over-produce. They are planting well above what they need to survive, as shown by the difference between the amount of maize necessary and the expected harvest based on area and type of milpa planted. These figures are graphically represented in Figure 9. Positive figures indicate that a household planned to produce more than was necessary, while negative figures show that the household planned to produce less than was necessary for the survival of that household. On the whole, households are over-producing; the average difference between expected yield and the amount necessary is 1,292 kg per household. If the X-Cacal Maya were part of a developed marketing system and had access to reliable transportation, such over-production is to be expected. Everything that the household did not consume could be sold in the market. However, in the absence of a marketing system, as is the case here, such over-production makes very little sense, and the obvious question arises: Why over-produce?

Overproduction among the X-Cacal Maya

One explanation for agricultural overproduction is that some households will over-produce, while others will under-produce. Under-producers can then call upon over-producers when they are in need, and everything within the social system averages out in the end. As Sahlins hypothesizes, the difference between over- and under-production is evidence of social organization and reciprocity. While this may explain his test case, this interpretation does not explain overproduction among the X-Cacal Maya. Sahlins' explanation can be disregarded for two reasons.

First, Villa Rojas states that cooperation between households and villages is uncommon among the X-Cacal Maya. Undoubtedly some reciprocity occurs within families or households, but the overall impression that Villa Rojas gives is that households produce for themselves alone. The only time that large-scale cooperation occurs is in response to an external threat from the federal government. Even communal work parties, so common just to the north in Chan Kom (Redfield and Villa Rojas 1934), are extremely rare among the X-Cacal Maya. Therefore, the individualistic nature of each household unit seems to preclude reciprocity as an explanation for overproduction.

Second, and more convincingly, the average per household production is much higher than is to be expected. For the entire X-Cacal area, households are overproducing. Even if the under-producing households drew on the resources of the over-producers, as Sahlins claims that they will, a net surplus still exists. And, this net surplus is large. The average household is producing over 1,200 kg of maize more than is necessary. At the end of the agricultural cycle, a huge surplus remains, yet there is no apparent mechanism for the disposal of this surplus.

The conclusion to be drawn from the data presented here is that the DMP does not explain the situation of the X-Cacal Maya, even though this case meets all of the basic assumptions of the model. One explanation for the failure of the DMP to explain this case is that Sahlins failed to include risk management in his model. In subsistence agriculture, the main source of risk is environmental variation. In variable environments, farmers will plan differently than if they did not have to deal with such variation. One strategy that farmers around the world have developed for dealing with this variation is agricultural overproduction. But first, what is the evidence for environmental variation in the X-Cacal area?

Climate and Risk Management

The climate of Quintana Roo is very similar to that of the rest of the Yucatan peninsula. Nights are cool and days warm. The average temperature is 78° F and rarely ever drops below 50° F. Villa Rojas

(1945:39) states that the temperature may drop to 38_ F, but an examination of weather records from Chichen Itza shows that this must be a very rare occurrence indeed (Steggerda 1941). While temperatures are quite important to agriculture in areas where they are more variable, for example the Mexican highlands, they do not appear to be a factor significantly impacting the agriculture of the Yucatan.

What does greatly impact agriculture in the Yucatan is rainfall. The year can be divided into two seasons based on amount of rainfall rather than on temperature. Figure 10 shows monthly rainfall for the years 1928 through 1935 as recorded by the Chichen Itza weather station (Steggerda 1941:132-133). The rainy season apparently begins in May and lasts through October; therefore the traditional belief that the rains begin on St. Mark's Day, the 25th of April, is fairly accurate. In the interior areas of the Yucatan, including the X-Cacal area, precipitation varies from 60 to 80 inches. Records show that precipitation can be three or four times the average in some years (Villa Rojas 1945:39). The dry season begins in November and lasts through April. Very little rain falls during these months, and a cold north wind blows over the land (Steggerda 1941:130).

Variation in rainfall can significantly impact the agricultural cycle, as all phases of slash-and-burn agriculture as practiced by the X-Cacal Maya must coincide with the most favorable weather conditions. Just before the maize crop ripens, men select their fields for the following year. The brush is cut and allowed to dry through December, January, and February, ordinarily months of little rainfall. In March and April, also months of little precipitation, farmers burn the brush in preparation for sowing the crop in May. Should heavy rains fall during these months, as it did in 1928, the brush will not dry, and the fields cannot be properly burned. Thus, less area can be planted. According to Steggerda (1941:131), May is the most critical month, for little rainfall may portend a famine.[7] Again, this was the case in 1928. Very little rain fell in May and June when the maize should be making its most rapid growth, and this drought caused famine conditions in 1929. Throughout the typical summer, though, the maize grows and matures, until September when the ears are bent down. Bending the ears prevents rain from running into the ear and causing various molds that ruin the crop. Harvest takes place from November through the beginning of the next agricultural cycle (Steggerda 1941:131-135).

Given that precipitation is so variable in its timing and amounts, farmers must plan, and this planning is the key element missing from the DMP model. For example, early rains may prohibit the proper burning of one's fields, thus restricting the amount of land available for cultivation. Therefore, the sensible thing to do is to clear a bit more than is needed so that in a year with early rains, enough land can be burned to plant a full crop. Drought may dramatically decrease one's harvest, so planting more than is needed is a way to mediate that risk. Plagues of rats and grasshoppers, in addition to the normal predation of animals on crops, also pose a risk for which farmers must plan. Again, the best bet is to over-produce. This strategy is used by farmers elsewhere to adjust to unpredictable environmental variation. In Melanesia, for example, "planting what will be more than enough should the weather be good is a means of ensuring that there will be enough or possibly just barely enough should the weather be bad" (Vayda, Leeds, and Smith 1961:70). According to Vayda, Leeds, and Smith, this adaptation exemplifies Liebig's law of the minimum, as farmers are planning for the extreme case rather than the average outcome. Thus, when subsistence farmers like the X-Cacal Maya are over-producing, and doing so in such a large amount and in the absence of a marketing system, they are experiencing cooperative weather conditions and a good agricultural season. They have planted more than is necessary – just in case the rains come early, or a drought hits in May, or some other environmental upheaval occurs.

Granaries and Piggy Banks

When harvests are more than adequate, what is to be done with the surplus? Several options immediately come to mind. Sell the extra maize: but given the lack of a developed marketing system, poor road conditions, and unreliable transportation, marketing is not feasible for the X-Cacal Maya. Eat more food: but a person can only eat so much until they are satisfied. Have more children who can eat more food: but this is an impractical solution with long-term consequences. Store the maize until it is needed during the next food shortage. Of the possible options, storage makes the most sense and is the easiest to accomplish. More importantly, storage of food allows environmental vicissitudes to be overcome more easily. Should a risk-conscious farmer plant more than enough maize, but a severe drought or flood destroys most of the crop, the harvest may still fall short of the amount needed to feed the household. But, maize that has been stored can be used to survive this slim season in the hopes that next year's harvest will be more bountiful. In fact, the X-Cacal Maya try to store enough maize to make it through two or three lean years (Villa Rojas 1945:60).

The X-Cacal Maya can store their surplus maize in one of two ways. The more widely acknowledged method of storage is a granary. Usually a small structure is built near the milpa, and maize is stored there for a year or more (Villa Rojas 1945:52). The problem with granaries is that the stored maize is vulnerable to rodents, theft, and spoilage, losses which are irrecoverable.

A less widely acknowledged way of preserving the use-value of maize is to feed it to livestock, primarily poultry and swine (Wilk 1981; Kyle 1995). Households can feed their surplus maize to swine, and then sell the pig when they are in need of cash or supplies. In this sense, swine are quite literally piggy banks, i.e., they store the use-value of maize just as a savings account preserves the use-value of money. Based on a survey of the ethnographic literature, this method of "banking" is common throughout Mesoamerica.[8] For example, the Kekchi Maya, who live in Belize, just south of the X-Cacal Maya, preserve their corn in this way (Wilk 1981, 1991). Pigs are thought of as secure sources of emergency cash: "If crops fail completely, a pig can be sold and food purchased from others or from shops in town" (Wilk 1981:22). For the Kekchi, pigs are the most important way to store surplus and reduce risk. Plus, they take resources not available to humans and make them available (Wilk 1981:23). These resources can be spoiled maize and maize-based household slop, wild resources that are foraged, or human excrement.[9] Thus, when maize harvests are bountiful, swine can be fed from the household's maize supply and fattened, but when times are lean, swine can be turned out to forage for their own subsistence.[10] According to Villa Rojas, at least two or three of a household's pigs are raised for sale, while the others are eaten on the Day of the Dead or at a patron saint's fiesta (Villa Rojas 1945:57). When a household chooses to sell a pig, they can either wait until an itinerant merchant comes through the area or take the pig to Belize and sell it there. Once or twice a year large parties of X-Cacal Mayans would travel to Belize to sell their swine in exchange for clothing and other merchandise (Villa Rojas 1945:59). These parties are taking advantage of another benefit of pigs (other than being edible and requiring little care), that is, pigs are mobile. Even though the X-Cacal area is not part of a developed marketing system, swine represent a commodity that is amenable to distance-marketing, since they can be herded (Ewald 1977). This quality led to the development of a thriving trade in swine throughout the Yucatan (Redfield 1941).

Regardless of the method chosen, the basic function of such storage for the X-Cacal Maya is to mediate environmental variation. Extra maize in the granary or a pig that can be eaten or sold provides a bit of security when households are faced with an uncertain environment and thus, an uncertain future.

Conclusions

Given an absolutely perfect test case, one that fulfilled all the basic assumptions of the model, Sahlins' DMP failed to predict or explain the behavior of the X-Cacal Maya. Rather than under-producing, or at the very least aiming to break-even, the X-Cacal Maya are over-producing. Overproduction, as practiced here, is a form of risk management. This is why Sahlins' model fails: the DMP does not incorporate or acknowledge risk management. In general, when conditions are variable, households will plan for that variation as much as is feasible. For subsistence agriculturalists, risk comes in the form of environmental variation, and this is particularly the case for the X-Cacal Maya, where every phase of the agricultural process is dependant on cooperative weather. Thus, in any given year, the typical X-Cacal household will seek to produce more than is necessary to subsist, just in case the yield is less than is expected. The result is that in an average year, with moderately cooperative conditions, the average farmer will not only produce enough to subsist, but will over-produce. In order to carry over this surplus to the next year, the household will store its maize—either in a granary or through feeding surplus maize to domestic animals, especially swine. Therefore, in order for the DMP (or any other theory explaining economic systems and their development) to be a viable model that explains actual human behavior in actual environments, it must take into account risk management through overproduction

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Footnotes

[1] At the time of Villa Rojas's fieldwork, no one spoke or understood Spanish, nor did many people express interest in learning Spanish. Villa Rojas noted that many people desired to learn English and saw it as a more prestigious language. Given the fervent dislike of the federal government by the people of this area, that point of view is unsurprising (Villa Rojas 1945:48).

[2] During the 18th century, pork products, especially lard, were part of an illicit export trade between the Yucatan and Cuba. Jars of lard and pork were secretly shipped to Havana (Pohl and Feldman 1982:304).
[3] Interestingly enough, Villa Rojas claims that this village is known as one of the more industrious of the X-Cacal sub-tribe.
[4] In the X-Cacal area, the mecate equals 23 m^2. This measure varies by area; e.g., in Chan Kom a mecate equals 20 m^2 (Villa Rojas 1945:60).
[5] For a more complete discussion of maize consumption in Mesoamerica, see Stuart (1990). This article also includes an interesting comparison of different field methods used to estimate consumption. For a more regional approach, see Kyle (1995).
[6] Expected yields are 1 carga per mecate in milpa *chacben*; 0.6 carga in milpa *zakab*; and 0.8 carga in milpa *hubche* (Villa Rojas 1945:60).
[7] Steggerda (1941:135) states that 15 great famines occurred in the Yucatan from 1535 to 1835, at an average interval of 20 years. Most of these famines could be directly linked to anomalous weather condition: drought, floods, and hurricanes.
[8] See Vayda, Leeds, and Smith (1961) for a description of swine "banking" in Melanesia (cf. Rappaport 1984).
[9] Though lots of anecdotal literature describes pigs' unbridled affinity for human waste (see Mary and Fred del Villar's *Where Strange Roads Go Down*, for example), swine do derive some essential nutrients from excrement, particularly amino acids. This assertion is based on Poovaiah, Napton, and Calloway's experimental work on the composition of coprolites (1977).
[10] Though neither Villa Rojas nor Wilk allude to feral swine populations in this area, pigs can and do subsist without the help of humans throughout South America and Mesoamerica, including the Yucatan (Lever 1985:114).

Figure 1: Location of the Maya of East Central Quintana Roo (adapted from Villa Rojas 1945)

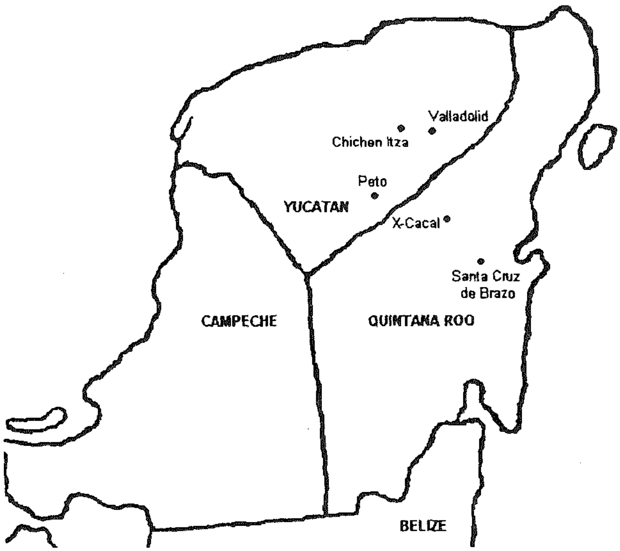


Figure 2: The Pueblos of the X-Cacal Maya (adapted from Villa Rojas 1945)

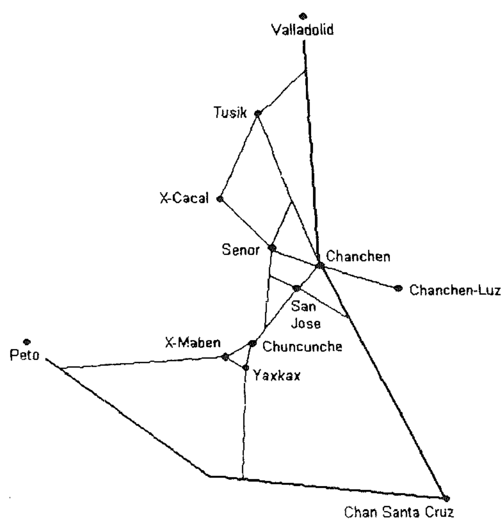


Figure 3: Population Distribution of the X-Cacal Maya (Villa Rojas 1945: 43-44)

Pueblo	Number of Households	Population
X-Cacal	no data	206
X-Maben	18	140
Tusik	23	116
Señor	13	71
Chuncunche	8	54
San José	7	45
Chanchen	7	42
Yaxkax	4	26
Chanchen-Laz	6	20
Total		720

Figure 4: Distribution of Time for an Average Tusik Man,1935 – 1936 (Villa Rojas 1945:77)

Activity	Number of Days
Labor	186
Fiestas and religious obligations	132
Diversions and trips	48
Total	366

Figure 5: Time Allocation for an Average Tusik Man, 1935 – 1936 (based on Villa Rojas 1945:77)

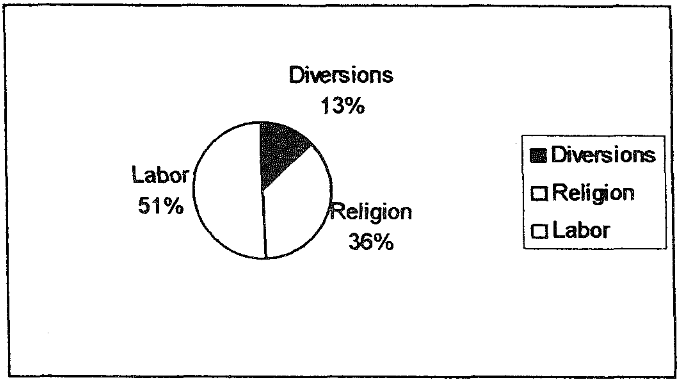


Figure 6: Labor Allocation for an Average Tusik Man, 1935 – 1936 (based on Villa Rojas 1945:77)

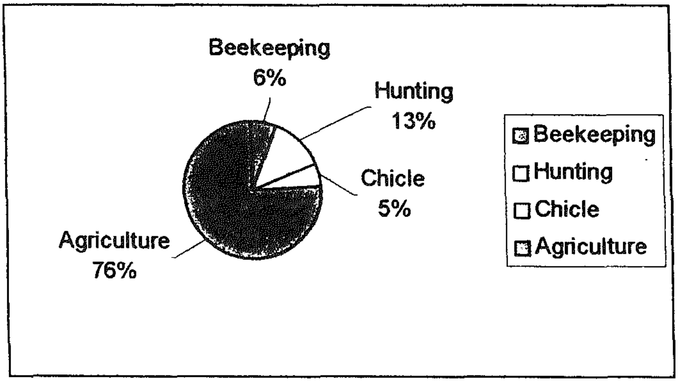


Figure 7: Amount Planted for Each Type of Milpa for 52 X-Cacal Households (Villa Rojas 1945)

Household #	Chacben Mecates Planted	Chacben Kilos Harvested	Zakab Mecates Planted	Zacab Kilos Harvested	Hubche Mecates Planted	Hubche Kilos Harvested	Total Mecates Planted	Total Kilos Harvested
1	26	1,196			24	1,104	50	2,300
2			12	552	40	1,840	52	2,392
3	18	828			25	1,150	43	1,978
4					118	5,428	118	5,428
5	100	4,600	10	460	60	2,760	170	7,820
6	18	828			42	1,932	60	2,760
7	25	1,150			35	1,610	60	2,760
8	18	828			84	3,864	102	4,692
9	12	552			20	920	32	1,472
10	5	230	11	506	28	1,288	44	2,024
11					48	2,208	48	2,208
12	90	4,140			180	8,280	270	12,420
13					70	3,220	70	3,220
14					45	2,070	45	2,070
15	90	4,140	15	690	95	4,370	200	9,200
16	40	1,840			18	828	58	2,668
17	20	920			30	1,380	50	2,300
18					52	2,392	52	2,392
19			22	1,012	67	3,082	89	4,094
20	23	1,058			20	920	43	1,978
21					43	1,978	43	1,978
22	20	920	12	552	15	690	47	2,162
23	30	1,380			40	1,840	70	3,220
24	100	4,600			50	2,300	150	6,900
25	30	1,380	20	920	14	644	64	2,944
26	25	1,150			15	690	40	1,840
27	200	9,200	250	11,500	20	920	470	21,620
28	80	3,680	60	2,760	15	690	155	7,130
29	60	2,760	50	2,300	20	920	130	5,980
30			10	460	25	1,150	35	1,610
31	20	920	15	690	20	920	55	2,530
32			25	1,150	15	690	40	1,840
33	15	690	12	552	20	920	47	2,162
34	15	690	15	690	20	920	50	2,300
35	15	690	15	690	20	920	50	2,300
36	30	1,380	20	920	20	920	70	3,220
37	20	920	15	690	15	690	50	2,300
38	15	690	15	690	20	920	50	2,300
39	30	1,380	20	920	15	690	65	2,990
40	40	1,840	15	690	50	2,300	105	4,830
41	50	2,300	50	2,300	30	1,380	130	5,980
42	60	2,760			15	690	75	3,450
43	40	1,840	6	276	5	230	51	2,346
44					50	2,300	50	2,300
45	12	552	15	690	18	828	45	2,070
46	15	690	14	644	25	1,150	54	2,484
47					58	2,668	58	2,668
48	40	1,840	20	920	30	1,380	90	4,140
49	70	3,220			90	4,140	160	7,360
50	15	690	15	690	50	2,300	80	3,680
51	100	4,600			35	1,610	135	6,210
52	100	4,600			70	3,220	170	7,820
Total	1,732	79,672	759	34,914	2,049	94,254	4,540	208,840

Figure 8: Total Maize Necessary, Expected, and Harvested for 52 Households

House-hold #	Family Size	Family Kilos Necessary	Animals Kilos Necessary	Total Kilos Necessary	Total Kilos Expected	Total Kilos Harvested	Difference of Expected & Necessary
1	6	1,409.27	574.88	1,984.14	2,079.20	2,898	95.06
2	6	1,409.27	574.88	1,984.14	1,803.20	2,392	(180.94)
3	3	704.63	574.88	1,279.51	1,748.00	2,392	468.49
4	7	1,644.14	574.88	2,219.02	4,342.40	5,428	2,123.38
5	6	1,409.27	574.88	1,984.14	7,084.00	10,580	5,099.86
6	5	1,174.39	574.88	1,749.26	2,373.60	3,542	624.34
7	4	939.51	574.88	1,514.39	2,438.00	3,450	923.62
8	9	2,113.90	574.88	2,688.77	3,919.20	5,382	1,230.43
9	2	469.76	574.88	1,044.63	1,288.00	1,978	243.37
10	2	469.76	574.88	1,044.63	1,564.00	2,208	519.37
11	4	939.51	574.88	1,514.39	1,766.40	2,530	252.02
12	12	2,818.53	574.88	3,393.41	10,764.00	15,410	7,370.60
13	7	1,644.14	574.88	2,219.02	2,576.00	3,680	356.98
14	5	1,174.39	574.88	1,749.26	1,656.00	2,300	(93.26)
15	4	939.51	574.88	1,514.39	8,050.00	11,500	6,535.62
16	5	1,174.39	574.88	1,749.26	2,502.40	3,680	753.14
17	4	939.51	574.88	1,514.39	2,024.00	2,990	509.62
18	3	704.63	574.88	1,279.51	1,913.60	2,760	634.09
19	6	1,409.27	574.88	1,984.14	3,072.80	4,232	1,088.66
20	4	939.51	574.88	1,514.39	1,794.00	2,714	279.62
21	4	939.51	574.88	1,514.39	1,582.40	1,380	68.01
22	6	1,409.27	574.88	1,984.14	1,803.20	2,714	(180.94)
23	8	1,879.02	574.88	2,453.90	2,852.00	3,910	398.11
24	23	5,402.18	574.88	5,977.06	6,440.00	12,650	462.94
25	6	1,409.27	574.88	1,984.14	2,447.20	4,416	463.06
26	3	704.63	574.88	1,279.51	1,702.00	2,484	422.49
27	12	2,818.53	574.88	3,393.41	16,836.00	15,870	13,442.60
28	9	2,113.90	574.88	2,688.77	5,888.00	7,590	3,199.23
29	3	704.63	574.88	1,279.51	4,876.00	4,830	3,596.49
30	4	939.51	574.88	1,514.39	1,196.00	1,610	(318.39)
31	6	1,409.27	574.88	1,984.14	2,070.00	2,208	85.86
32	4	939.51	574.88	1,514.39	1,242.00	1,840	(272.39)
33	5	1,174.39	574.88	1,749.26	1,757.20	2,484	7.94
34	6	1,409.27	574.88	1,984.14	1,840.00	2,622	(144.14)
35	8	1,879.02	574.88	2,453.90	1,840.00	2,622	(613.90)
36	7	1,644.14	574.88	2,219.02	2,668.00	5,290	448.98
37	4	939.51	574.88	1,514.39	1,886.00	1,978	371.62
38	5	1,174.39	574.88	1,749.26	1,840.00	3,542	90.74
39	9	2,113.90	574.88	2,688.77	2,484.00	5,060	(204.77)
40	10	2,348.78	574.88	2,923.65	4,094.00	5,750	1,170.35
41	11	2,583.65	574.88	3,158.53	4,784.00	7,130	1,625.47
42	12	2,818.53	574.88	3,393.41	3,312.00	4,830	(81.40)
43	3	704.63	574.88	1,279.51	2,189.60	4,416	910.09
44	5	1,174.39	574.88	1,749.26	1,840.00	2,760	90.74
45	4	939.51	574.88	1,514.39	1,628.40	3,036	114.01
46	5	1,174.39	574.88	1,749.26	1,996.40	3,404	247.14
47	4	939.51	574.88	1,514.39	2,134.40	2,760	620.02
48	7	1,644.14	574.88	2,219.02	3,496.00	5,290	1,276.98
49	8	1,879.02	574.88	2,453.90	6,532.00	9,430	4,078.11
50	8	1,879.02	574.88	2,453.90	2,944.00	4,830	490.11
51	9	2,113.90	574.88	2,688.77	5,888.00	8,510	3,199.23
52	14	3,288.29	574.88	3,863.16	7,176.00	7,820	3,312.84
Total	336.00	78,918.84	29,893.50	108,812.34	176,023.60	247,112	AVE = 1292

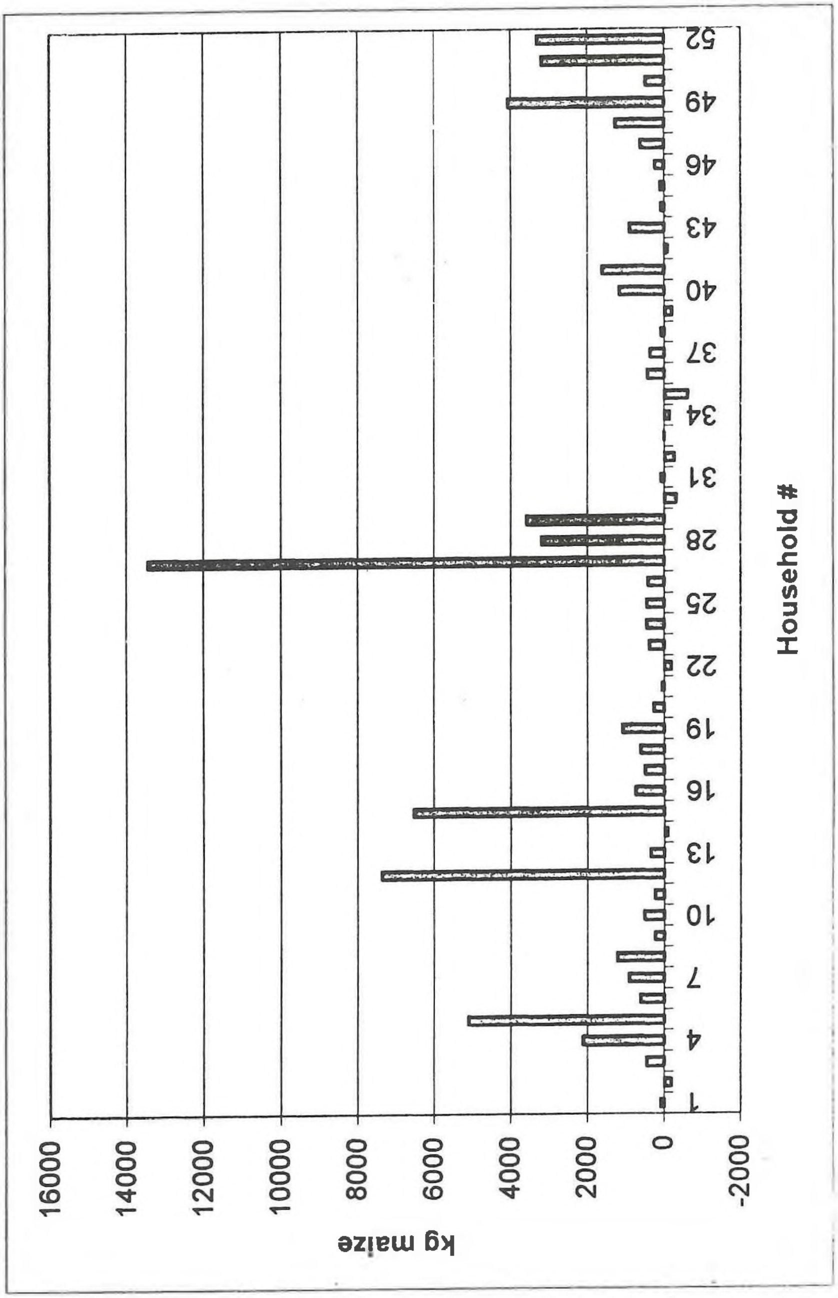
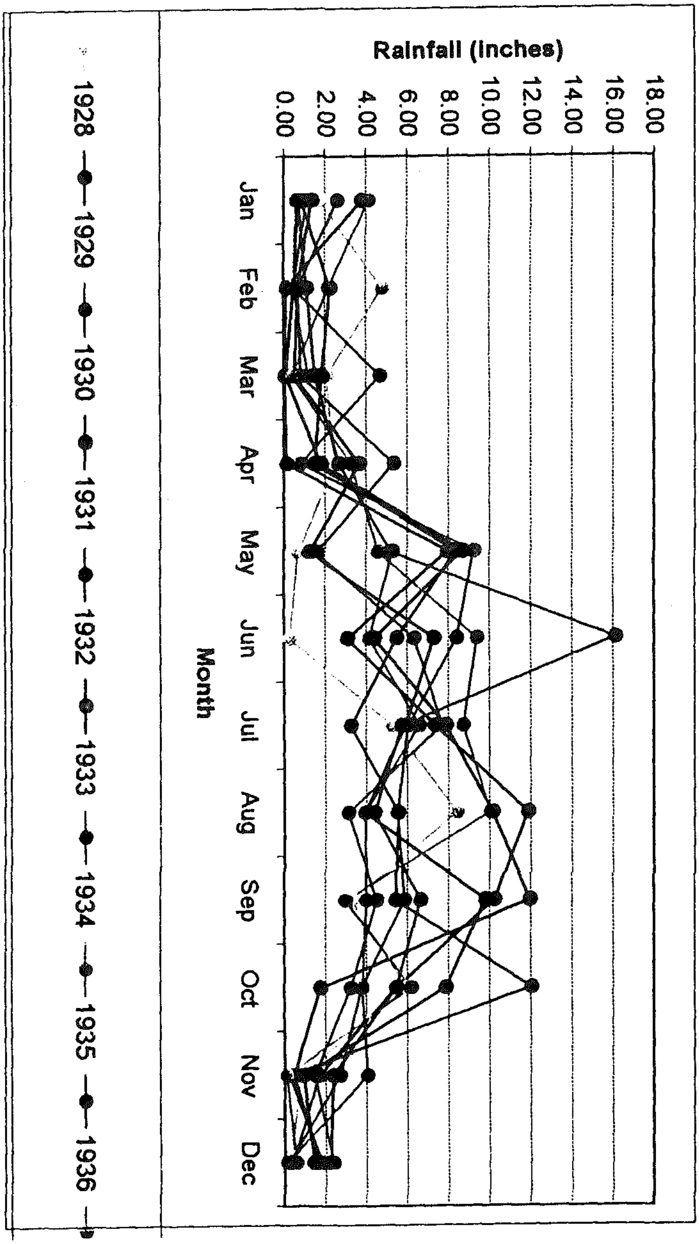


Figure 9: Expected Maize Production as Compared to Household Need

Figure 10: Rainfall for Chichen Itza, 1928-1935 (Steggerda 1941:131-132)



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(Humor Department: This sign has been displayed in the office of an instructor at a local university, and might interest others)

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When you work at this university, you celebrate a normal day, and you celebrate when activities work out as you want them to, because:

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...whether someone will be parked illegally in your expensive, reserved, space.

...whether the custodian will have collected the trash from your wastebasket
(But you can be sure that no-one has swept your floor)

...whether any particular student will show up for class

...whether any students that come to class have actually read the text or done the assignment due that day

...whether, when you come to class, there will be a new student who has just been signed into the class (even 1/3 or more of the way through the semester!). You can, however, be sure that the student will expect to get special favors (such as doing makeups on missed exams) to get him/her up to speed in the class.

...whether the article/book you sent the students to read in the library is still there

....whether the group that was listed to do an oral report today ever got together and hence have anything to say (or even if they will all be there, even though they signed up for the report).

...whether the students will have any of the textbook(s) assigned for the course; you can be almost certain, however, that the bookstore didn't order enough copies.

...whether there will be an available and working VCR and TV for the video you special ordered for the next class.

...whether there will be an available and working LCD projector and computer for the major presentation that you just spent the last week preparing.

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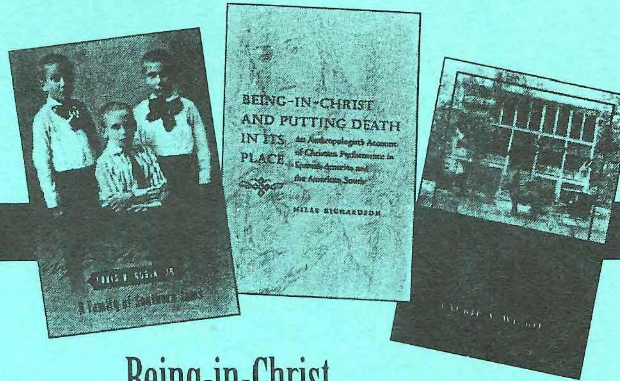

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