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ORIGINAL PAPER

Commentary: feeding Teotihuacan in the context of commodities research

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Abstract This commentary on the Feeding Teotihuacan collection of papers provides an "outsider" perspective on the contributions, by an archeologist who conducts research on agriculture and plant use by the ancient Maya.

Keywords Plant-food · Food staples · Commodities · Teotihuacan · Maya

What makes the topic of "Feeding Teotihuacan" of particular interest is that Teotihuacan developed into *the* classic urban center of Mesoamerica (Cowgill 2015). During its height, Teotihuacan was a dense, crowded city with greatly reduced potential for households to grow or gather their own plant food, or hunt or trap their own meat. Population estimates for the city, covering about 20 to 25 km^2, hover around 100,000 (Cowgill 2008, 2015), implying averaged population densities of over 4000 people per square kilometer (see also Drennan 1988 for higher density estimates). While urban gardening may have provided some produce for the city residents, it is clear that the vast majority of food must have come from the surrounding hinterland (see the introduction to this special issue by Sugiyama and Somerville). I would argue that this is a very different situation than was the case with the ancient Maya, who I study. I do research on lowland Maya subsistence and settlement systems, cultivation systems, and more recently on indigenous food plants of the Maya Lowlands. At the same annual meeting of the Society for American Archeology at which the "Feeding Teotihuacan" symposium was held, I was invited to give a presentation on plant-food commodities of the ancient Maya (part of my discussion here of commodities is adapted from that presentation; Fedick 2014). The topic of plant-food commodities actually seems more appropriate as a question to ask for Teotihuacan rather than the lowland Maya. My view of ancient Maya farming practices emphasizes households producing most of their own food in a relatively dispersed settlement pattern and making use of homegardens, high-performance milpa, forest farming, and a mix of cultivation technologies including wetland transformation and hillslope terracing (see recent overviews by Ford and Neigh 2015; Lentz et al. 2015; Thompson et al. 2015).

Estimates for urban population and settlement densities at Classic period centers of the Maya Lowlands are very difficult to calculate do to the lack of clear boundaries to settlements. Residential settlement around monumental "urban" architecture generally follows the distribution of prime agricultural land. For Tikal, one of the largest Maya centers, recent population estimates for the Late Classic period range from 53,000 to 67,000 for the "core" area of the site, with settlement densities of 204–263 people per square kilometer in favored upland soils, although the actual boundary of the hinterland remains uncertain (Webster and Murtha 2015:226–227). At the higher end of the scale for estimated settlement densities at a Late Classic Maya site, Caracol is said to have included a population of over 100,000, comparable to Teotihuacan, but spread over an area of 200 km^2, with an averaged population density of 500 people per square kilometer (Chase and Chase 2014). I suspect that there was actually little need for commodification of food by the ancient lowland Maya. Teotihuacan, however, presents a very different situation. Food commodities were likely necessary to enable urban development at Teotihuacan.

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In economics, there are two definitions for food commodities (Magdoff 2012). First, there are food commodities as agricultural goods (in unprocessed or minimally processed form) that are commonly produced in multiple locations, that are bought and sold, or exchanged, at prices determined by current demand. Second, food commodities can be nutritional supplements distributed by centralized agencies to individuals or groups in need (e.g., Fox et al. 2004). This distinction between food redistribution and marketing came up in several of the Feeding Teotihuacan papers, but the general consensus seems to be that it is currently difficult to identify, or distinguish between, centralized redistribution of food at Teotihuacan and distribution through a marketing system. It is important to note that the Feeding Teotihuacan symposium was not really intended to examine where or how the food was produced (with the exception of the Somerville et al. paper on rabbit production). This is not meant as a criticism of the symposium, it is just a recognition that the subject matter focuses on the question of "what were the people of Teotihuacan eating"? If we accept the premise that residents of the city must have relied on importation of a significant proportion of their food, then consideration of commodities is embedded in the question "what were the people of Teotihuacan eating?", returning us again to the topic of commodities.

Food commodities are generally synonymous with food staples, or basic dietary items. However, all food staples are not necessarily commodities, and all food commodities are not necessarily staples. Plant foods valued for ritual, prestige, or pleasure, sometimes referred to as sumptuary foods, can also be considered as commodities. For the Maya, cacao clearly served as a sumptuary commodity used primarily in a ritualized drink (McNeil 2006), while for Teotihuacan, the contribution by Robertson and his colleagues examines the use of maguey sap, used to make the fermented drink, pulque.

One defining characteristic that helps in sorting out which staple foods are also commodities is that the food must be transportable and storable. In the world commodities market of today, the standard plant-food commodities are: grains (corn, wheat, oats, rice, soybeans), coffee, rape seed (for oil), sugar, cocoa, and frozen orange juice concentrate (Investor Guide Staff 2013). Modern preservation technology obviously plays a role in food commodities, in that orange juice concentrate could not be stored and transported without being frozen. Many other plant foods are traded on the commodity market, particularly plant foods that function as commodities in regional markets that are subject to cultural food preferences. Papers in this symposium make some very interesting suggestions about cultural food preferences for the people of Teotihuacan, and perhaps our own cultural biases in food preferences that have unduly influenced both our archeological recovery methods and our interpretations of stable foods. Specifically, I refer to the contribution by story and Widmer that highlights the importance of animal proteins derived from insects, small fish, and rodents. Researchers working in the Maya Lowlands need to take heed of our own biases in what we think of as food. Certainly, there is no lack of insects and other small animals that may have served as sources of nourishment for the ancient Maya. I recently returned from a trip to Belize that included discussion of, and sampling, termites and grubs.

A research plan to identify food commodities at Teotihuacan might address three basic questions: (1) what plant and animal foods were available to ancient Teotihuacanos; (2) which of the available plant foods and animals are most likely to have been used as commodities or dietary staples; and (3) what forms of processing/preservation technology would have been used to make the plant or animal food commodity storable and transportable?

Relating to the first question posed above, the contribution by Martinez-Yrizar and McClung de Tapia emphasizes ecology, ethnography, and history as important interdisciplinary sources to help in the analysis of recovered archeological plant remains. I would suggest that researchers also need to build a database of indigenous plants and animals that would have been available in the region and are documented in the ethnohistoric and ethnographic records to have been used by the indigenous people. Once this database is developed, caution must be observed in the interpretation of species represented by recovered remains. For an example drawn from the Maya area, of 500 indigenous food plants known ethnographically to have been used by the Maya, over 88 % of the species are animal-pollinated, and are not likely to be represented in the archeological pollen record (Fedick and Islebe 2012; see also Fedick 2010; Ford 2008). As alluded to by Martinez-Yrizar and McClung de Tapia, careful consideration of taphonomic/formation processes must be incorporated into interpretation of archeological plant remains.

In addressing the second question, identifying the most likely food commodities might be accomplished by documenting food remains that have been most commonly recovered archeologically, as long as these recovery frequencies are interpreted through the lens of taphonomic/formation processes, as mentioned above. Martinez-Yrizar and McClung de Tapia call for making full use of contextual evidence for the study of foodways, as well as multi-proxi approaches to identifying foods used, ranging through residues, isotope signatures, human osteological remains, and archeological sediments. These researchers list nine plant foods that they feel were most significant based on various lines of evidence. The order of importance (or ubiquity of recovery) is not apparent in their presentation, so I list them alphabetically as; amaranth, beans, chenopodium, chili, jaltomate, maize, portulaca, squash, and tomatillo. While they do not mention it in their presentation, I find it interesting that nearly half of these plants use a C4 photosynthetic pathway

(amaranth, chenopodium, maize, and portulaca). The Teotihuacan researchers show a level of awareness of C4 plants besides maize that seems to be sorely lacking among subsistence researchers working in the Maya area, where C4 signatures are generally assumed to derive only from maize. My own examination of indigenous food plants of the Maya Lowlands identifies 15 C4 species and 28 CAM species (Fedick and Santiago 2012).

In a different approach, Casar et al. use stable isotope analysis of enamel and dentine from human molars to identify important foods of Teotihuacan. They specifically look at the photosynthetic pathways used by plants in the diet, and find that 72 % of the diet is composed of plants using the C4 or CAM pathway; agave (CAM), amaranth (C4), cactus (CAM), and maize (C4). The remainder of the diet is composed of C3 plants such as beans, squash, tomatoes, etc. Similarly, they find for protein intake that 80 % is from C4 derived meat or freshwater resources, with the other 20 % coming from C3-derived meat and beans. They also find that game animals have a higher C3 signature for the plants they fed on, while domesticated animals (dog and turkey) show a higher C4 signature for the plants they were fed.

The contribution by Nado et al. also relies on biogeochemical analyses of stable carbon, nitrogen, and oxygen isotopes to examine differences in diet between sacrificial victims interred within the offering complex of the Feathered Serpent Pyramid and burials associated with two residential compounds within Teotihuacan. The results suggest intriguing differences in the long-term diets of the sacrificial victims and the residential burials, while confirming that both of those populations appear to originate from the same geographic region. Further, differences were suggested by the analysis between elite and commoner residents of Teotihuacan as well as variation in the diets of males and females. Beyond the innovative use of carbon isotopes to trace maize consumption of Teotihuacan residents, analysis of oxygen isotopes could be applied to maize remains to determine the geographic origins of imported maize, as has been done for other regions such as the southwestern USA (Benson 2012).

Focusing on animals, the papers by Sugiyana et al. and by Somerville et al., re-evaluate the pattern of faunal use at Teotihuacan, showing the great diversity of animals used, and specifically the importance of smaller animals. Of particular interest is the topic of rabbit management and breeding at Teotihuacan as addressed by Somerville et al. We need a lot more studies like this for animal management in Mesoamerica. Somerville and his colleagues made good use of stable isotope analysis of rabbit bones from different context within Teotihuacan, as well as a comparison with modern wild rabbits, to build the case that rabbits were being raised at Oztoyahualco. Rabbit raising may also have contributed to gardening in or around Teotihuacan, since rabbit droppings are second only to bat guano in fertilizer value for plant growth.

Turning to research question 3 as presented above, it is evident that the study of food processing and preservation technology in ancient Mesoamerica is very under-developed, and we need more research on these topics to help determine which foods could have served as commodities (e.g., Cox 1980; Lancaster and Coursey 1984). In order for food to be used as a commodity, it needs to be preservable and transportable.

Biskowski's paper on "Staple Food Preparation at Teotihuacan" is a welcome contribution to this area of research. Bislowski considers maize grinding, lime treatment, and tortilla production, and very nicely demonstrates how, together, this processing leads to improved nutrition, dependability as a staple, and portability, while also lowering fuel costs for maize preparation. Maize in the form of tortillas is an excellent commodity, and Bislowski expands on Elizabeth Brumfiel's previous work on the economic significance of Aztec tortilla production and transport (Brumfiel 2005).

The contribution by Robertson and his colleagues addresses storage and transport of maguey sap, in the form of fresh sap (aguamiel), sap boiled and reduced to a thick, honey-like substance, or fermented to produce a mildly alcoholic drink (pulque). While specifying some areas on the outskirts of Teotihuacan that may have been used for maguey production, the most innovative aspects of the study combine identification of ceramic vessel forms that would be suitable for liquid transport (specifically amphora) with residue analysis of sherds that might retain chemical markers of maguey juice. Are there other forms of Teotihuacan ceramics that might suggest associations with preparation, storage, or transport of foodstuffs that might also be tested through residue analysis (besides, of course, the link between ceramic comals and maize tortillas)? This line of research brings to mind the recent identification of cacao residue in cylinder vases from Chaco Canyon in the southwestern USA (Crown and Hurst 2009). Cacao does not grow in New Mexico, but is commonly associated with cylinder vases of the Maya Lowlands, where the cacao tree has long been cultivated.

In this commentary, I have focused on the issue of commodities, as I feel this is one of the strongest contrasts between the food economy of Teotihuacan, and that of the Maya Lowlands, where I work. Recalling Robert Drennan's (1988) overview of compact versus dispersed settlements in ancient Mesoamerica, he makes the point that large, compact settlements, such as Teotihuacan, must have served as central places that imply the provisioning of food from outside of the center, while the dispersed settlement of the Maya implies intensive agricultural production that is imbedded within the residential area. In a final evaluation, this collection of papers represents wide ranging approaches to answering some of the most basic questions about feeding Teotihuacan. The

collection succeeds in large part to answer the call by Martinez-Yrizar and McClung de Tapia to integrate both analytical methods and contextual interpretations to provide an increasingly satisfactory understanding of how this ancient metropolis was fed. As noted in the introductory article of this collection, several of the authors are pushing research forward from a more materialistic "food systems" approach of examining food production and distribution (which would include commodities research), to a broader and more social approach of considering "foodways" that include ritual and symbolic aspects of food and feasting, gender relations imbedded in food preparation, and complex issues of scale, both geographic and social, in supplying, and distributing food; a welcome and productive approach, indeed.

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