

# Preparation for propagation: understanding germination of giwa (Astrocaryum standleyanum), wagara (Sabal mauritiiformis), and eba (Socratea exorrhiza) for future cultivation

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**Abstract.** This article reports on domestication as a simple way to promote plant conservation in indigenous villages. We developed simple methods to germinate or transplant palm species central to the traditional livelihood of two Panamanian nations: the Emberá and the Wounaan. The target species were *Astrocaryum standleyanum, Sabal mauritiiformis* and *Socratea exorrhiza*. The youngest fully expanded leaf of *Astrocaryum* provides prime material for weaving baskets that are a major source of income for the Emberá and Wounaan communities of Panamá. *Sabal* and *Socratea* are the two most important species for traditional architecture. They provide, respectively, the roofs and floor of the round, opensided Emberá–Wounaan houses. For each of the three target species, different treatments were tested to obtain germination rates as high as possible. Regardless of the treatments to which seeds were subjected, germination success was around 40%. However, the two other species, especially *Socratea*, were easy to germinate. Our project succeeded in introducing the practice of nursery and cultivation in over 20 indigenous villages of Panamá. It is hoped that such forestry approaches to conservation can help protect important components of biodiversity while giving access to the resource to people whose lifestyle depends on them.

### Introduction

This article focuses on domestication as a simple way to promote plant conservation. The work is part of a larger project aiming to implement sustainable management strategies for biological diversity with two indigenous people of Panamá, the Emberá and the Kuna (Dalle et al. 2002). The research presented here was carried out over several years, in different villages, and concentrates on three species of palms. These palms are known locally by their Emberá or Spanish names giwa, wagara and eba and were identified using the herbarium collection of the Smithsonian Tropical Research Institute as, respectively, *Astrocaryum standleyanum* Bailey, *Sabal mauritiiformis* (H. Wendl. ex H. Karts.) Griseb. and H. Wendl., and *Socratea exorrhiza* (Mart.) H. Wendl.

Community members and leaders from Emberá-Wounaan villages in the province of Darién explained to us that palms considered crucial to traditional lifestyle as well as economic livelihood were becoming increasingly difficult to encounter. The concern that populations of giwa, wagara, and eba were diminishing was expressed using walking time as a measure of resource scarcity. "We used to find giwa half an hour from the village, now we have to walk for 3 hours. We fear that soon we will have to walk 6 hours to find the material that we need". The marketing of intricate basketry, woven with fibers of juvenile A. standleyanum leaves, provides a significant income source for indigenous women. It acts as their unique link to the Panamanian tourism industry and art trade at an international level (personal observation). The foreboding spine-covered trunk of A. standleyanum makes the conventional climb and harvest technique impossible. In the Province of Manabi, Ecuador, bamboo poles affixed with hooked blades are used to cut spear leaves from shorter A. standleyanum (<10 m) (Pedersen 1994). In contrast, the Emberá fell entire A. standleyanum to harvest individual 'cojollo' necessary to weave baskets. Sabal mauritiformis leaves are used to thatch roofs for traditional, stilted Emberá-Wounaan houses. A typical Emberá roof contains from 400 to 800 S. mauritiiformis leaves, or the equivalent of 40 harvested palms (C. Potvin, personal observation). While for short S. mauritiformis individual leaves can be harvested with a machete, leaves of taller S. mauritiiformis are collected by felling the entire palm. The outer sheath of the trunk of our third focal species, Socratea exorrhiza, is used for domestic flooring because its flexibility and smooth texture are ideal for both living and sleeping surfaces (Potvin et al. 2002). In villages along Parque Nacional Darién, S. mauritiiformis have become so rare that machete fights in defense of the palms have been reported (Narciso Bristán 1996, Deputy Director of Parque Nacional Darién, personal communication). We believe that increased demand and unsustainable harvest practices for the single spear leaf of A. standleyanum, costa-palmate fronds of S. mauritiiformis, and stems of S. exorrhiza have led to rarefaction at various sites around Emberá villages (Dalle et al. 2002). Similar patterns of resource rarefaction have been reported elsewhere. For example, local populations of Socratea exorrhiza, a prized species for construction amongst the Yanomama of Amazonian forests, have become depleted (Anderson 1978). Here we argue that domestication can prove an easily implemented strategy against extinction for species under high pressure of use.

Our attempts to protect both the traditional lifestyle of the Emberá–Wounaan, as well as the biodiversity that fostered it, relied on two specific objectives: (1) develop simple propagation methods for the three target species, and (2) promote the adoption of these methods by Emberá–Wounaan communities. Experiments covered in this paper were carried out in the provinces of Darién and Panamá. Darién, the physical junction between Central and South America, is one of the least populated areas of Central America and represents the only hiatus in the Pan-American Highway from Alaska to Argentina. The exceptional biodiversity of Darién's forests was recognized internationally when Parque Nacional Darién was declared a World Heritage Site (1981) and then, in 1983, a UNESCO World Biosphere Reserve (INRENARE, Instituto de Recurso Naturales Renovables 1980).

Darién's forests are among the world's last and most threatened frontier forests (Bryant et al. 1997). According to a recent population census, 14659 Emberá and 2605 Wounaan live in the province of Darién (Contraloria General de la República de Panamá 1990). The two groups share a common ancestry; however, they maintain distinct languages and cultural traits. In 1983, certain land inhabited by the Emberá and Wounaan of Darién was granted the status of Comarca, or autonomous indigenous territory, by the Legislative Congress of the Republic of Panamá (Herlihy 1997).

#### Methods

The fruits of *Astrocaryum standleyanum* are orange, obovoid, 4–4.5 cm long and are suspended in pendulous bunches. Seeds are cached and dispersed primarily by mammalian vectors (Croat 1978; Smythe 1989; Hoch and Adler 1997; Milleron and Forget 1997). *Sabal mauritiiformis*, crowned by 15–20 glaucous, weakly costapalmate leaves, reaches heights of 10–25 m. It bears spherical to pyriform small fruits, black at maturity (Zona 1990). *Socratea exorrhiza* is a monoecious palm with a solitary stem of 10–20 m height, positioned on 20–30 stilt roots that are covered in small conical spines (Henderson et al. 1995). The yellow-green fruits are ovoid and 2–3 cm long (Croat 1978).

A preliminary round of germination studies was conducted on *Astrocaryum* standleyanum seeds in Capetuira, while transplantation studies were performed on *Sabal mauritiiformis* seedlings in Union Chocó, two nearby villages located by the Tuira River (8°6'23" N, 77°37'30" E) in the Cemaco District of the Comarca Emberá, Darién. These villages are, respectively, the largest Wounaan and Emberá settlements in Panamá. The decision to work with *A. standleyanum* and *S. mauritiiformis* came from the villagers themselves. Because populations of *S. mauritiiformis* around Union Chocó and Capetuira were practically non-existent, a third site with a similar biogeographical context, Ipetí-Emberá (8°57'0" N, 78°3'0" E), was chosen to perform further germination studies on *S. mauritiiformis*. Villagers of Ipetí-Emberá requested that *Socratea exorrhiza* be added to the study. Germination treatments differed from species to species, depending on fruit characteristics.

#### Astrocaryum standleyanum seeds

For the first germination trial, *A. standleyanum* seeds were collected when mature, as indicated by their deep orange color (Croat 1978). In May 1995, fruits were collected from a forest held as a reserve by the villagers, a 90 min walk from Capetuira. A total of 577 ripe fruits were collected from 10 individuals. Pericarps of all fruits were removed to facilitate germination and avoid damage by bruchid larvae, which are known to infest *A. standleyanum* fruit (Smythe 1989). The seeds were subjected to three germination treatments: (a) control seeds, peeled and rinsed; (b) insecticide treatment seeds peeled, rinsed and submerged for 5 min in a carbaryl insecticide mixture (Ortho Sevin Liquid 5 ml: 3.8 1 water; http://www.ortho.com/

content/products/faq/sevin.cfm); (c) water was brought to boiling point, seeds were immediately immersed in the water for 1 min and taken out.

Seeds were planted in a site identified by villagers as a previous habitat for *A. standleyanum*. Ten 1 m<sup>2</sup> plots were established and divided into three sub-plots. The treatment groups were assigned at random to one sub-plot per plot. To test for the impact of mammalian predation, a fence was placed around 5 of these 10 plots. Fencing was established around the plots at a depth of 10 cm to 0.5 m above the soil surface. Sixty seeds (20 per treatment) were planted in each plot approximately 3 cm below the soil surface. Two measurements of germination of *A. standleyanum* seeds were made in June and July of 1996. Unfortunately, after the first two observation periods, severe flooding disturbed the *A. standleyanum* plots, making it impossible to continue the observations. The *G* test for contingency table (Sokal and Rohlf 1995) was used to test treatment effects on germination.

#### Sabal mauritiiformis seeds

A preliminary germination experiment on *S. mauritiiformis* seeds established outside of Union Chocó was destroyed by fire in February of 1997. A second attempt was made in Ipetí-Emberá in mid-December, 1997. Because *Sabal* is very tall and fruits are small, we were not able to get fruits from the trees. Instead fruits were collected from the ground in a re-growth area near the village where *Sabal* is very abundant. Seeds were separated into five treatment groups: (a) control, black seeds with the peel left on; (b) green seeds, not peeled; (c) black, peeled seeds; (d) black, peeled seeds, submerged in water for 1 day; and (e) black, peeled seeds which, once planted, were watered to keep the soil continually moist. The day after collection, the seeds were planted in a random block design. The germination plot was  $5 \times 5$  m and seeds were planted at 5 cm spacing. Germination was recorded in May and August 1998. The *G* test for contingency table (Sokal and Rohlf 1995) was used to test treatment effects on germination.

#### Sabal mauritiiformis seedlings

In November of 1995, 146 *S. mauritiiformis* seedlings were collected, near Union Chocó, from a wet area of partially primary forest in the Rio Aruza site, Darién. All seedlings were at the two leaf stage. Extreme care was taken when handling the roots and transplantation took place the following day. Ten seedlings were planted in each of 15, 1 m<sup>2</sup> plots. Wire fencing, from a depth of 10 cm to 0.5 m above the soil surface, was used for 5 of the 10 plots to test the effect of mammalian predation. Seeds were planted at a depth of 5 cm. The following treatments were applied shortly after transplantation: (a) control, no treatment; (b) 1 l of water enriched with soluble all purpose fertilizer 20N:20P:20K (NH<sub>3</sub> 3.9%, NO<sub>3</sub> 6.2%, urea 9.9%, P<sub>2</sub>O<sub>5</sub> 20%, K<sub>2</sub>O 20% and traces of B, Cu, Fe, Co, Mg, Mo, Zn) poured at the seedling's base; and (c) insecticide, 1 l of the Ortho Sevin Liquid insecticide mixture (see above) poured at the seedling's base. The last two treatments were applied once. Starting in May of 1995, five observations of growth and number of leaves were

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Table 1. Seed germination of Astrocaryum standleyanum under different treatments.

Treatment	Germination (%)	
	June 1996	July 1996
Control (194)	30.4	41.7
Insecticide (192)	23.4	34
Boiling water (191)	3.6	7.3

The sample size of each treatment is shown in parentheses.

made at 6-months intervals. To examine treatment effects, a two-way analysis of variance of repeated measures (ANOVAR) was performed, using SuperAnova (Abacus Concepts 1989), for leaf number and height with fencing and germination treatments as the two between subject effects.

#### Socratea exorrhiza seeds

A third germination experiment on *Socratea exorrhiza* was carried out in Ipetí-Emberá in April of 1999. To test if maturation would differ between fruit collected from the palm or the forest floor, 200 *S. exorrhiza* seeds were collected from the ground and 200 were collected from a palm by means of a hooked branch. The following four experimental treatments were used: (a) control, no treatment; (b) enclosure in a plastic bag for 1 week; (c) peeling of the exocarp and mechanical thinning of the sprouting area; and (d) peeling of the exocarp and immersion in warm water for 1 week. Treatment groups were divided in half and planted adjacently so that 25 seeds from each treatment group could be watered on a weekly basis, while 25 seeds from each treatment group were not watered. The plantation plot, encircled in wire fencing, was located on a shaded plateau between the village and Rio Ipetí.

Germination, growth (height from base of seedling to tip of longest leaf), and number of leaves were measured in January 2000, 9 months after planting. Because no germination occurred in seeds treated with warm water, this treatment was excluded from the analyses. Germination data were analyzed using a two-way analysis of variance (ANOVA) with seed treatment and seed source as main effects. Log transformed leaf production and seedling growth data were analyzed using a split-plot ANOVA, where watering was considered as the main plot effect and germination treatment and seed source as split-plot effects.

#### Results

Of the 577 Astrocaryum standleyanum seeds planted in May 1995, 19% germinated within 13 months. The germination rate was more than six times lower for the boiled seeds than for the other treatments (Table 1). The difference was statistically significant (G = 56.8, P < 0.01). By August 1997, 27 months after plantation of the



*Figure 1.* Seed germination of *Astrocaryum standleyanum* over a period of 27 months between June 1996 and August 1997 in the predator exclusion test. Two hundred and eighty two seeds were sown in fenced enclosures and 295 seeds were sown in plots without fences.

Table 2. Seed germination of Sabal mauritiiformis under different treatments.

Treatment	Germination (%)	
	May 1998	August 1998
Control, black skin (13)	_	69.2
Green, with skin (40)	_	62.5
Black, peeled (40)	_	62.5
Black, peeled, 1 day in water (40)	_	70
Black, peeled, water after sowing (40)	42.5	65

The sample size is shown in parentheses.

A. standleyanum seeds, germination was slightly over 40% (Figure 1). The data did not show a significant effect of fencing on seed germination (G = 2.8, P = 3.8).

In contrast with the very slow germination of *A. standleyanum*, 4.5 months after plantation, by May 3rd, 1998, 17 *Sabal mauritiiformis* seedlings from the continually watered treatment group had emerged (Table 2). At that date, no seedlings from other treatment groups were visible. By the 11th of August, 1998, however, a consistent germination percentage, 65% on average, was seen across all treatment groups. In the four treatment groups that were not watered during the dry season, seedlings had produced a single leaf by mid-August; seedlings from the continually watered treatment had produced between two and three leaves by mid-August.

Of the 146 seedlings in the transplant experiment, 136 (93%) survived between mid-November 1995 and mid-August 1997. The control, fertilizer, and insecticide treatment groups did not differ significantly in their mean heights (33, 32, and 31 cm, respectively; F = 0.669, NS), nor in their mean number of leaves (3.9, 3.7, and 3.7, respectively; F = 0.213, NS). In addition, there was no significant difference between the mean height (F = 0.379, NS) and mean number of leaves (F = 0.822, NS) of fenced-in seedlings (32.7 cm, 3.8 leaves) and seedlings grown without a fence (32.1 cm, 3.8 leaves).

Of the three target palm species, the highest germination percentages were achieved by *Socratea exorrhiza*. The greatest germination success of *S. exorrhiza* seeds was seen for the combination of mechanical scarification, watering, and collection from the ground (Figure 2). None of the seeds undergoing the warm water treatment germinated. Germination was not affected by the other treatments and was completed after 9 months. Seed source had a significant effect on seed germination (F = 7.577, P = 0.033) and later on leaf number (F = 14.672, P = 0.000), and height (F = 3.555, P = 0.061). Neither height nor leaf number were affected by watering.

#### Discussion

Periods of pre-germination and seedling establishment often reflect the most vulnerable stages in a species' life history (Janzen 1970; Harper 1990). Yet to implement any cultivation for domestication, understanding of germination is an essential first step. Germination was problematic for one of the three target species, A. standleyanum. Seeds of the genus Astrocaryum are notoriously difficult to cultivate (Braun 1968) due to a combination of a lengthy germination time, the need for mammalian dispersal and plantation agents (Smythe 1989), and insect and mammalian predation (Cintra 1997). The A. standleyanum seeds in our plantation plot required approximately 13 months to germinate, while the literature states a germination range of 68 days to 11 months (Kobernik 1971; Smythe 1989). In natural forests, mammalian seed dispersal agents, such as agoutis (Dasyprocta punctata), pacas (Cuniculus paca), and coatis (Nasua nasua), remove or eat the A. standleyanum seed's mesocarp and bury the seeds at a depth of 2-5 cm (Smythe 1989). We cleaned and buried the Astrocaryum seeds to minimize larval infestation and mammalian predation. Burying seeds likely added another level of protection from scavengers, as Smythe (1989) observed 100% mortality of A. standleyanum fruit, scattered on the forest floor, by mammalian predators, namely peccaries (Tayassu tajacu), spiny rats (Proechimys semispinosus), and bruchid beetles (Caryobruchus spp.). In fact, we failed to detect any significant difference in germination potential between fenced and non-fenced germination plots. Furthermore, because there was no significant difference between control and insecticide treated A. standleyanum seeds, it is possible that the pericarp removal served to protect the seeds from larval infection.

Despite the difficulties encountered in germinating A. standleyanum, the experi-



*Figure 2.* Seed germination of *Socratea exorrhiza* under different treatments. Each treatment combination had a sample size of 25. The top panel presents data from seeds collected on the ground, while the bottom panel shows seeds collected from the palm. Seeds were subjected to three germination treatments and were either watered or not during germination.

ment had a strong impact on several Emberá villages who adopted our cultivation method. A Canadian non-governmental organization (NGO), 'Alternatives', obtained, with the help of R.C. and C.P., a grant from the Canadian International Development Agency to diffuse the result of the Astrocaryum germination work. In 1997, an emerging Emberá NGO, Fundacion Darién, with the support of R.C., planted more than 2000 seeds in nurseries in each of 20 Emberá communities along the Tuira and Chico Rivers. When one of us (C.P.) visited one of these villages 2 years after planting, she was proudly shown the nurseries by villagers. They had adopted germination and cultivation as a way to obtain A. standleyanum leaves and were not aware that all had started by a research project some years ago. It had become a part of their own way to relate with the palm! Further experiments testing various propagation techniques, such as filing the seed's end for easier exit of the sprout, and soaking in lukewarm water (García et al. 1997), would nevertheless be useful for improving the cultivation potential. It has been difficult for villagers participating in the experiment to wait almost two years before A. standleyanum emerged.

While establishing a germination protocol for *Astrocaryum* was not easy, we saw a substantial proportion of *Sabal mauritiiformis* germinating, regardless of the treatment. Seedling emergence in the treatment group which was kept continually moistened throughout the dry season was markedly accelerated, which is a relatively simple cultivation strategy in areas where water is plentiful. The successful growth of *S. mauritiiformis* in Ipeti-Emberá led to the establishment of the community's first production, as opposed to experimental plot, of the species. Some 500 *S. mauritiiformis* seeds were planted in February of 1999 and every year thereafter. Due to a delicate root network of long, thin roots, Caballero (1994) suggested that transplantation of *Sabal* seedlings may be precarious and that plantations should be started from seed instead of seedling. Our results, however, do indicate that seedling transplantation is a possible means of plantation establishment. Yet, because of the ease of germination, the villagers of Ipetí-Emberá involved in the project have promoted germination over transplantation as a way to maintain a stable supply of *Sabal*.

Local sources said that *Sabal mauritiiformis* had never been cultivated in Ipetí-Emberá before. At the onset of the study, when C.P. was walking in the field with I.C. and showed him seeds of *Sabal*, he could not believe that 'planting these small rounded objects' would eventually lead to the birth of a palm. The palm and its seeds were, in his mind, two separate entities. However, having seen that seed germinated into a 'palm-like' seedling, skepticism soon disappeared. At this date, various community members have planted *S. mauritiiformis* seeds in their land. A similar complex relation with the cultivation of wild species has been reported earlier on by Caballero (1994). He found that, while *Sabal* spp. were commonly cultivated in the Yucatan Peninsula, *S. mauritiiformis* cultivation had yet to be developed there, as it was still abundant in forested and pasture areas.

Of all three species, *Socratea exhorriza* was the easiest to grow from seeds. Seed source, whether the seeds were gathered directly from the palm or from the ground, however, clearly played a role in germination, growth, and leaf production. The risk

of collecting seeds from the ground is the potential for larval infection and rotting (García et al. 1997). However, the trade-off in this experiment was worthwhile, most likely because the ground seeds had more consistently reached an appropriate maturity for germination.

### Conclusions

The villages of Capetuira, Union Chocó, and Ipetí-Emberá have limited financial resources. Therefore an emphasis on simple techniques and inexpensive materials was essential to render the results useful to the community. The project allowed first hand observations of the lengthy time to germination in *Astrocaryum standleyanum*, and emphasized the ease in cultivating *Sabal mauritiiformis*. In the case of *Socratea exorrhiza* the simple technique of collecting seeds from the ground may significantly improve germination, leaf production, and growth rates. Hopefully such projects will present possible strategies and encourage further investigations into propagating the palms that are essential to the traditional lifestyle of the indigenous people.

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