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The effect of Maya traditional harvesting on the leaf production, and demographic parameters of *Sabal* palm in the Yucatán Peninsula, Mexico

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ABSTRACT

Palm leaves are an important resource for family households. The effect of harvest on leaf production, growth and fecundity of wild individual palm trees has been studied, but little is known about palm harvest in agro-forestry systems. In the Maya area of the Yucatán Peninsula, Mexico, leaves of the xa'an palm (*Sabal yapa*, and *Sabal mexicana*) have been used since pre-Hispanic days for thatching the roofs of traditional Maya houses. The Maya have introduced xa'an palms in homegardens and the care they provide them improves their growth. Maya householders agree on what they consider to be the best harvest intensity for xa'an, recommending one or two harvest events per year, and leaving one or two leaves in each event; however, there is not ecological information documenting whether the traditional harvesting practices are the most adequate to maintain or increase leaf production, and their effect on the growth and fecundity of the palm trees. In Maxcanú, Yucatán, we studied eight family homegardens with *S. yapa* and *S. mexicana*. The selected individuals from each homegarden ($n = 252$) underwent six harvest treatments for 2 years C: control, no harvest, Al: annual harvest, leaving three leaves on the palm, Am: annual harvest leaving two leaves, Ah: annual harvest leaving one leaf, Sl: two harvests per year leaving three leaves, Sm: two harvests per year leaving two leaves. Treatments Ah and Sm simulated the traditional harvest method, and the remaining treatments simulated higher or lower harvest intensities and frequencies. Leaf production was higher in individual palms under higher harvest intensities and frequencies (Ah, Sl and Sm), but palm growth and leaf size were not affected by harvest. Number of inflorescences per palm differed between treatments and between homegardens during the first year only, but we could not find a clear pattern of variation. Production of new leaves was affected by initial palm size and initial leaf number. Removing mature leaves while leaving the young ones, as well as the intensity and frequency, with which traditional harvest is practiced, stimulate palms to compensate the defoliation effects by producing new leaves. This practice is based on empirical Maya knowledge that enables the manipulation of micro-environmental conditions and the development of sustainable harvesting strategies for the xa'an palm in traditional agro-forestry systems.

1. Introduction

Palms are important non-timber forest products (NTFP) in most tropical regions of the world (Balick and Beck, 1990; Khan and De Granville, 1992; Pedersen and Balslev, 1992). Arecaceae is among the plant families with the largest number of useful species, providing food, medicine, household utensils, and handicrafts (Balick, 1988; Balick and Beck, 1990; Khan and De Granville, 1992; Pedersen and Balslev, 1992), and also constitute an important part of incomes for rural households (Hodel, 1992).

Palm leaves are frequently used in the construction of house roofs (Caballero, 1994; Ratsirarson et al., 1996; Zuidema and Werger, 2000a). In the Yucatán Peninsula, leaves of the *xa'an* palm (*Sabal yapa* Wright ex Becc., and *Sabal mexicana* Mart., Arecaceae) are used for this purpose by the Maya people (Caballero, 1994). In some regions, palm leaves are extracted from the natural vegetation (Pulido and Caballero, 2006), but reduction in size of natural areas has led to introduce *Sabal* palms in managed systems such as homegardens (Caballero, 1994)

There is a consensus among farmers throughout the Maya area of Yucatán regarding the harvesting regime of *xa'an* palm leaves (Gama, 2001). Traditionally, only mature leaves are cut from

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individuals with stems 5 m height or less, and at least one, or preferably two, mature leaves are left remaining on the palm along with the new unfolding leaf (cogollo). Harvest takes place once or twice per year, never more, depending on household demands. Individual palm trees are never felled to make the harvest easier. Some studies document cases of over-exploitation of palm leaves (O'Brien and Kinnaird, 1996) or the felling of complete individuals to ease leaf harvest (Peters et al., 1989; Vásquez and Gentry, 1989; Pedersen and Balslev, 1992), but in general, leaf extraction experiments in natural vegetation show positive effects on the palm plant (Mendoza et al., 1987; Oyama and Mendoza, 1990; O'Brien and Kinnaird, 1996; Zuidema and Werger, 2000b). The extraction of palm leaves, therefore, has been documented to be a sustainable activity throughout time (Nations, 1992; Reining and Heinzman, 1992; Pulido and Caballero, 2006).

Palms from natural vegetation are highly tolerant to defoliation (Zuidema and Werger, 2000b) although the effect of the intensity and frequency of defoliation on leaf production varies between palm species. Common understory species such as *Geonoma deversa* and *Astrocaryum mexicanum* do not appear to completely compensate the effect of defoliation, the production of new leaves diminishes when 100% of the leaves are frequently removed (Mendoza et al., 1987; Zuidema and Werger, 2000b). Other species such as *Chamaedorea radicalis* and *Livingstonia rotundifolia* increase leaf production proportionally to the extraction rate, although leaf size decreases (O'Brien and Kinnaird, 1996; Endress et al., 2004). Growth, survival, and flower and fruit production are affected by harvesting in *Chamaedorea tepejilote*, *C. radicalis* and *Sabal uresana* (Oyama and Mendoza, 1990; Joyal, 1996; Endress et al., 2004). In general, low light availability below the forest canopy and intense leaf extraction seem to negatively affect the production of new leaves and the palm's vital rates (O'Brien and Kinnaird, 1996; Svenning and Macías, 2002; Endress et al., 2004).

Several authors have suggested that species managed in natural vegetation may be introduced into agro-forestry systems to increase leaf production, encouraging their sustainable use (Svenning and Macías, 2002). Nevertheless, the harvest of cultivated palm leaves has been overlooked. In these systems, palms occur under different conditions than those thriving in the forest understory, so their response to defoliation could be different from the one observed in the wild populations. Xa'an palms in the Yucatán peninsula have been exploited since pre-Hispanic times and their introduction to family homegardens during the Spanish colonial period has enabled peasants to manipulate their populations (Caballero, 1994) and sustain their population growth (Martínez-Ballesté et al., 2005). Traditional harvest practices have been the result of empirical learning socially shared and transmitted from one generation to the next.

Previous results show that various management practices used in homegardens (such as seedling protection, occasional seeding and watering) favor the sustainability of *Sabal* populations and increase the numbers of palms with stem-sizes appropriate for harvesting leaves (Martínez-Ballesté et al., 2005). However, it had not evaluated whether the harvest intensity recommended by Maya farmers is the most appropriate one to increase or maintain leaf yield or if other defoliation intensities would be better. In this study we conducted such evaluation, which was considered to be important because, in addition to the local traditional use, xa'an leaves are commercialized in other regions of Yucatán Peninsula to roof buildings of tourist resorts along Mexico's Caribbean coasts. Despite the commercial demand of leaves has markedly increased (Caballero et al., 2004), the harvest strategies remain the same in the entire Peninsula. Thus, our results could contribute to design an appropriate strategy to face the new pressures that have been set on leaf extraction. Our specific questions were: (1) are traditional Maya harvest practices the most appropriate for sustainable leaf production in homegardens? and (2) what is the impact of different defoliation intensities on growth, fecundity, and new leaf production in the palms growing in homegardens?

2. Methods

2.1. Study site and species description

A defoliation experiment was carried out in the town of Maxcanú, Yucatán, Mexico, in homegardens where *S. mexicana* and *S. yapa* were managed. In these agro-forestry systems, palms are combined with a great variety of wild and cultivated trees and bushes (Caballero, 1992). Various management practices, such as watering and weeding, are carried out by local people to foster the growth of promoted species.

After having obtained permission from the Maya farmers, a defoliation experiment was conducted in eight homegardens. Six of them had both species and two had only *S. mexicana*. The eight homegardens had at least one building with palm roof, which indicates that *Sabal* leaves were still in use. All selected individuals of both *Sabal* species in the homegardens showed evidence to have been harvested. Some of the households had a higher palm tree species density than others, and therefore a great variation in the intensity of solar radiation was found. We observed irrigation practices in only one garden and a very high weed density in two others. Soil, according to Maya classification (Aguilera, 1958), was black (lithosol) in seven homegardens and one had red soil (rendzin).

Palms of the genus *Sabal* are hermaphrodite, 15–20 m tall, with single trunks, fan-shaped leaves, and inflorescences approximately 3 m long produced between January and March. *S. mexicana* is more robust than *S. yapa*, even though the reproductive structures are similar (Quero, 1992). *S. yapa* is the most widely distributed species in the Yucatán Peninsula, a common element in primary forests and secondary vegetation in the central and northern part of the Peninsula. It is found in agro-forestry systems such as pasturelands, corn fields (*milpas*) and homegardens (Zona, 1990; Caballero, 1994). *S. mexicana* is also widely distributed in Mexico, although in the central and northern parts of the Yucatán Peninsula it is only found cultivated in homegardens.

2.2. Experimental defoliation

The defoliation experiment lasted from July 2000 to July 2002. Taking into account traditional harvest strategies, we considered three factors in the experimental design.

(a) *Plant size*: We included only harvestable-sized individuals in the experiment. Since annual leaf production depends on plant height (Martínez-Ballesté, 2006) we stratified the sampling procedure, selecting six individuals from each of three categories: 1–100 cm, 101–200 cm, and 201–500 cm.
(b) *Harvest intensity*: We applied three harvest intensities: h: high, with only one leaf remaining after harvest, m: medium, with two leaves remaining and l: low, with three leaves remaining. In every case the unfolding leaf bud called "cogollo" was left intact.
(c) *Harvest frequency*: A: annual, and S: semestral.

We also included a control (C) that was not harvested (Table 1).

Treatments Ah and Sm corresponded to the traditional harvest method and the remaining treatments simulated higher or lower harvest intensities and frequencies. A treatment consisting of two annual harvests with only one leaf remaining on the palm (Sh) was