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Experimental anthracology: Evaluating the role of combustion processes in the representivity of archaeological charcoal records in tropical forests, a case study from the Maya Lowlands

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ABSTRACT

Observation of archaeological charcoal records from Maya sites, and in particular, the Classic site of Naachtun (Northern Peten, Guatemala), indicates that certain woody taxa tend to occur in proportions that are highly inconsistent with their representation in the local forests today. We note this phenomenon for two taxa in particular: 1) the genus *Manilkara*, which dominates the charcoal assemblages of Naachtun, but grows in relatively low proportions in modern Central Lowlands forests, and 2) breadnut (*Brosimum alicastrum*), which is widespread in the modern forests of the region, but whose wood is almost absent in the archaeological record. Based on ethnographic and ethnohistoric accounts, many researchers have argued that both of these trees would have played a major role in ancient Maya agroforestry. Therefore, it becomes necessary to determine how accurately the occurrence of *Manilkara* and *Brosimum* in archaeological charcoal records reflects their use in the past. We explore the hypothesis that combustion processes may create taphonomic biases that lead to the differential preservation of certain Maya Lowland tree taxa, and thus distort the representivity of the charcoal spectra recovered from ancient Maya sites. To evaluate this hypothesis, we conducted 35 experimental fires using five of the principal tree species of the modern forest around the site of Naachtun, including *Manilkara* and *Brosimum*. The charcoal assemblages produced through these fires were systematically identified and studied using quantitative methods. Our results indicate that significant differences exist among these taxa as a result of combustion, and that these phenomena are consistently observed for each taxon through multiple controlled trials. Thus, anthracological analyses are indeed appropriate for reconstructing human-environmental interactions in the Central Lowland forest, but certain predictable taphonomic biases must be taken into account when interpreting the charcoal data.

1. Introduction

The Central Maya Lowlands, today covered by a semi-evergreen tropical forest and extending through Northern Guatemala, Belize, and the southern parts of Campeche and Quintana Roo (Mexico), once supported a high population density until the abandonment of its major centers toward the end of the first millennium. The city of Naachtun, located in Northern Petén (Guatemala), 2 km south of the Mexican border, was a major center of the Classic period, occupied at least from 150 to 950 CE. It has been intensively excavated since 2010 as part of the ongoing Naachtun Archaeological Project (University Paris 1 Panthéon-Sorbonne/CNRS UMR 8096/University San Carlos of Guatemala). As at other Maya cities, Naachtun developed extensive economic networks (Nondédéo et al., 2016a, 2016b), but its inhabitants also relied on local forest resources, particularly wood for fuel. However, despite the fact that forest management practices by ancient Maya people have been one of the main concerns of environmental archaeology in the Maya Lowlands (e.g. Abrams and Rue, 1988; Ford and Nigh, 2015; McNeil, 2012; Wiseman, 1983), very few studies have focused specifically on wood economy and its impact on the forests through time.

Archaeological charcoal analysis provides data on firewood use and forest management strategies among ancient societies. It also provides

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at least a partial image of the composition of woodlands and their evolution through time. However, charcoal remains in the Maya area are rarely considered by archaeologists, and systematic anthracological studies are still uncommon (but see Dussol et al., 2016; Lentz et al., 2014; Miksicek, 1991; Morehart, 2011; Thompson et al., 2015) despite the numerous unanswered questions that exist relative to the importance of certain wood species in the economies of these societies. In the forests of the Maya Lowlands (Fig. 1), sapodilla (*Manilkara zapota*, Sapotaceae family) and breadnut (*Brosimum alicastrum*, Moraceae family) are both slow-growing species characteristic of the oldest forest succession stages. They are among the most important trees in the agroforestry of modern Maya societies, used for fruit, timber, firewood, animal fodder and latex (Atran et al., 1993; Nations and Nigh, 1980; Sanabria, 1986). Due to their current economic and ecological value, many researchers have suggested that these two tree species would have played a key role in ancient Maya agroforestry as well (e.g. Atran et al., 1993; Gómez-Pompa, 1987; Lentz and Hockaday, 2009; Lundell, 1938; Puleston, 1968, 1982). This hypothesis highlights the interest of these two tree species for reconstructing the long-term relations between Maya societies and their forested landscape through anthracological studies. However, the data currently available indicate that their proportions in the charcoal records of central Maya cities throughout the Classic period (250–950 CE) do not correspond to their proportions in the region's modern forests. More precisely, *Manilkara* tends to be dominant in the charcoal records of sites like Naachtun, while *Brosimum* is often represented in less frequent amounts. Various explanations can be proposed to explain these apparent inconsistencies:

1) Environmental changes: the abundance of these trees in the environment was different during the Classic period, whether due to natural or anthropogenic factors.
2) Human selection: sapodilla wood was preferentially collected, whereas breadnut wood was not, or only occasionally, used as firewood.
3) Taphonomic bias: combustion or post-depositional processes impact these species differently, resulting in their over- or under-representation in the charcoal records compared to the proportions of wood present prior to combustion.

To investigate the two first hypotheses in an appropriate manner, it is necessary to start evaluating empirically the impact of taphonomic factors on the representivity of sapodilla and breadnut wood in the anthracological assemblages of the Central Lowlands. However, issues of charcoal taphonomy have rarely been addressed for the Maya zone. This lacuna is surprising because the North American tradition of paleoethnobotany has studied other aspects of taphonomy, in particular the impact of different sampling strategies on seed recovery and the influence of various methods of quantifying macroremains on the final results (e.g., Ford, 1979; Gasser, 1985; Hageman and Goldstein, 2009; Lennstrom and Hastorf, 1995; Pearsall, 2000; Popper, 1988; Wagner, 1988; White and Shelton, 2015). European charcoal analysts, on the other hand, have long investigated questions regarding the representivity of anthracological assemblages, and a number of methodological approaches have been developed to address these issues. Thus, while accurate approaches to palaeoenvironmental reconstructions using quantitative charcoal analysis have been established for European wood taxa and archaeological contexts (Chabal, 1992, 1994; Théry-Parisot et al., 2010a), methods and models specific to Neotropical contexts remain to be developed.

This paper presents a study of the effects of combustion on wood charcoal assemblages that targets five Central American tree species representative of the Maya Lowland forest. Our principal objective is to understand, for each of these species, the relationship between the quantity of wood burned and the taxonomic frequencies of the charcoal that are left behind. These data then allow us to verify empirically whether the combustion process impacts distinct species uniformly, differently, or if the effects are instead random and unpredictable. Finally, we discuss the potential consequences of our findings for the interpretation of charcoal data carried out at Maya sites.

Fig. 1. Map of the Central Maya Lowlands with locations of the sites mentioned in the text.