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Past, present and future itineraries in Maya bioarchaeology

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Summary – *During the first half of the last century, studies of Maya skeletal remains gave emphasis mainly to head shaping and dental decoration, while little or no attention was bestowed to the ancient Maya's skeletal biology and bioarchaeology. It was not until the late 1960's and early 1970's that more comprehensive approaches started visualizing this ancient society from its biological and cultural aspects by perceiving skeletal remains as a direct indicator of past cultural interactions. The recent growth in skeletal studies was also a natural consequence of the emergence of "bioarchaeology" as a specific discipline. From then on, increasing numbers of studies have been carried out, applying more and more sophisticated and modern techniques to the ancient Maya skeletal remains. This works attempts to briefly review the research history on Maya skeletal remains, from the pioneering works in the 1960's to the development of more conscientious approaches based on theoretical, methodological and practical concepts in which the individual is the basic unit of biocultural analysis. Although, ecological issues and the biological evidence of social status differences still remain central cores in Maya bioarchaeology, new methodologically and topically oriented approaches have proliferated in the last years. They contribute to the development of a more complete, wide-angled view of the intermingled biological and cultural dynamics of a population that has not disappeared in the past and that continues to raise the interest of scholars and the public in general.*

Keywords – *Bioarchaeology, Ancient Maya, Biocultural studies.*

Introduction

When Spanish explorers first touched ground on the Yucatán Peninsula in the early 16th century, they hit upon a major native civilization that was definitely more sophisticated than anything the Spaniards had previously met in the New World. The region, that was later called Mesoamerica, was densely settled by complex agricultural populations administered by urbanized ruling elites, knowledgeable in reading and writing and erudite in astronomic and calendar recording. This cultural realm was shared also by Mayan speaking groups. These occupied southern and eastern Mexico, Guatemala, Belize, Honduras, and El Salvador, extending as far south as to the Nicoya Peninsula of Costa Rica on the Pacific side of Central America.

The whole area's environmental setting is extremely varied, as well as its distribution of languages and ethnic groups that share its space. The social development of the Maya world goes back to the second millennium b.C. Its climax, for which it is most known archaeologically (and touristically), occurred during the so-called Classic period that ranges approximately between A.D. 250 and A.D. 900, with specific chronologies varying among sites. The area's magnificent sites deep in the tropical rain forest have charmed and triggered the curiosity of many generations of scholars. The ruined temples and architectural structures hidden by the dense vegetation still witness the power of an ancient culture that has not been fully uncovered yet. Nonetheless, as Stephens firstly noted (1843), the ancient Maya people have not disappeared in the mist of time, but have lived on to our days (Buikstra, 1997).

If the material culture left behind by this ancient civilization is what predominantly attracts the attention of archaeologists and amateurs, one important source of information has been left

Figure 1 – Geographical map of the Maya area with some of the major sites during the Classic and Postclassic periods.

relatively underutilized so far: the skeletal remains of those who made up ancient society. Several factors account for this lack of attention. Firstly, the ancient Maya did not bury their deads in cemeteries but most likely in close range of their living quarters and to a much lesser extent in the ceremonial edifices and public spaces of site's cores. Since most of the archaeological explorations still center their attention on the ceremonial centers, this condition naturally limits sample size, while the lack of true necropolises prevents systematical recovery of the skeletal assemblages (Tiesler, 1996; Cobos, 2003). Furthermore, the aggressive tropical environment that characterizes most of the Maya world engenders the notoriously degraded state that characterizes most human remains, translating into reduced numbers of individuals, and lack of information and analytical possibilities. This situation is further aggravated by modern looting, which specifically targets tombs. Apart from the above circumstances, probably the most important drawbacks in bioarchaeological approaches are due to the way archaeological research is conducted in the Maya realm. Albeit this situation is starting to change in recent years, many archaeologists still appear to be unaware of the great potential that skeletal data sets have in cultural reconstruction. Conventional research of the Prehispanic Maya has relied almost exclusively on its material culture, while human remains have been treated as peripheral evidence, ending up in the annexes of archaeological reports or extricated works on skeletal biology, disengaged from major interdisciplinary ambitions for understanding the broader social or biosocial networks of the past. From this perspective, much of past Maya osteology appears therefore rather technical and descriptive.

While present research goals in Maya archaeology are not particularly different from those pursued in the past decades (Smith, 1991), the paths to approach these goals have increased considerably in number in recent years, incorporating epigraphic research, statistics and an increasing amount of sophisticated special analyses. These multiple lines of evidence end up testing, reinforcing or opposing one another. Put to work within integrated frames of social studies, these may dramatically enhance the power of explanation (White, 1999). In the past twenty years, also biocultural approaches are gaining attention in the Mayanist community, thanks to a new mind-set, awareness and profound dedication of newer generations of scholars, coupled with attractive technical innovations. As noted by Buikstra (1997: 223) already a decade ago, "it seems clear that the degree to which physical anthropological data assume prominence in archaeological inquiries also has to do with the theoretical orientation of contemporary archaeologists".

The term "biocultural" refers to a large array of features in the human skeletal remains that are linked to cultural elements despite their biological substrate. They define those traits that materialize conditions associated to the life cycle, like age and death, physionomy, living circumstances, nutrition and health, violence, and biocultural practices (Tiesler, 1999). Both aspects that make up the biocultural concept are not conceived as separate entities but ideally envisioned as an indivisible complex of entangled dynamics.

In recent years, the analysis of skeletal materials has increasingly responded to parameters set forth by bioarchaeological agendas, which favor integrated approaches that combine population and cultural data sets. "Bioarchaeology" may be described broadly as a thematic specialization in

archaeology or physical anthropology that studies human remains in their context and as part of the archaeological body of information employing explicit biocultural approximations (Blakely, 1977; Powell *et al.*, 1991; Klepinger, 1992; Owsley and Jantz, 1994; Konigsberg and Buikstra, 1995; Buikstra, 1997; Larsen, 1997). In this review, we wish to briefly trace the advances reached by bioarchaeology in the Maya area since the early, pioneering anthropological approaches in the 1960s.

Frameworks in Maya bioarchaeology

The sociocultural development of mankind has been conditioned by its human biological properties. Nevertheless in practice we tend to envision humanity in the somewhat artificial categories of "organism" "social" and "psychological". Similarly, the "archaeological being", i.e. human vestiges, display a vast array of features that are both inherited and generated during life, as are health record, habits or living conditions. From this perspective, the analysis of skeletal remains is of paramount importance both for social and anthropological sciences, archaeology in particular. What varies between both approaches is the specific research tools, the immediate object of study and the kind of data: material culture versus skeletal materials. Regarding Maya research, it is no wonder that skeletal anthropology shares several research topics with archaeology. Such is the case in demographic and mortuary investigation, dynastic studies and the study of ritual expression. Regrettably, these subjects have mostly been pursued more or less independently by each line. An integrated examination of both data sets, conducted within a coherent theoretical framework, thus poses a challenge for this and future generations of scholars.

Skeletal studies on the ancient Maya set out as case descriptions and standard inventories of small skeletal collections that contained the basic information on (mainly cranial) morphology and measurements. Up to the middle of the last century, emphasis was placed on the skull and the practices of head shaping and dental decoration, while no attention was bestowed on lifestyle issues or contextual information beyond chronology. Comparisons with series from other parts of the world still figure prominently in those early accounts, revolving around diffusions or evolutional arguments. The lack of scholarly interest displayed by the archaeologists is expressed by the paucity of comparable skeletons from the area, which led physical anthropologists like Stewart (1943, 1949: 114) to plea for more time and effort in the recovery of human remains. Noteworthy is also Earnest Hooton's pioneering work on the Sacred Cenote at Chichen Itzá (1940) in which he provided a fairly detailed but descriptive account of the skeletal collection recovered in 1909. Hooton busts the myth of virgin victims by establishing that the majority of individuals are male, but makes no efforts to put his findings into context with the other materials retrieved from the bottom of the Cenote.

More recently, works by Haviland (1967) and Saul (1972) have fostered a more systematic interest in Maya skeletal biology. As part of a broader archaeological investigation on Tikal, Haviland compares the adult statures from different burial contexts and settlement areas and concludes that the members of the elite were taller than the rest of the population. In a more comprehensive approach, Saul promotes "osteobiography" as a means to learn about the ancient Maya and their life styles. He specifically attempts to provide new answers to the questions of identity, origins, living conditions and demise of the population at *Altar de Sacrificios*, Guatemala. Both Haviland's and Saul's work are now considered landmark studies in Maya bioarchaeology in that their interpretations clearly link skeletal data to cultural contexts. For the first time, human remains are treated as direct material indicators of past cultural interaction, although it may be argued that neither Saul nor Haviland laid down any grounded conceptual schemes for the incorporation of skeletal studies. On the methodological side, sample size limitations and statistical testing still didn't seem to be of real concern for either project. Saul's ambitious osteobiographic approximation to the Altar population still appears quite unaware of the many paleodemographic pitfalls that are inherent in any attempt to infer about the living from the dead, especially considering the complex burial record that characterizes the ancient Maya. These and other issues were to be addressed more systematically in the following years. Maya

bioarchaeology started to grow steadily during the '80s, as more and more scholars dedicated their interests to this line of research mainly in Belize, Guatemala and Honduras (mostly Copan) (see Danforth *et al.*, 1997 and Wright 2004, for a review of literature).

The new biocultural interest in the Maya area was also a side-product of a more general trend in anthropology and specifically the fields of physical anthropology and the freshly reformulated "new archaeology". Bioarchaeology, as such, emerged as part of this process during the seventies. Ideally defined as a thematic specialization that studies human remains from a biocultural perspective and as an integrated part of the material culture, the term 'bioarchaeology" was coined in 1976 and was promoted at first by Anglo-Saxon scholars (Blakely, 1977; Buikstra, 1981; Powell, 1991; Larsen, 1997; see also Tiesler, 1996). These academics sought to promote a long due interdisciplinary cooperation in the archaeological recovery and study of human remains with the goal of obtaining a broader understanding of ancient life ways (Buikstra, 1991). Buikstra (1991) underscores the need to build a truly integrated research design led by the priority analysis of the mortuary context. Along with her fellow scholars, she recommended to focus on the concept of adaptation and biocultural theory (Powell, 1991) and the comparison of multiple lines of evidence within a regional frame of reference (Smith, 1991). Subsequently, more theoretical and methodological starting points have been provided, designed to sustain and fortify the empirical evidence. Definite progress has been achieved now in terms of technical procedures and statistical testing, along with the integration of bioarchaeologists in many research teams. These, together with a subtler, critical approach to ancient human studies, have led to a broader understanding of biocultural dynamics and their role in ancient sociocultural evolvement.

Given the general development of bioarchaeological research, it is not difficult to understand that Maya research has benefited from its agenda in the past twenty five years, also because most of the research has been carried out by non-Mesoamerican scientists, the majority of them working in North America. The only Mesoamerican institution that has been offering formal training in physical anthropology are the *Escuela Nacional de Antropología e Historia* and the *Universidad Nacional Autónoma de México*, both in Mexico City, were research has traditionally centered around the Central Highlands. In recent years, the *Universidad Autónoma de Yucatán* at Mérida, Yucatán, has opened a Masters Program in Skeletal Anthropology with strong focus both on forensic investigation and Maya bioarchaeology, promising to promote regionally based research.

Within the broad frame set by bioarchaeology, Maya investigations have tended to blend human biological and cultural information mainly through an ecological, adaptive focus. Anthropological studies that follow this line typically anchor around concepts derived from biodiversity, demography, health and nutrition, physiological adaptation, reproduction and the ecosystem (Saul, 1972; Storey, 1985a, b; 1986; 1992; 1999; Marquez and del Angel, 1997; Danforth, 1997; Marquez *et al.*, 2002a; Wright and White, 1996; Wright, 1997). In the practice, this approach is apt to promote broader generalization within the field of biological anthropology, but has been less suitable to advance the joint archaeological or sociocultural reconstruction, thus limiting its interpretative potential to insights into nutritional or health factors, without being able to exploring their deeper causal impact in the economic, social or cultural realms of explanation.

Recently, an attempt was made for a more integrated, explicitly social approach in the interpretation of biocultural practices, coined "archaeology of people". Resting upon a series of integrated theoretical, methodological and practical concepts, this proposal was developed by incorporating parameters derived from taphonomy, contextual and social archeology (Schiffer, 1987; Bate, 1998; Tiesler, 1999, 2001a). The model parts from the definition of the "individual", taken as a singular phenomenon constitutive of the system in which he or she participates, and considered as the basic unit of biocultural analysis. A set of concepts was demarcated to define an "archeological individual", vestige of the "social individual" first subjected to mortuary treatments, later to become part of the material record and source of biocultural information. A regional model was developed to conceptualize the social role of the attributes under study and compare characteristics within the social frame of reference with promising results on Maya

biocultural practices.

However, ecological issues and the biological evidence of social status differences still remain a central core in general Maya bioarchaeology (Wright, 2004). Towards the end of the '90s, two important edited books were published in this field: "*Bones of the Maya*", edited by Whittington and Reed (1997), and "*Reconstructing ancient Maya diet*" that was edited by Christine White in 1999. Both volumes mark the pace of bioarchaeology in the 1990s, providing a representative overview of the increasingly vast information produced on Maya skeletal samples, different attempts of combining multiple lines of evidence and methodologies, many of them new.

"*Bones of the Maya*", edited by Whittington and Reed (1997), focuses on different aspects of Maya skeletal studies: osteological, dental and special studies (isotopes and DNA). The book strongly promoted and at the same time consolidated the emerging field of Maya bioarchaeology, for it provided the state of art in the already varied branches of regional skeletal research. A comprehensive list of references on Maya skeletal studies appears at the end of the volume. It is noteworthy that the contributors of Bones of the Maya include several archaeologists. With only two exception (Marquez and del Angel in chapter 4 and Lopez Olivares in chapter 8), all authors are non-Mesoamerican scientists whose geographical areas of interest were mostly Guatemala, Belize and Honduras. Some of the contributions go into efforts to contextualize the skeletal evidence, while others are more limited in this respect. Casuistic evidence or sampled information still figures prominently, apart from methodological approaches. Many of the interpretations that appear in the chapters' discussions evolve around an ecological frameworks rather than a socio-economic theoretical one, and consequently do not succeed in closing the chasm between biological and social, cultural and archaeological interpretations. Only Chase and Chase contextualize the remains under study according to their taphonomy, interment position, location and other related factors.

As from its title, the second volume "*Reconstructing ancient Maya diet*" focuses on dietary issues. Clearly, as White states in her introductory chapter, studies on paleodiet are not just intended to infer on what the ancient Maya were eating but rather aim at understanding more complex and entangled processes that go well beyond simple food intake. The volume centers therefore on subsistence patterns as a fundamental piece of evidence and considers broader issues linked to social structure, economic relationships and, ultimately, collapse. Like the piece edited by Whittington and Reed (1997), White's book represents a milestone in ancient Maya studies in bioarchaeology and a term of comparison for future research on Maya paleodiet. Similarly, it is divided into three mayor topics (botanical and faunal analysis, paleopathology and bone chemistry). Again, no "local" investigators are included in the authors' list and all the samples are from Belize, Guatemala and Honduras. All of the manuscripts that rested on osteological analyses encountered that maize was the basic constituent in the ancient Maya diet; nonetheless variation occurred diachronically according to social status and among sites. Most of the authors analyze diet by contextualizing the pathological evidence displayed by the skeletal remains. These include caries, as a somehow direct indicator of carbohydrate consumption, along with enamel hypoplasia and *ante-mortem* tooth loss. Secondary indications are growth pattern and adult stature. The different approaches and lines of evidence succeed in providing a convincing overall perspective on ancient Maya diet in relation to subsistence strategies and broader social factors. Despite the central focus which is mainly limited to diet itself, the volume provides new and alternative indications that may represent new pedestals for archaeological studies.

Unfortunately, since the American scholars' attention has been directed mainly to Belize, Honduras and Guatemala, there is presently a reduced amount of comparable published data on the Mexican side of the Maya area. Here, studies on paleodiet and population generally adapt more conservative frames, as shown by the work of Márquez (1982, 1987), Márquez and Miranda (1984) or Márquez *et al.* (2002b). This region has been the object of later, more recent bioarchaeological studies. Direct correlations between subsistence patterns, paleopathology and social status distinguish the work by Cucina and Tiesler (2003) on the sites of Calakmul, Dzibanché and Kohunlich, in the Mexican side of the northern

Peten area. Social status, as inferred from the archaeological evidence of place of interment, associated funerary attire and modality of deposition, resulted to discriminate between high and low status groups, as well as between sexes within the high status one. Stature, health and activity profile also seem to differ between different subsistence patterns and according to status, following a regional study by Tiesler (1999, 2000a, 2001a), conducted on skeletons from more than ninety Prehispanic Maya settlements. Other works revise the health and put it into context with single sites' ecology and economy, like Palenque in Chiapas (Márquez *et al.*, 2002b), Xcambó in northern Yucatan during the Classic period (Cucina *et al.*, 2003, 2005a) or on the economic, social role and status of a colonial multiethnic society in Campeche (Cucina, 2005).

Methodologically and topically oriented approaches

In the last twenty years, sophisticated biochemical methods have started to proliferate in Maya bioarchaeological research. These new analytical tools have been borrowed from other fields of investigation like geology (stable isotopes and trace element), physics or chemistry. Their incorporation in Maya research has allowed to provide new answers on old hypotheses on migration and population history (see Merriwether *et al.*, 1997; González-Oliver *et al.*, 2001; Hodell *et al.*, 2004; Price *et al.*, 2005; 2006; Wright, 2005) and a more detailed information on diet (White *et al.*, 1993; 2001; Whittington and Reed, 1997; Wright, 1997; Reed, 1999; Nalda *et al.*, 1999; Tiesler *et al.*, 2002a; Tejeda *et al.*, 2002).

Migration patterns and detection of individual provenance is a fairly recent topic in Maya bioarchaeology. Price and colleagues have been applying strontium isotopes analysis to the enamel of the first permanent molars at individual level to assess the place of origin of Pakal, the well-known ruler of Palenque, Chiapas (2006) or at population level to infer on the provenance of African ethnicity individuals unearthed in the colonial cemetery of Campeche, Campeche (2005). Such kind of studies is still at its dawn in the area, but holds enormous potentials for the new generations of Maya bioarchaeologists and archaeologists alike, as it allows fresh insights on residential mobility and migratory dynamics not only of the ruling elite but also of the general population. These pieces of evidence are apt to provide a subtler understanding of the complex regional demic, trade, social and political dynamics, which have so far been examined almost exclusively through the study of the material record.

The application of chemical analysis for nutritional purposes has led to relate nutritional expectations to social status in different populations (mainly from Belize and the southern Lowlands), (Tiesler 2001b; White *et al.*, 2001), ecology (Wright and White, 1996; Wright, 1997) and sites' size or relative political importance (Coyston *et al.*, 1999). It has started shedding light on the variability that existed in terms of subsistence patterns and access to resources, as well as the production system and its socio-political and economic consequences.

Parallel to this, a series of dental studies, that are already widely applied elsewhere, are being increasingly adopted also in Maya research, as illustrated by the work on biological affinities both within (Jacobi, 2000; Rhoads, 2002) and among sites (Lang, 1990; Wrobel, 2003; Sherer, 2004; Cucina *et al.*, 2005b; Cucina and Tiesler, 2006). Dental morphology is of great value in the Maya area due to the otherwise poor preservation of the skeletal remains. Most of the studies rested upon the theoretical concepts originally expressed by Austin (1978) for *Altar de Sacrificio* and retaken by Pompa (1990) at Chichen Itza, all attempting to infer on internal variability and/or chronological continuity to answer specific research questions. Recent studies of non-metrical dental traits like those by Jacobi's (2000), Wrobel's (2003), Scherer (2004), Cucina *et al.*, (2005b), and Cucina and Tiesler (2006) have elevated the original site by site scope of these studies to a wider regional level. Although preliminary and hampered by looming inter-observer variations and limited sample size, their results offer a starting point for a new overall appraisal of Maya population and group affinities, evolvement and population dynamics.

Modern techniques and the new awareness of the importance of human skeletal remains in the reconstruction of the lost history of ancient civilizations gather together the information that multiple lines of evidence may offer. Examples are

Figure 2 – Pakal's skeletal remains harbored in the monolithic sarcophagus tomb in the Temple of the Inscriptions, Palenque, Chiapas (Photo by Vera Tiesler).

the recent multidisciplinary works on dynastic Maya history, such as the studies coordinated by Buikstra *et al.* (2004) on the Early Classic Copán's ruling elite and the work on the well known ruler of Palenque, Janaab' Pakal, edited by Tiesler and Cucina (2004).

In both cases, direct analysis of the remains in their taphonomic context benefited from novel methodological approaches and the explicit goal to reconstruct jointly the biographies of the personages under study. The latter study, in which Buikstra herself participated, centered on the re-examination of the skeleton of the famous Maya ruler, who still rests in his sarcophagus tomb inside the Temple of the Inscriptions of Palenque, Mexico. Fifty years after the initial study, the new investigations were conducted by an international team of experts in skeletal biology, forensics, genetics, histomorphology, Maya archaeology and taphonomy, and epigraphy. This project, triggered by several debates that arose around the ruler's remains since the time of the discovery in 1952, was able to solve the most important controversy between epigraphy and osteology on the ruler's age at death, as well as offer explanations to others. As for Pakal's age, epigraphers read an age of 80 years, which doubles the skeletal age estimate published fifty years ago. The new information, in almost unanimous consensus among the contributors, revealed an age well over 50 without being able to confirm the epigraphic readings of 80.

Another line of bioarchaeological research that is particularly apt to contribute directly to sociocultural studies is that of biocultural practices. These refer broadly to those cultural habits that are prone to leave traces in the skeletal remains. As regards the ancient Maya, dental decoration and head shaping were widely practiced in pre-Hispanic times and have been the focus of several investigations, conducted mostly in earlier years (Buikstra, 1997). Recently, this topic was taken up again by Tiesler (1993, 1997, 1998, 1999, 2000b, 2001b). Her evaluation of the regional skeletal material on presence, techniques and visual styles is oriented in an explicitly sociocultural perspective, conceiving biocultural patterns directly as part of the information derived from the funerary and broader archeological context. The results make a convincing case of the role of biocultural practices in the Maya life cycle, as emblems of cultural identity and sometimes used as visible signs of the privileged. The results and their interpretation, along with new classification parameters, laid new groundwork for future projects along the same line, although Anglo-Saxon speaking scholars have has not taken up so far much of the approach and results, which were mostly published in Spanish.

Of different origin are those anthropogenic marks in human remains that denote *peri-mortem* violence and posthumous body processing. These, just like the biocultural practice originated during life, trace a line of research that hasn't been fully explored yet despite its great potential for integrated research on ancient Maya ritual conduct. Anthropogenic marks have been discovered relatively recently by the Maya scholarly community, which comes as a surprise because a wide range of posthumous body manipulations are known for this area, mainly related to post-sacrificial practices, although ancestral processing was equally carried out (Helfrich, 1973; Moser, 1973; Nájera, 1987). Broadly accepted are the marks of flaying and dismemberment in a skull pit from Colha, Belize (Massey and Steele, 1997) and further cases have been reported from other sites

(Tiesler and Cucina, 2003; Tiesler *et al.*, 2002b; Nance *et al.*, 2003; Buikstra *et al.*, 2004).

The Maya "collapse"

The different lines and approaches of Maya bioarchaeological research have encountered a common goal in the understanding of a research theme that has been explored and discussed extensively both from an empirical and theoretical point of view: the so-called "collapse" of Maya hegemonic structures at the end of the Classic period. Their disintegration led to the destruction and abandonment of a large number of sites in the central lowland regions, eventually to be replaced by other centers that rose to power and political importance further north. The discovery of Maya ceremonial centers, characterized by population densities that were in some cases heavier than the modern ones (Haviland, 1970; Culbert and Rice, 1990), triggered the question whether the slash-and-burn (*milpa*) subsistence economy described ethnohistorically could have indeed sustained larger human settlements. Moreover, the tropical ecosystem is very fragile to stand the rigors of an extensive *milpa* economy (White, 1999). Therefore, subsistence practices and diet became the mayor point to understand the Maya development and decline.

The initial theoretical approach to give an explanation to a widespread phenomenon was the ecological one (Coe, 1980; Culbert, 1988; Webster *et al.*, 1992). According to those supporting this model, the Maya had overexploited the environment and exceeded its carrying capacity to sustain an increasing population. As a consequence of agricultural intensification, mono-cropping and environmental degradation, infections and malnutrition spread and the demographic structure collapsed (Cohen and Armelagos, 1984), which implied a social and economic decline with important socio-political consequences.

Nonetheless, the large acquired data sets on skeletal remains point to the collapse as a way more complex problem that cannot be reduced and described by a single model. Marquez and Angel (1997) support the ecological model resting upon the reduction is stature in Northern Yucatan, though they found that the mayor reduction took place between the Preclassic and Classic periods, hundreds of years before the actual "collapse". In turn, Cetina and Sierra (2003) find that at Xcambó, a center along the northern coast of the peninsula, stature was significantly higher than other inland samples, coupled with low rates of porotic hyperostosis and *cribra orbitalia*, supposedly reflecting better and more diversified diet in a marshland environment. Despite this, Xcambó fell in disuse around the 8th century AD, apparently not for ecological reasons but most likely due to a shift in political and economic spheres (Sierra, 2004). In reality, the ninth-century Classic Maya collapse was limited to the southern Maya Lowlands and occurred in a mosaic-like fashion (Shaw, 2003).

Decline for reasons other than the ecological ones is supported by White (1997) who states that nutritional and pathological along with political and economic factors might have had a key role in the decline at Lamanai, but at the same time does not reject the hypothesis that ecological causes might have mined the socio-economic basement at Pacbitun. Similarly, Wright (1997) argues that the variability in data from the Pasión Maya lowland region indicate a wide array of possible reasons accounting for the collapse. Also Danforth (1991) inferred from the heterogeneous reduction in stature that the collapse was a complex phenomenon with many patterns of manifestation across the lowland and it is likely that the possible explanations can be pretty diverse.

Although the ecological model is considered as part of the explanations for the decline of the Maya civilization, it takes its place among other models (Fash, 1994). In first place, the evidence reported by the Spaniards in the 16th century of a subsistence economy based on the "*milpa*" might not have represented the economy of the Maya during the Classic period. In this period they had developed highly intensive and productive technologies for irrigation and land use like raised fields and terraces (Turner and Harrison, 1983). Similarly, other crops played a role in the Maya diversified ecological and geographical environment, like beans, peppers, tomatoes and staples (Lentz, 1999). Although it is hard to sustain this model on a large regional and chronological scale, it is indicative of the inner variability that distinguishes this civilization. It is more and more evident that the "collapse" was confined to some part of the regions, Palenque,

Calakmul, Tikal and Copan to name some of the most famous sites. As the south declined, the northern regions were acquiring greater and greater importance with sites like Chichén Itzá first and Mayapán after that (Folan *et al.*, 2000). Folan *et al.* (2000) discuss the collapse issue detecting environmental draughts as an important natural factor for the decline, even though they also stress the multicausal issue, where ecological, nutritional, environmental, economic and political reason undermined the inner structure of a society that was undergoing an internal disruptive process.

In this perspective, Maya bioarchaeology is not to be intended as the biocultural research of a homogeneous context where only limited sets of explanation hold true, rather an assortment of regionally, socially and ecologically distinct entities that in some cases might have followed different trajectories (see Powell, 1991 for a similar overview of the Mississippians in North America).

Discussion

Almost four decades have passed since the pioneering studies by Haviland (1967) and Saul (1972). Since then, the anthropological studies of the ancient Mayas have blossomed thanks to the combined contributions of many scholars using multiple lines of evidence. With the years, both archaeologists and bioarchaeologists have grown increasingly aware of the importance of newer techniques to promote what is known on the ancient Maya. The ecological model of collapse has been called into question only by the time that diet could be reliably investigated by means of stable isotopes composition of skeletal remains and when other lines of evidence turned in their valuable contributions. That maize was the crop in ancient (and nowadays) Maya culture is a matter of fact. In terms of nutrition, it represented the main available subsistence element throughout the whole Maya world around which the whole subsistence strategy was built up, with some few exceptions (White, 1999). However, it would be erroneous to generalize on the quantity and quality of maize consumption by stating that diet was based on maize, squash and beans, for extrinsic (ecological and socioeconomic) factors influenced the access and the availability to these as well as other important food resources. The ancient centers were enormously different in terms of size, geographical location, biotic environment, economic, social and political importance, and inner social "stratigraphy", all pieces of a mosaic that entangled to one another to give shape to a very vast array of subsistence strategies (White, 1999; Gerry and Krueger, 1999; Cucina and Tiesler, 2003). For example, the tropical inland rain forest stands out against the coastal lines for which the marine resources where of paramount importance (Sharer, 1994; Glassman and Garber, 1999). At the same time, the Yucatan peninsula's northern subtropical semi-arid environment with its aquifer geological structure and the lack of surface rivers implied a different organization of cultivation and irrigation systems (Dahlin, 2002). Not taking all these elements into account in a truly biocultural, holistic fashion, would lead to an unnecessary oversimplification of our views of this complex society. We cannot overlook that the Maya society spread around an area wider than 250,000 squared kilometers if only the Lowlands are considered (Webster, 1997).

Sauer (1955: 61) rightly stated that "intimate knowledge of historic sources, archaeological sites, biogeography and ecology, and the processes of geomorphology must be fused in patient field studies, so that we may read the changes in habitability through human time for the lands in which civilization first took for."

Human beings, as individuals or population, are shaped both by biology and culture (Storey, 1992). The biocultural approach requires knowledge or at least consideration, of all the different facets that fashioned the society. The "individual" represents the basic step of analysis, but its contribution should go beyond the simple "biological" information, to place it and its group first into its social, economic and political micro-cosmos and then into the regional macro-cosmos frame.

Another concluding remark refers skeletal preservation, which still poses a substantial problem in Maya bioarchaeology. It is undeniable that without large samples it is almost impossible to build and test hypotheses that are not superficial or at best just indicative of patterns, and that modern techniques are of paramount importance to get out of the descriptive tunnel to learn more on this ancient society. Wright's conclusions in her review

paper on Maya osteology (2004) put emphasis on the integration of individual life histories into a population approach to understand the ancient Maya biological history. Although statements like these are correct in terms of population history, they betray at the same time the lack of a wider biocultural mind-set, one that encompasses at the least biology, iconography, archaeology and environmental history.

So, what is on the horizon? Important steps ahead in Maya research have been made since Haviland's and Saul's works. It must be underscored that nowadays scholars are no longer purely descriptive, their methodological and statistical approaches are rigorously scientific and not much is left to chance during data recording and elaboration. However, regardless of the methodological know-how and ability to use new techniques in a practical phase of the analysis, the actual profound knowledge of the ancient Maya is what permits to shift from a methodological (though highly sophisticated) application to a truly interpretive and theoretical model (see also Webster, 1997). After all, as Webster stated almost a decade ago, mayanists have an incredible advantage over investigators of many other ancient societies in the world, because of the extremely rich understanding of ancient Maya culture and society supported by an abundant and rich burial database (1997: 6). It is our task now to canalize these ample sources of information into a unified frame for reconstructing and interpreting ancient Maya peoples and their life ways.

References

Austin D. M. 1978. The biological affinity of the ancient populations of Altar de Sacrificios and Seibal. *Estudios de Cultura Maya*, 11: 57-73.

Bate F. 1998. *El proceso de investigación en arqueología*. Ed. Crítica, Grijalvo-Mondadori, Barcelona.

Blakely R.T. (ed) 1977. B*iocultural Adaptation in Prehistoric America*. University of Georgia Press, Athens.

Buikstra J.E. 1981. Mortuary practices, paleodemography and paleopathology: a case study from the Coster site (Illinois). In R. Chapman, I. Kinnes & K. Randsborg (eds): *The Archaeology of Death*, pp. 123-132. Cambridge University Press, Cambridge,

Buikstra J.E. 1991. Out of the appendix and into the dirt: comments on thirteen years of bioarchaeological research. In M.L. Powell, P.S. Bridges & A.M. Wagner Mires (eds): *What Mean These Bones? Studies in Southeastern Bioarchaeology,* pp. 172-188. The University of Alabama Press, Tuscaloosa.

Buikstra J.E. 1997. Studying Maya bioarchaeology. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 221-228. Smithsonian Institution Press, Washington.

Buikstra J.E., Price T.D., Wright L.E. & Burton J.A. 2004. Tombs from the Copan acropolis: a life history approach. In E.E. Bell, M.A. Canuto & R.J. Sharer (eds): *Understanding Early Classic Copan,* pp. 191-212. University of Pennsylvania, Museum of Archaeology and Anthropology, Philadelphia.

Cetina A. & Sierra T. 2003. Acercamiento a las condiciones de vida y nutrición de los antiguos habitantes de Xcambó, Yuactán. *Los Investigadores de la Cultura Maya,* 11: 504-513.

Cobos R. 2003. Prácticas funerárias en las tierras bajas mayas del norte. In A. Ciudad, M.H. Ruz & M.J. Iglesias Ponce de Leon (eds): *Antropología de la eternidad: la muerte en la cultura maya,* pp. 35-48. Sociedad Española de Estudios Mayas, Madrid.

Coe M.D. 1980. *The Maya*. Thames and Hudson, London.

Cohen M.N. & Armelagos G.J. (eds) 1984. *Paleopathology at the Origins of Agriculture*. Academic Press, Orlando.

Coyston S., White C.D. & Schwarcz H.P. 1999. Dietary carbonate analysis of bone and enamel for two Maya sites in Belize. In C.D. White (ed): *Reconstructing Ancient Maya Diet,* pp. 221-243. The University of Utah Press, Salt Lake City.

Cucina A. 2005. Procedencia y estatus social de los africanos en la villa colonial de Campeche: un estudio químico y antropológico preliminar. *Estudios de Antropología Biológica* (in press).

Cucina A. & Tiesler V. 2003. Dental caries and ante mortem tooth loss in the northern Petén area, Mexico: a biocultural perspective on social status differences among the Classic Maya. *Am. J. Phys. Anthropol.,* 122: 1-10.

Cucina A. & Tiesler V. 2006. Las relaciones biológicas entre poblaciones pretéritas mayas desde la evidencia de la morfología dental. In R. Cobos (ed): *V Mesa Redonda de Palenque.* Instituto Nacional de Antropología e História, Mexico City (in press).

Cucina A., Sierra T. & Tiesler V. 2003. Sex differences in oral pathologies at the late classic Maya site of Xcambó. *Dent. Anthropol.,* 16: 45-51.

Cucina A., Tiesler V. & Sierra T. 2005a. Marcadores epigenéticos dentales, salud oral y estructura social en el sitio maya de Xcambó, Yucatán. *Temas Antropológicos* (in press).

Cucina A., Tiesler V. & Wrobel G. 2005b. Afinidades biológicas y dinámicas poblacionales mayas desde el Preclásico hasta el periodo colonial. *Los Investigadores de la Cultura Maya*, 13 (in press).

Culbert T.P. 1988. The collapse of classic Maya civilization. In N. Yoffee & G.L. Cowggill (eds): *The Collapse of Ancient States and Civilizations*, pp. 69-101. University of Arizona Press, Tucson.

Culbert T.P. & Rice D.S. (eds) 1990. *Precolumbian Population History in the Maya Lowland*. University of New Mexico Press, Albuquerque.

Dahlin B.H. 2002. Climate change at the end of the Classic period in Yucatan. *Ancient Mesoam.*, 13: 327-340.

Danforth M.E. 1991. Coming up short. Stature and nutrition among the ancient maya of the southern lowlands. In C.D. White (ed): *Reconstructing Ancient Maya Diet*, pp. 103-117. The University of Utah Press, Salt Lake City.

Danforth M.E. 1997. Late Classic Maya health patterns: evidence from enamel microdefects. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 127-137. Smithsonian Institution Press, Washington.

Danforth M.E., Whittington S.L. & Jacobi K.P. 1997. Appenndix. An indexed bibliography of prehistoric and early historic Maya human osteology: 1839-1994. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 127-137. Smithsonian Institution Press, Washington.

Fash W.L. 1994. Changing perspectives on Maya civilization. *Ann. Rev. Anthropol.,* 23: 181-208.

Folan, W.J., Faust B., Lutz W. & Gunn J.D. 2000. Social and environmental factors in the Classic Maya collapse. In W. Lutz, L. Prieto & W. Sanderson (eds): *Population, Development and Environment on the Yucatan Peninsula: from Ancient Maya to 2030*, pp. 2-32. International Institute for Applied System Analysis, Laxenburg.

Gerry J.P. & Krueger H.W. 1999. Regional diversity in classic Maya diets. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 196-207. Smithsonian Institution Press, Washington.

Glassman D.M. & Garber J.F. 1999. Land use, diet, and their effects on the biology of the prehistoric Maya of Northern Ambergis Caye, Belize. In C.D. White (ed): *Reconstructing Ancient Maya Diet*, pp. 119-132. The University of Utah Press, Salt Lake City.

González-Oliver, A., Márquez L., Jiménez J. & Torre-Blanco A. 2001. Founding amerindian mitochondrial DNA lineages in ancient Maya from Xcaret, Quintana Roo. *Am. J. Phys. Anthropol.,* 116: 230-235.

Haviland W.A. 1967. Stature at Tikal, Guatemala: implications for classic Maya demography and social organization. *Am. Antiq.*, 32: 316-25.

Haviland W.A. 1970. Tikal, Guatemala, and Mesoamerican urbanism. *World Archaeol.*, 2: 186-197.

Helfrich K. 1973. *Menschenopfer und Tötungsrituale im Kult der Maya.* Mann Verlag, Berlin.

Hodell D.A., Quinn R.L., Brenner M. & Kamenov G. 2004. Spatial variation of strontium isotopes ($^{87}Sr/^{86}Sr$) in the Maya region: a tool for tracking ancient human migration. *J. Archaeol. Sci.*, 31: 585-601.

Hooton E.A. 1940 - Skeletons from the Cenote of Sacrifice at Chichén Itzá. In C.L. Hay, R.L. Lindton, S.K. Lothrop, H. Shapiro & G.C. Vaillant (eds): *The Maya and Their Neighbors*, pp. 272-280. Appleton-Century Company Inc., New York.

Jacobi, K.J. 2000. *Last rites for the Tipu Maya: Genetic Structuring in a Colonial Cementery.* The University of Alabama Press, Tuscaloosa.

Klepinger L.L. 1992. Innovative approaches to the study of past human health and subsistence strategies. In S.R. Saunders & M.A. Katzenberg (eds): *Skeletal Biology of Past Peoples: Research Methods,* pp. 121-130. Wiley Liss, New York.

Konigsberg L.W., & Buikstra J.E. 1995. Regional

approaches to the investigation of past human biocultural structure. In L.A. Beck (ed): *Regional Approaches to Mortuary Analysis*, pp. 191-219. Plenum, New York.

Lang C.A. 1990. *The Dental Morphology of the Ancient Maya from Lamanai and Tipu, Belize: a Study of Population Movement*. Master Thesis, Trent University, Petersborough, Ontario (Canada).

Larsen C.S. 1997. *Bioarchaeology. Interpreting Behavior from Human Remains*. Cambridge University Press, Cambridge.

Lentz D.L. 1999. Plant resources of the ancient Maya. The paleoethnobotanical evidence. In C.D. White (ed.): *Reconstructing Ancient Maya Diet*, pp. 3-18. The University of Utah Press, Salt Lake City.

Márquez L. 1982. *Playa del Carmen - una Población de la Costa Oriental en el Posclásico*. Colección Científica 119, Instituto Nacional de Antropología e Historia, México, D.F..

Márquez L. 1987. Qué sabemos de los mayas peninsulares a partir de sus restos óseos. In *Memorias del Primer Coloquio Internacional de Mayistas*, pp. 43-56. Universidad Nacional Autónoma de México, México City.

Márquez, L. & Miranda T. 1984. Investigaciones osteológicas en la península de Yucatán. In *Investigaciones Recientes en el Area Maya, XVII Mesa Redonda,* pp. 49-61. Sociedad Mexicana de Antropología, San Cristóbal de las Casas.

Marquez L. & del Angel A. 1997. Height among Prehispanic Maya of the Yucatán peninsula: a reconsideration. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 51-61. Smithsonian Institution Press, Washington.

Márquez L., Jaén M.T. & Jiménez J.C. 2002a. El impacto biológico de la colonización en Yucatán: la población de Xcaret, Quintana Roo. In C. Serrano & L.A. Vargas (eds): *Antropología Física Latinoamérica*, vol. 3, pp. 25-42. UNAM, Instituto de Investigaciones Antropológicas, Mexico City.

Marques L., Hernandez P.O., & Gomes A. 2002b. La población urbana de Palenque en el Clásico tardío. In V. Tiesler, R. Cobos & M. Greene (eds): *La Organización Social Entre los Mayas,* pp. 13-34. INAH/UADY, Mexico City.

Massey, V.K. & Steele D.G. 1997. A Maya skull pit from the terminal classic period, Colha, Belize. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 62-77. Smithsonian Institution Press, Washington.

Merriwether, D. A., Reed D.M. & Ferrell R.E. 1997. Ancient and contemporary mitochondrial DNA variation in the Maya. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 208-217. Smithsonian Institution Press, Washington.

Moser C.L. 1973. *Human Decapitation in Ancient Mesoamerica*. Dumbarton Oaks, Washington, D.C.

Nájera M.I. 1987. *El Don de la Sangre en el Equilibrio Cósmico*. Centro de Estudios Mayas, Universidad Nacional Autónoma de México, México City.

Nalda E., Tejeda S., Velásquez A. & Zarazúa G. 1999. Paleodieta en Dzibanché y Kohunlich: diferenciasy tendencias preliminares. *Arqueología*, 21: 35-44.

Nance R.C., Whittington S.L. & Borg B.E. 2003. *Archaeology and Ethnohistory of Iximché.* University of Florida, Gainesville.

Owsley D.W. & Jantz R.L. 1994. *Skeletal Biology in the Great Plains. Migration, Warfare, Health and Subsistence*. Smithsonian Institution Press, Washington D.C.

Pompa J.A. 1990. *Antropología Dental: Aplicación en Poblaciones Prehispánicas*. Serie Antropología Física, Colección Científica 195, Instituto Nacional de Antropología e Historia, México City.

Powell M.L., Bridges P.S. & Wagner Mires A.M. (eds) 1991. *What Mean These Bones? Studies in Southeastern Bioarchaeology*. The University of Alabama Press, Tuscaloosa.

Price D.T., Tiesler V. & Burton J. 2005. Conquerors, conquered, and slaves: bioarchaeological evidence of the early colonial inhabitants of Campeche, Mexico. *Am. J. Phys. Anthropol.* (in press).

Price D.T., Burton J.H., Tiesler V. & Buikstra J.E. 2006. Geographic origin of Janaab' Pakal and the Red Queen. Evidence from strontium isotopes. In V. Tiesler & A. Cucina (eds): *Janaab'Pakal of Palenque. Reconstructing the Life and Death of a Maya Ruler*. The University of Arizona Press, Tucson (in press).

Reed D.M. 1999. Cuisine from Hun-Nal-ye. In C.D. White (ed): *Reconstructing Ancient Maya*

Diet, pp. 183-196. The University of Utah Press, Salt Lake City.

Rhoads M.L. 2002. *Population Dynamics at the Southern Periphery of the Ancient Maya World: Kinship at Copán*. Ph.D. Thesis, University of New México, Albuquerque. University of Michigan, ProQuest Information and Learning Company, Ann Arbor.

Sauer C.O. 1955. The agency of man on the earth. In W.L. Thomas Jr. (ed): *Man's Role in Changing the Face of the Earth*, pp. 49-69. University of Chicago Press, Chicago.

Saul F.P. 1972. *The Human Skeletal Remains of Altar de Sacrificio, an Osteobiographyc Analysis*, vol. 63, n. 2. Paper of the Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge

Scherer A. 2004. *Dental Analysis of Classic Period Population Variability in the Maya Area.* Ph.D. Thesis, Texas A&M University, College Station.

Schiffer M.B. 1987. *Formation Processes of the Archaeological Record.* University of New Mexico, Albuquerque.

Sharer R.J. 1994. *The Ancient Maya*. Stanford University Press, Stanford.

Shaw J.M. 2003. Climate change and deforestation: implication for the Maya collapse. *Ancient Mesoam.*, 14: 157-167.

Sierra T. 2004. *La Arqueología de Xcambó, Yucatán, Centro Administrativo Salinero y Puerto Comercial de Importancia Regional Durante el Clásico.* Ph.D. Thesis, Universidad Nacional Autónoma de México, México City.

Smith B.D. 1991. Bioarchaeology in a broader context. In M.L. Powell, P.S. Bridges & A.M. Wagner Mires (eds): *What Mean These Bones? Studies in Southeastern Bioarchaeology,* pp. 165-171. The University of Alabama Press, Tuscaloosa.

Stephens J.L. 1843. *Incidents of Travel in Yucatan*. Harper and Brothers, New York.

Stewart T.D. 1943. Skeletal remains from Tajamulco, Guatemala. In B.P. Dutton & H.R. Hobbs (eds): *Excavations at Tajamulco, Guatemala*, pp. 111-114. University of New Mexico, Albuquerque.

Stewart T.D. 1949. Notas sobre esqueletos humanos prehistóricos hallados en Guatemala. *Antropología e Historia de Guatemala* 1:23-34.

Storey R. 1985a. La paleodemografía de Copan. *Yaxkin*, 7: 151-160.

Storey R. 1985b. *Burial and Social Class at Copan, Honduras: Biological Aspects*. 50th Annual Meeting of the Society for American Archaeology, Dept. Anthropology, Unversity of Houston, Houston.

Storey R. 1986. Mortalidad prenatal en Teothiuacán y Copan. *Yaxkin*, 9: 29-42.

Storey R. 1992. Life and Death in the Ancient City of Teotihuacan. University of Alabama Press, Tuscaloosa

Storey R. 1999 - Late Classic nutrition and skeletal indicators at Copan, Honduras. In C.D. White (ed): *Reconstructing Ancient Maya Diet*, pp. 169-182. The University of Utah Press, Salt Lake City.

Tejeda, S., Tiesler V., Folan W. & Coyoc M. 2002. Nutrición y estilo de vida en Calakmul, Campeche. *Los Investigadores de la Cultura Maya*, 10: 335-340.

Tiesler V. 1993. Algunos conceptos y correlatos para la consideración del individuo en arqueología. *Boletín de Antropología Americana,* 28: 5-16.

Tiesler V. 1996. Restos humanos como fuente de información arqueológica. Aplicaciones en la investigación mayista. *Cuicuilco*, 2: 213-222.

Tiesler V. 1997. El esqueleto vivo y muerto: una propuesta para la evaluación de restos humanos en el registro arqueológico. In E. Malvado, G. Pereira & V. Tiesler (eds): *El Cuerpo Humano y su Tratamiento Mortuori*, pp. 77-89. Colección Científica, Instituto Nacional de Antropología e Historia, México City.

Tiesler V. 1998. *La costumbre de la deformación cefálica entre los antiguos mayas: aspectos morfológicosy culturales.* Colección Científica/Instituto Nacional de Antropología e Historia, México, D.F.

Tiesler V. 1999. *Rasgos Bioculturales Entre los Antiguos Mayas. Aspectos Arqueológicos y Sociales*. Ph.D. Thesis, Universidad Nacional Autónoma de México, Mexico City.

Tiesler V. 2000a. Eres lo que comes. Patrones de desgaste oclusal en poblaciones mayas prehispánicas. *TRACE,* 38: 67-79.

Tiesler V. 2000b. *Decoraciones Dentales Entre los Antiguos Mayas.* Ediciones Euroamericanas, Instituto Nacional de Antropología e Historia, México City.

Tiesler V. 2001a. Patrones ocupacionales y subsistencia en la sociedad maya de la costa peninsular. Consideraciones bioculturales. *Mayab,* 14: 30-41.

Tiesler V. 2001b. La estatura entre los mayas prehispánicos. Consideraciones bioculturales. *Estudios de Antropología Biológica, 10*: 257-273.

Tiesler, V. & Cucina A. 2003. Sacrificio, tratamiento y ofrenda del cuerpo humano entre los mayas del Clásico: una mirada bioarqueológica. In A. Ciudad, M.H. Ruz & M.J. Ponce de León (eds): *Antropología de la eternidad: la muerte en la cultura maya*, pp. 337-354. Sociedad Española de Estudios Mayas, Madrid.

Tiesler V. & Cucina A. (eds) 2004. *Janaab' Pakal de Palenque. Vida y Muerte de un Gobernante Maya*. Universidad Nacional autonoma de Mexico, Mexico City.

Tiesler V., Tejeda S. & Sierra T. 2002a. Nutrición y condiciones de vida en la costa norte de la península durante el Clásico: una visión desde Xcambó, Yucatán. *Memorias del XV Simposio de Investigaciones Arqueológicas en Guatemala*, pp. 863-873. Museo Nacional de Arqueología y Etnología, Guatemala City.

Tiesler V., Cucina A. & Romano A. 2002b. Vida y muerte del personaje hallado en el Templo XIII-sub, Palenque: I. Culto funerario y sacrificio humano. *Mexicon,* 24: 75-78.

Turner B.L. & Harrison P.D. (eds) 1983. Pulltrousers, Swamps: Ancient Maya Habitat, Agriculture and Settlement in Northern Belize. University of Texas Press, Austin.

Webster D., Sanders W.T. & van Rossum P. 1992 - A simulation of Copan population history and its implications. *Ancient Mesoam.*, 3: 185-197.

Webster D. 1997. Studying Maya burials. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 3-12. Smithsonian Institution Press, Washington D.C..

White C.D. 1997. Ancient diet at Lamanai and Pacbitun: implications for the ecological model of collapse. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp.171-180. Smithsonian Institution Press, Washington D.C..

White C.D. (ed) 1999. *Reconstructing Ancient Maya Diet*. The University of Utah Press, Salt Lake City.

White C.D., Healy P.F. & Schwarcz H.P. 1993. Intensive agriculture, social status and maya diet at Pacbitun, Belize. *J. Anthropol. Res*., 49: 347-375.

White C.D., Pendergast D.M., Longstaffe F.J. & Law K.R. 2001. Social complexity and food systems at Altun Ha, Belize: the isotopic evidence. *Lat. Am. Antiq*., 12: 371-393.

Whittington S.L. & Reed D.M. (eds) 1997. *Bones of the Maya*. Smithsonian Institution Press, Washington.

Wright L.E. 1997. Ecology or society? Paleodiet and the collapse of the Pasión Maya lowland. In S.L. Whittington & D.M. Reed (eds): *Bones of the Maya*, pp. 181-195. Smithsonian Institution Press, Washington D.C..

Wright L.E. 2004. Osteological investigations of ancient Maya lives. In C.W. Golden and G. Borgstede (eds): *Continuities and Changes in Maya Archaeology: Perspectives at the Millenium*, pp. 201-215. Routledge Press, New York.

Wright L.E. 2005. Identifying immigrants to Tikal, Guatemala: defining local variability in strontium isotope ratios of human tooth enamel. *J. Archaeol. Sci*., 32: 555-566.

Wright L.E. & White C.D. 1996. Human biology in the Classic maya collapse: evidence from paleopathology and paleodiet. *J. World Prehist*., 10: 147-198

Wrobel G.D. 2003. *Metric and Non-Metric Dental Variation Among the Ancient Maya of Northern Belize*. Ph.D. Thesis, University of Indiana, Indiana.