PRINCIPES

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THE INTERNATIONAL PALM SOCIETY

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PRINCIPES

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Contents for October

Cover Picture

A staminate tree of the recently described *Ammandra natalia* Balslev & Henderson, a vegetable ivory palm growing in eastern Ecuador. See pp. 181–190. Photo by A. Henderson.

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Editorial

Our cover photographs introduce a remarkable new ivory nut palm discovered by Henrik Balslev and Andrew Henderson in Ecuador and described recently in the journal *Brittonia.* It has been named *Ammandra natalia.* The discovery of such a distinctive palm, used locally as a source of piassava fiber, illustrates the richness of the palm flora of Ecuador and emphasizes how incompletely it is known. The covers also introduce the article by Anders Barfod on the rise and fall of vegetable ivory produced by the phytelephantoid palms. Once an important item of international trade, vegetable ivory could not compete with plastics. Now there is growing interest in the use of vegetable ivory as a substitute for true ivory.

We often state how extensive are the palm floras of South American nations but we have very few careful studies which actually quantify that richness. Alcidir Scariot, Ari Oliviera Filho, and Eduardo Lleras have analyzed a palm community in eastern Amazonia, counting all palm individuals and thereby obtaining a real indication of the variety of the palms in that habitat. This they have compared with other sites in South America. It would be of great value to have similar studies in other areas of the tropics. In strong contrast Kyle Brown describes an isolated population of *Sabal palmetto* at the very limit of its distribution. He speculates that this outlier originated from seed dispersed by birds.

Most readers of *Principes* will be aware of the seriousness of lethal yellowing disease, which has changed so dramatically the palm landscape of Florida and has had such severe economic impact on coconut growing areas of the Caribbean, yet it is some time now since we carried an article about the disease. F. W. Howard and C. L. Barrant bring us up-to-date on practical implications of the disease with a valuable series of questions and answers.

Germination of palm seeds can be related to many factors. Of interest to growers is the article by William Carpenter on the effects of temperature on the germination of seed of *Sabal causiarum.*

As we draw this volume to a close we would like to acknowledge the fine pictures which have been sent to us for the photographic competition. We could use more. The contest will continue until April 1, 1990. Please send in your photos before then. We hope, also, that you have all enjoyed the covers of this first volume of *Principes* to carry color and that you will send us your best pictures for future covers.

JOHN DRANSFIELD
NATALIE W. UHL

Principes, 33(4), 1989, pp. 160–162

The Cabbage Palms of Billy's Island

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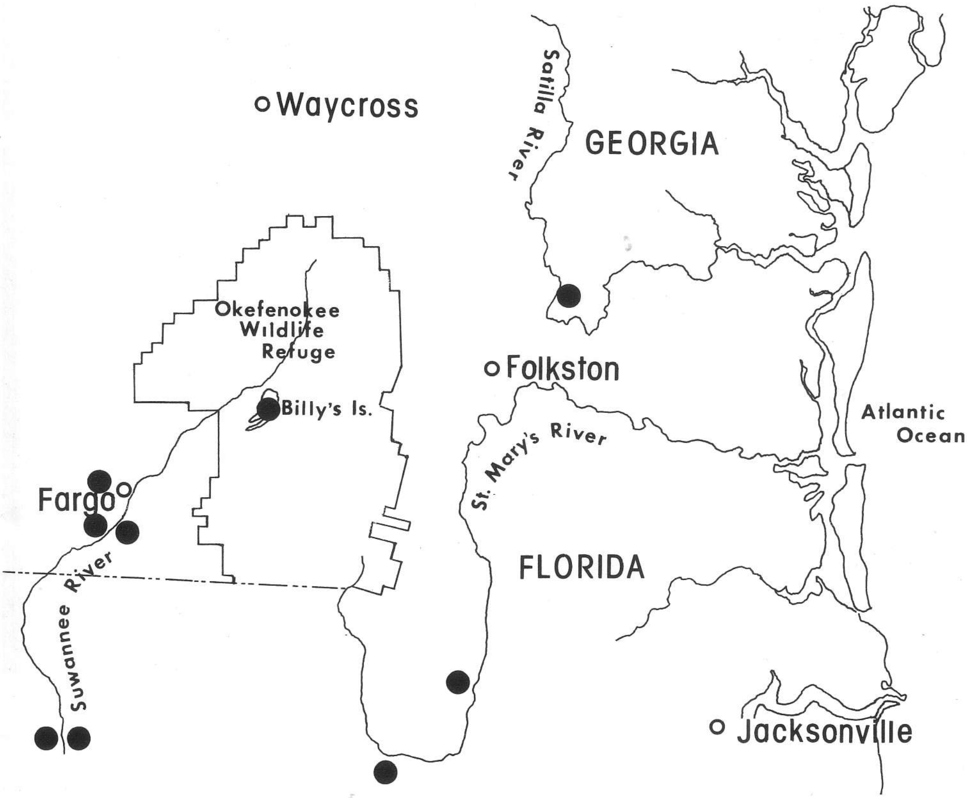
It never ceases to amaze me how much one can find out by following a lead, even if the lead is tenuous. It is also amazing how quickly time slips by and such leads are left on the back burner or even forgotten altogether. One such instance relates to a story that I first heard almost twenty years ago when I became a serious student of the cabbage palm, *Sabal palmetto*. In searching all possible sources of information for records of cabbage palm locations, I heard reports from fishing guides that cabbage palms were growing deep within the Okefenokee Swamp, Georgia. I was unable to find any documented evidence to verify these reports. During trips to the swamp fishing and botanizing in my earlier undergraduate days, I had never encountered any cabbage palms. As a result these reports were relegated to the category of interesting but improbable and promptly put out of mind.

However, in the fall of 1987 my assumptions proved to be false. An October trip to Stephen Foster State Park on the west side of the swamp near Fargo, Georgia, culminated in a boat ride to Billy's Island (Fig. 1). The island is approximately two miles by boat from the boat landing at the state park. It was named for the last Seminole chief in the swamp, Billy-Bow-Legs. The island's 3,140 acres make it one of the largest in the swamp. This size, along with its elevation of several feet above the swamp, has allowed development of a mixed pine-oak forest over most of its area.

While several Indian mounds give clear evidence of very early occupation of the island by man, significant disturbance of the forest has occurred only in the last 125 years. Billy's Island was first settled by the white man in 1853 by the James Lee family. It remained in the Lee family until just after 1900 when Billy's Island, along with approximately 290,000 additional acres of the swamp, was bought by the Hebard Cypress Company. The company set up its field operations center on Billy's Island and began lumbering the area in 1908. Billy's Island Town was a thriving community of 600 persons with a hotel, school, churches, movie theater, doctor, and large company store. In only 19 years the harvest of virgin cypress was over and the town died. Very little evidence is left today. Salvageable materials were hauled out. Forest fires and the weather have removed most of the rest.

Through all of this disturbance and activity three large cabbage palms have survived on Billy's Island (Fig. 2). How did these trees come to be on an island in such a remote area many miles from the nearest cabbage palm locality southwest of Fargo along the Suwannee River and its tributaries, Cypress Creek and Suwanaoochie Creek? Several stories have persisted through the years as part of the folklore of the swamp. The most intriguing is one involving Spanish treasure. As the story goes, Hernando DeSoto, on his trek through northern Florida in the 1750's, wandered into the swamp and found Billy's Island. For some unknown reason he buried gold there and planted three palm trees in a triangulation scheme to conceal the exact location of the treasure. DeSoto and some of his officers were the only humans privy to the information. Having fallen on



1. Location of Billy's Island in the Okefenokee Swamp of Georgia. Solid black dots indicate other *Sabal palmetto* sightings in the area.

bad times farther west later on, they never returned. Of course, the "treasure" has never been found. At least the local yarn spinners "ain't lettin on to it" if it has.

A second story has the palms coming to the island as a result of the actions of a very influential woman. The wife of the owner of Hebard Cypress Company was apparently responsible for bringing culture, such as it was, to Billy's Island Town from 1918 to 1927. Among her endeavors was public landscaping including the planting of the palms. While this is a more believable tale, it too is erroneous. Photographs taken by the Wright and Wright expedition from Cornell University in 1912 show mature palms in a fence row on the old Lee family farm which became the town site in 1908.

So much for DeSoto and Mrs. Hebard. I cast my vote for the natural distribution theory espoused by Dr. Bill Cribbs, a lifelong resident of the area and professor of biology at Valdosta State College. Dr. Cribbs is a descendant of the Lee family and believes cabbage palms arrived on the island after his ancestors. The photographs of 1912 support this idea by showing palms in old fence rows. Their height in the photographs is also within the range to be expected after 40 to 50 years.

I propose the following scenario to explain the presence of the three palms of Billy's Island. Sometime after the original homestead was established in 1853, fields were cleared and fences erected (probably wooden). Corn would have been a staple crop. Fish crows, which are known to feed

2. The three mature specimens of *Sabal palmetto* located on the north end of Billy's Island.

on ripe cabbage palm fruits, in their forays up the Suwannee River would have found the corn fields eventually. Some of these crows, having recently fed on cabbage palm fruits downstream in Georgia, would pass seed while perched on the fence. There is nothing tenuous about this idea as I have observed cabbage palms many times growing in fence rows all over Florida. Fish crows may not be the only birds involved in dispersing cabbage palm seeds. At any rate, the young plants on Billy's Island would have grown and thrived in the absence of any natural enemies. In fact, Dr. Cribbs indicates that there were many more than three there originally. Some twenty years ago an outbreak of palm weevils decimated the population leaving only the current three mature trees alive.

An additional mystery remains concerning the Billy's Island cabbage palms. In addition to the three mature trees, several young trees up to eight feet in height, as well as numerous well established seedlings in the one to two foot height range, are thriving. However, there is an obvious lack of individuals in size classes between the larger juveniles and the mature trees. Dr. Cribbs attributes the lack of mid-size trees to the history of continuous agricultural activity on the island after establishment of the original trees. With the cessation of agricultural activity and the establishment of the Okefenokee National Wildlife Refuge in 1937 opportunity for reproduction and local spread of the species began. It is occurring very slowly but steadily, which is typical of *Sabal palmetto*. Someday in the distant future I would not be surprised to see Billy's Island heavily populated throughout with cabbage palms descended from the original trees of the Lee family homestead.

Principes, 33(4), 1989, pp. 163–171

Questions and Answers about Lethal Yellowing Disease

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Lethal yellowing (LY) disease is one of the most serious threats to palms worldwide because it is fast-spreading, kills palms rapidly once they are infected, incurable at present, and affects many species of palms. Thanks partly to some members of the International Palm Society, a research program with a multidisciplinary team of six scientists representing the fields of plant pathology, entomology and horticulture was established by the State of Florida in the 1970's at the University of Florida's Fort Lauderdale Research and Education Center to try to find solutions to this problem. The Fort Lauderdale group soon formed a close working relationship with a similar LY research group which had been organized in the Research Department of the Coconut Industry Board of Jamaica by the British Oversees Development Ministry.

By the early 1980's, due to changes in budgetary priorities and other administrative considerations, both LY research programs were phased out by their respective governments. This was unfortunate. Together, the two groups had developed more knowledge of the basic nature of the disease, as well as practical ways to manage it, than had been accumulated in the 100 years or more since LY had been known in the Caribbean Region. Lethal yellowing is still with us, and in fact, has spread into new localities in the last few years, but the momentum of these research programs has been lost and research on the disease is comparatively limited at present.

The careers of most of the members of the original Florida and Jamaica "LY research teams" have taken them separate ways. Having been associated with the original LY research teams, the authors continue to conduct research on LY as a part of the Ft. Lauderdale Center's long-term interest in tropical ornamental horticulture and the Coconut Industry Board's mission to serve the coconut industry of Jamaica.

Over the years, we have received many questions on LY from growers, horticulturists, and others interested in palms. The most frequent and some of the most interesting questions are presented here.

Q. Which palm species are most susceptible to LY?

A. The coconut palm (*Cocos nucifera*) and species of *Pritchardia* are the most susceptible species (Howard et al. 1979). However, there are different degrees of susceptibility among the many varieties of coconut palm. The 'Jamaica Tall' variety, which is the most common coconut palm seen throughout the Caribbean Region and formerly in southeastern Florida and the Keys, is one of the varieties that is highly susceptible to LY (Harries 1971, 1974). In Jamaica, where this was once the prin-

1. A plantation in Jamaica of 'Jamaica Tall' coconut palms destroyed by lethal yellowing disease.

cipal variety grown, entire plantations were lost to LY within periods of a year or two (Fig. 1). There are more than 30 species known to be susceptible to LY (Table 1).

Q. What causes LY?

A. Scientific studies have indicated that LY is caused by mycoplasmalike organisms (MLOs). Mycoplasmas are microorganisms that are intermediate between viruses and bacteria. They have been known for some time as pathogens that cause certain diseases of animals. In the last two decades, similar organisms have been found to be associated with certain plant diseases. Since it has not been definitely established that they are mycoplasmas, they are called mycoplasma*like* organisms.

Q. How do palms "catch" LY disease?

A. The mycoplasmalike organisms which cause LY are transmitted by the American palm cixiid, *Myndus crudus*. (A cixiid is a planthopper of the family Cixiidae.) This information is based on field evidence (e.g., Howard 1980) and on experiments in which American palm cixiids were collected from palms in areas where the disease was active and introduced into cages containing palms previously unexposed to the disease. Palms in cages into which the insects were introduced contracted LY. Palms in similar cages kept free of these insects remained healthy (Howard et al. 1983). Further testing was done with younger palms and palms of different species with similar results (Howard et al. 1984).

Q. Are there insects other than the American palm cixiid that could spread LY?

A. Our studies indicate that the American palm cixiid is the principal and possibly the only vector of LY in the Americas. If there were other insect species capable of transmitting the disease, they would be limited to localized areas. In most cases in which diseases are spread by more than one species of insect, all of the species are taxonomically closely related. Thus, if there is a vector of LY additional to the American palm cixiid, we would expect it to be another species of cixiid. Except for the American palm cixiid, species of this group are quite rare on palms in the Caribbean Region. In conclusion, if we could control the American palm cixiid, we could control LY in most (if not all) places in the Americas where the disease is present.

Q. Where did LY come from?

A. Lethal yellowing may have originated in the Western Caribbean area, as there were reports of what appears to have been this disease in coconut palms in the Cayman Islands as early as 1832, and in Cuba, Jamaica and Haiti in the late 1800's. Palm species native to the Americas, particularly to the Caribbean Region, are almost never affected by this disease, suggesting that perhaps in past ages the disease spread repeatedly through this region, thus selecting out resistant strains of these palms (reviewed by Howard 1983). There are also reasons to suspect that LY may have evolved in Asia (Harries 1979).

Table 1. List of palm taxa susceptible to lethal yellowing in Florida, and relative susceptibility, June 1989.

Palm	Relative Susceptibility[1]
Aiphanes lindeniana	unknown
Allagoptera arenaria	unknown
Arenga engleri	3
Borassus flabellifer	2
Caryota mitis	2
Chrysalidocarpus cabadae	1
Cocos nucifera	3
Corypha elata	3
Dictyosperma album	2
Gaussia attenuata	unknown
Howea belmoreana	unknown
Hyophorbe verschaffeltii	2
Latania spp.	2
Livistona chinensis	1
Nannorrhops ritchiana	unknown
Neodypsis decaryi	unknown
Phoenix canariensis	2
P. dactylifera	3
P. reclinata	1
P. rupicola	unknown
P. sylvestris	unknown
Pritchardia spp.	3
Ravenea hildebrandtii	unknown
Syagrus schizophylla	2
Trachycarpus fortunei	2
Veitchia arecina	unknown
V. merrillii	2
V. montgomeryana	2
Veitchia sp. (Sunshine palm)	2

[1] Susceptibility ratings based on combined observations of Fort Lauderdale Research and Education Center personnel. 1 = slightly susceptible, 2 = moderately susceptible, 3 = highly susceptible.

Q. In which countries has LY been reported?

A. In the Western Caribbean Region: Cuba, Jamaica, the Cayman Islands, Hispaniola (Haiti and the Dominican Republic), New Providence (Bahamas), Yucatan and Quintana Roo (Mexico); in the United States: Florida and Texas. In Tropical West Africa, a similar or perhaps identical disease has been reported in Ghana, Togo, Cameroon and Nigeria. Also, in Tanzania (East Africa) an LY-like disease is being studied. Since no major differences have been detected between the diseases of Africa and the Americas, they are all referred to as LY (reviewed by Howard 1983).

Q. What is the current distribution of LY in Florida (June of 1989)?

A. Key West was where LY was first discovered in Florida, possibly as early as 1937. Between 1955 and 1960, an epidemic of LY eliminated about 15,000 (75%) of the coconut palms in Key West (Martinez and Roberts 1967). Today, a visitor travelling the Overseas Highway to Key West will pass over many islands with abundant stands of healthy coconut palms (the 'Malayan Dwarf' and 'Jamaica Tall' varieties and hybrids between these are represented) but may occasionally spot a palm or perhaps a cluster of palms with LY symptoms. Coconut palms are still common on Key West, and some of the old 'Jamaica Tall' palms (e.g., near the beach on the south side of the island) survived the earlier LY epidemics. Some islands, e.g., Conch Key and Pigeon Key, have remained virtually free of LY.

The epidemic of the 1970's and early 1980's on the east coast from Miami to the Palm Beaches (Howard 1980) has subsided because few palms of susceptible species are left. LY continues to spread among these widely separated susceptible palms. (The extensive plantings of coconut palms along beaches are notable exceptions.) During the 1970's there were relatively few cases of LY on the west coast of Florida or on the east coast north of Jupiter Inlet (Howard 1980). However, within the last few years there has been a serious outbreak of LY in Stuart, which is the northernmost city on the east coast of Florida with extensive plantings of coconut palms. And within the past two years, the disease killed more than three hundred coconut palms on Estero and Sanibel Islands and Ft. Myers on the west coast of Florida.

Q. What is the current situation regarding LY in Jamaica?

A. In Jamaica there were formerly an estimated 5 million 'Jamaica Tall' coconut palms (Harries 1974). LY destroyed most of these by the 1980's, and they were replaced by 'Malayan Dwarf' palms. There are still some 'Jamaica Tall' coconut palms throughout the island, and they continue to be eliminated by LY.

Q. Since LY is spread by an insect, can the disease be controlled by spraying the palms with an insecticide?

A. Although the American palm cixiid can be controlled by insecticides on a limited basis (Reinert 1977), insecticidal control of the vector is not promising as a long-range strategy to control this disease. We were able to suppress populations of this insect and bring about a reduction of 50 to 75% in the rate of spread of LY in large experimental blocks by spraying palms biweekly for 14 months. A 50% reduction in the spread means that it would take twice as long for all of the palms to die. Perhaps the rate of spread could be slowed further by more frequent applications of more toxic and more persistent insecticides to even larger blocks of palms, but large scale use of insecticides to control this disease would entail unacceptable costs and environmental hazards (Howard and McCoy 1980; Howard, unpublished data).

Q. How was it determined that LY is caused by MLOs?

A. Researchers have observed mycoplasmalike organisms consistently in tissue samples from palms with LY symptoms, but have never observed these organisms in healthy palms (Beakbane et al. 1972; Heinze et al. 1972; Plavsic-Banjac et al. 1972; Thomas 1974, 1979; Thomas and Norris 1981). In one experiment, tissue samples of palms with LY symptoms and of healthy palms grown under identical conditions were compared. Only the palms with LY symptoms had MLOs (Howard et al. 1983). In addition, researchers injected various materials into palms with LY, and found that only tetracycline antibiotics, which are known to be active against MLOs, suppressed the disease. Penicillin, which is effective against bacteria, did not suppress LY symptoms (McCoy 1972, McCoy and Gwin 1977, Hunt et al. 1974, Steiner 1976).

Q. Can tetracycline injections be used to control LY?

A. The tetracycline treatment developed by Dr. R. E. McCoy and co-workers (McCoy 1972, McCoy et al. 1976) is very effective, but involves regular injections every 4 months for the life of the tree. It suppresses the symptoms of the disease so that a palm infected with lethal yellowing stays alive and healthy. But if the injections are stopped, the infection will break out again and kill the palm. Therefore, this treatment was never recommended by the University of Florida as a permanent cure for LY, but as a means of saving infected or immediately threatened palms while resistant palms were planted and grown to take their place. The method is generally considered impractical for use in commercial coconut plantations because of the cost and other factors.

Q. Someone told me that St. Augustine grass is an alternate host of LY disease. Is this true?

A. It is plausible, but remains to be proven. It is known that St. Augustine grass (*Stenotaphrum secundatum*), as well as many other species of grasses, serves as a host to the immature stages of the American palm cixiid (Eden-Green 1978, Zener de Polania and Lopez 1977). When this insect becomes an adult, it flies to palms, returning to grasses to lay eggs and begin the cycle again. This raises the question whether the insects can transmit the MLO to the grasses. If so, grasses could serve as a reservoir of the pathogen. We have attempted to investigate this point, but our results were inconclusive because adequate experimental techniques have not yet been developed.

Q. Given present technology, what is the best method for controlling LY in coconut plantations?

A. Coconut plantations affected by lethal yellowing should be replanted to certified seednut of either 'Malayan Dwarf' or the 'Maypan' coconut palms, which are highly resistant to lethal yellowing disease (Harries 1970, Harries and Romney 1974). The 'Maypan' is a hybrid obtained by crossing the 'Malayan Dwarf' with a 'Panama Tall,' the latter which is significantly more resistant to LY than the 'Jamaica Tall' (Harries and Romney 1974). We have investigated several sites in both countries where there were unusually high losses of 'Malayan Dwarf' or 'Maypan' coconut palms to LY. We have not conclusively determined why these losses were so high at these sites (Howard et al. 1987). However, since millions of these palms in Jamaica and many thousands of them in Florida have survived LY epidemics, they are thus far the most recommendable coconut palms for LY-affected areas.

Q. Are there additional resistant varieties of coconut palm?

A. The 'Fiji Dwarf,' 'Ceylon King' (a semidwarf), 'Cuban Dwarf,' 'Ceylon Yellow Dwarf,' 'Indian Green Dwarf' and 'Red Spicata Dwarf' are varieties of coconut palm that appear to be resistant, based on limited trials in Jamaica. These are undergoing further field tests in Jamaica, and some of them are being tested in Florida with the cooperation of the Coconut Industry Board.

Q. For landscaping use, which lethal yellowing-resistant palms can be recommended?

A. In addition to the resistant coconut palm varieties already mentioned, there are many species of palms that are suitable as ornamentals and which are resistant to lethal yellowing disease. More than 30 species of palms are known to be susceptible to LY (Table 1). But in Florida, at least 386 species of palms can be grown. This is the number of palm species identified in Fairchild Tropical Garden, Miami (Howard et al. 1979). On the other hand, many of the palm species in the Garden cannot be said to have been adequately tested for LY susceptibility. For example, during the peak of the LY epidemic in the Garden (1973–1977), LY had not affected *Bactris ottostapfeana*, a species which was represented in the Garden by one palm. This palm is still there, leading one to suspect that this species is not susceptible to LY. However, this does not constitute a conclusive test of the effect of LY on this species. By contrast, in 1977, *Coccothrinax argentea* was represented in the Garden by 40 palms, none of which was lost to LY. The higher the number of palms exposed to LY, the more confident are we of its resistance or susceptibility to the disease. We can be quite confident about palms that are popular in southern Florida, because by now they have had ample exposure to LY without succumbing to it. *Acoelorrhaphe wrightii, Chrysalidocarpus lutescens, Phoenix roebelenii, Ptychosperma elegans, Roystonea regia, Sabal palmetto, Syagrus romanzoffiana*, and *Washingtonia robusta* are very common in southern Florida cities and we can say with a great deal of certainty that there has never been a case of LY in these palms in Florida. Notice that five of these eight species are native to the Americas. In Florida we found that most of the susceptible species are native to Asia, Oceania and Africa. Only four species native to the Americas are known to be susceptible to LY (*Aiphanes lindeniana, Allagoptera arenaria, Gaussia attenuata* and *Syagrus schizophylla*).

A booklet listing the numbers of palms of different species in Fairchild Tropical Garden, their geographic origins and the numbers lost to lethal yellowing from 1971–1977 is available from the Ft. Lauderdale Center.

Q. Are the date industries of Arizona and California threatened by LY?

A. It was once believed that LY was exclusively a disease of coconut palms. When it invaded Florida, where many species of ornamental palms are common, it was discovered that it had a broader host range. Even then, it was suspected that coconut palm was a primary host, and that the disease would not spread outside of tropical and semi-tropical areas where coconuts grow. The appearance of LY in the Rio Grande Valley of Texas, where it spread rapidly and devastated plantings of Canary Island date palm (*Phoenix canariensis*), was a grim lesson (McCoy et al. 1980). Arizona and California have imposed quarantine regulations to try to prevent LY from invading those states and affecting the date industries and also the Canary Island date palms which are an essential part of the distinctive landscape of cities of the American Southwest. Methods of preventing and controlling LY in coconuts and other tropical palms developed through research in Florida and the Caribbean would usually be applicable to date-growing regions. In addition, some research in Florida emphasizes management of LY in date groves. A preliminary evaluation of susceptibility of different date palm varieties has been completed (Howard et al. 1985), and an apparently resistant variety, the 'Halawy,' is being tested further. Also, Canary Island date palms grown from seed of different provenances are being tested for LY resistance, with some early promising results.

Q. Is LY a threat to Hawaii?

A. In spite of its isolated geographic position and strict quarantine measures practiced by agricultural officials, Hawaii has more than its fair share of plant pests and diseases inadvertently introduced from sometimes very distant lands. If LY were introduced into Hawaii, it would have a devastating effect. To evaluate the susceptibility of Hawaiian coconut palms, a field trial was conducted at the Ft. Lauderdale Center, in which 18 palms of a tall variety common in Hawaii and 13 of a dwarf variety referred to in Hawaii as 'Samoan Dwarf' were grown from seednut obtained from Hawaii. For comparison, 18 'Jamaica Tall' coconut palms were grown from seednut obtained locally. The seednuts were held in a seedbed until two years after sprouting and then were planted in a field in April 1983. The palms were examined frequently for disease symptoms, and diagnoses by symptoms were substantiated by taking bud tissue samples from one symptomatic palm of each of the three varieties and examining them under the electron microscope for MLOs.

MLOs were observed in tissue samples from all three varieties, confirming that our diagnoses by symptoms were correct. After four years of field exposure to LY (April 1987), losses of the three varieties to the disease were as follows: 'Jamaica Tall'—88.8%; tall variety from Hawaii—83.3%; 'Samoan Dwarf'—92.3%. In addition to coconut palms, other palms in Hawaii would be affected by LY. We have found *Pritchardia affinis*, a native of Hawaii, to be highly susceptible to LY, as are other species of this genus when grown in Florida.

Q. Can LY be carried in the seed of palms?

A. There is no evidence that MLOs can be tranmitted *via* the seed of plants, and experts doubt that this occurs. For one thing, palms infected with LY shed their seeds. However, the possibility of seed transmission of MLOs has not been disproven.

Q. Under what conditions are palms most susceptible to LY?

A. We lack conclusive experimental data to answer this question, but based on field observations by a number of scientists, palms are apparently most likely to contract LY when grown under the following conditions: (1) in full sun, (2) on a site with grasses that serve as hosts to immature stages of the American palm cixiid, and (3) when given plenty of water and fertilizer. Also, in our experience (4), LY spreads faster and destroys more palms if susceptible species are planted in blocks or monocultures, rather than mixed with non-susceptible palms or other trees.

Q. Under what conditions do palms of susceptible species escape LY infection?

A. Palms of susceptible species grown in the shade (e.g., of a large, spreading live oak or similar tree) often escape the disease. In southeastern Florida extensive plantings of 'Jamaica Tall' coconut palms on the ocean beaches survived the severe LY epidemic of the 1970's and early 1980's and are still standing. The disease appeared to spread relatively slowly in palms surrounded by large paved areas, e.g., parking lots, and some 'Jamaica Tall' coconut palms have continued to survive in such areas, while in nearby areas with lawns the palms died from LY. In general, the disease appears to spread more slowly in areas where palms are presumably "stressed" due to lack of maintenance or otherwise inhospitable environmental factors than in areas where they are given ample water and fertilizer, especially high rates of nitrogen. For example, in Florida LY spreads particularly fast on golf courses as opposed to areas of the cities where the lawns and trees are neglected by the residents. This relationship needs further investigation.

Q. What is the current status of research on lethal yellowing disease?

A. At the Ft. Lauderdale Center, methods of controlling the vector are being investigated. A key to control of this insect is that the immature stages develop on grasses, and the adults fly to palms. There is considerable interest throughout the humid tropics in the conversion of ground-covers of coconut plantations to improved forage grasses. Use of grasses that do not support the American palm cixiid could prevent or help control the spread of LY. Recently, the authors completed a three-year cooperative project funded by the U.S. Agency for International Development. This project resulted in the identification of grasses that are poor hosts of the American palm cixiid and that are valuable tropical forage grasses well-adapted for use as ground-cover in coconut plantations. This work continues at Ft. Lauderdale, with increased emphasis on finding turfgrasses and other ornamental ground-covers that do not support the vector of LY. Research on varieties of coconut that are resistant to LY continues to receive high priority in Jamaica and Florida. Testing of date palms and other species continue at Ft. Lauderdale.

Dr. Nigel Harrison, a plant pathologist at the Ft. Lauderdale Center, is currently attempting to develop a biochemical test to diagnose LY in its pre-symptom stage. Pre-symptom diagnosis of LY has been a goal of a number of researchers for many years because of the importance of such a technique to many research problems directed towards developing practical methods of managing and preventing the disease.

Research on LY is also being conducted by the Mexican Secretaria de Agricultura y Recursos Hidraulicos by personnel stationed in Veracruz and at the experiment station in Chetumal, Quintana Roo (Villanueva et al. 1987).

Acknowledgments

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CLASSIFIED

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Species Richness, Density and Distribution of Palms in an Eastern Amazonian Seasonally Flooded Forest

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ABSTRACT

Species richness, density and distribution of a palm community found in a seasonal swamp forest in the Eastern Amazon Basin (Serra dos Carajás, Pará, Brazil) is here reported. In the hectare sampled, eight species in eight genera were found. Of the 3,975 palm individuals in the study area, 60% belong to only one species, *Orbignya phalerata*, which occurs in greater density in the less humid areas, while *Socratea exorrhiza* and *Geonoma baculifera* prefer the more humid sites. Results are discussed in terms of soils, water and light.

RESÚMEN

La riqueza de especies, densidad y distribución de palmeras en una comunidad localizada en un bosque periodicamente inundable de la Amazonía oriental son discutidas aqui. En la hectárea estudiada, 8 especies en 8 genéros fueron encontradas. De las 3,975 palmeras encontradas en el área de estudio, 60% pertenece a una sola especie, *Orbignya phalerata*, que ocurre en mayor densidad en las áreas menos húmedas, mientras que *Socratea exorrhiza* y *Geonoma baculifera* prefieren los sítios más humedos. Los resultados se discuten en relación a suelos, agua y lúz.

In spite of the particular difficulties involved in palm research, not only in regard to taxonomy but also to the study of population biology and reproductive systems, palms are receiving increasing attention, due in part to the economic potential and to the special position they occupy within tropical ecosystems.

Among the papers on palms focusing on population biology those of Bouillenne (1930) with *Mauritia*, Oldeman (1969) with *Euterpe oleracea*, Granville (1977) with several species, Anderson (1983) with *Orbignya phalerata* and Piedade (1985) with *Astrocaryum jauari*, can be cited. Communities have been studied by Kahn and Castro (1985), who worked with species occurrence in relation to water; Kahn (1986*a*, 1987), and Kahn et al. (1988) who have looked into species richness and density, and Kahn (1986b) who studied life forms, size, and density in relation to forest structure and dynamics.

This paper presents data on species richness and distribution in terms of light and water gradients for a palm community in a seasonal swamp forest of the eastern Amazon basin.

Methods

Research was carried out in a seasonal swamp forest at the margins of Igarapé Azul (06°00'S, 50°42'W), in the area worked by the Companhia Vale do Rio Doce, Projeto Carajás, Marabá Municipality, state of Pará, Brazil (Fig. 1). The study area was ca. 1.5 km upstream from the intersection of the creek with the road between DOCEGEO'S "N1" and "Alpha" camps.

Soils are predominately very acid yellow-red latosols, with very low concentrations of exchangeable ions, sandy at the stream margins, gradually turning more clayish with increasing distance from the stream.

Five 20 × 100 m transects, perpendicular to the stream, were laid out, with each transect being divided into ten 10 × 20 m plots. Using a Blume-Leiss hypsometer, the height above the water surface level of the stream was taken at the center of each plot.

All palm individuals, separated into either adults, juveniles, or seedlings, were counted in each plot. For caespitose species, each stem was considered as a separate individual. Adults were considered as those individuals that were already reproductively active; juveniles as those that had well formed trunks and crowns but that were not yet active in reproduction, and seedlings as those individuals that lacked well-formed trunks and crowns and presented first leaves.

Quantitative data are presented based on horizontal distance from the stream bed, as well as in terms of height above the surface of the creek. In the latter case, the 50 study plots were grouped according to 1 meter class intervals: 0–1 m (6 plots), 1–2 m (16 plots), 2–3 m (15 plots), 3–4 m (8 plots) and 4–5 m (5 plots).

Density per hectare was calculated for each size class, per species, within each class interval along the water gradient.

Voucher specimens of all palm species were collected and deposited at the CENARGEN (CEN) Herbarium in Brasília.

1. Localization of the study area.

Results

In the hectare studied, eight species of palms, belonging in eight different genera were found: *Astrocaryum munbaca* Martius, *Euterpe oleracea* Martius, *Geonoma baculifera* (Poit.) Kunth, *Socratea exorrhiza* (Martius) Wendland, *Maximiliana maripa* (Corrêa de Serra) Drude, *Oenocarpus distichus* Martius, *Orbignya phalerata* Martius and an unidentified species of *Bactris*.

Table 1 presents the number of individuals per species in each size class found in the study area. *Orbignya phalerata* was the most abundant species overall (60.2%), while *Geonoma baculifera* had the highest number of adults. *Oenocarpus distichus* and *Maximiliana maripa* were the least abundant, with no seedlings found in the study area. Seedlings of all species accounted for 70.3% of all individuals.

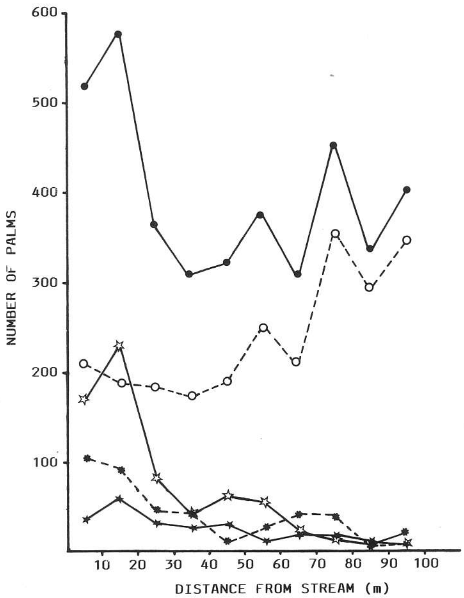
Densities of palms with increasing distance from the stream are shown in Figure 2. Although no clear cut patterns can be discerned, highest densities were found in the first 20 m, due mainly to the high number of individuals of *Geonoma baculifera*, *Euterpe oleracea* and, to a lesser extent, *Socratea exorrhiza*, which were more abundant closer to the water. In contrast, the density of *Orbignya phalerata* increased with distance, due to greater number of seedlings. For *Astrocaryum munbaca* density remained practically constant. The low number of individuals of *Bactris* sp., *Maximiliana maripa* and *Oenocarpus distichus* makes it impossible to infer distribution patterns.

Overall densities for the species in question, on a vertical gradient from the surface of the stream, can be seen in Figure 3. Highest densities were found closest to the water level: for example, the 5,092 individuals/ha in the 0–1 m class decreased

Table 1. Palm densities on 1 hectare of seasonally flooded forest at Igarapé Azul, Serra dos Carajás, Pará, Brazil.

Species	Number of Individuals			
	Seedlings	Juveniles	Adults	Total (%)
Orbignya phalerata	2,177	199	17	2,393 (60.2)
Geonoma baculifera	84	396	222	702 (17.7)
Euterpe oleracea	334	9	58	401 (10.1)
Socratea exorrhiza	117	105	15	237 (6.0)
Astrocaryum munbaca	78	80	38	196 (4.9)
Bactris sp.	4	36	1	41 (1.0)
Oenocarpus distichus	—	—	3	3 (—)
Maximiliana maripa	—	2	—	2 (—)
Total	2,794	827	354	3,975

to 3,610/ha at 4–5 m. The species responsible for this trend were chiefly *Geonoma baculifera, Socratea exorrhiza* and, to a much lesser extent, *Euterpe oleracea.* As before, *Astrocaryum munbaca* maintained relatively constant densities. *Orbignya phalerata* presented higher densities on higher ground.

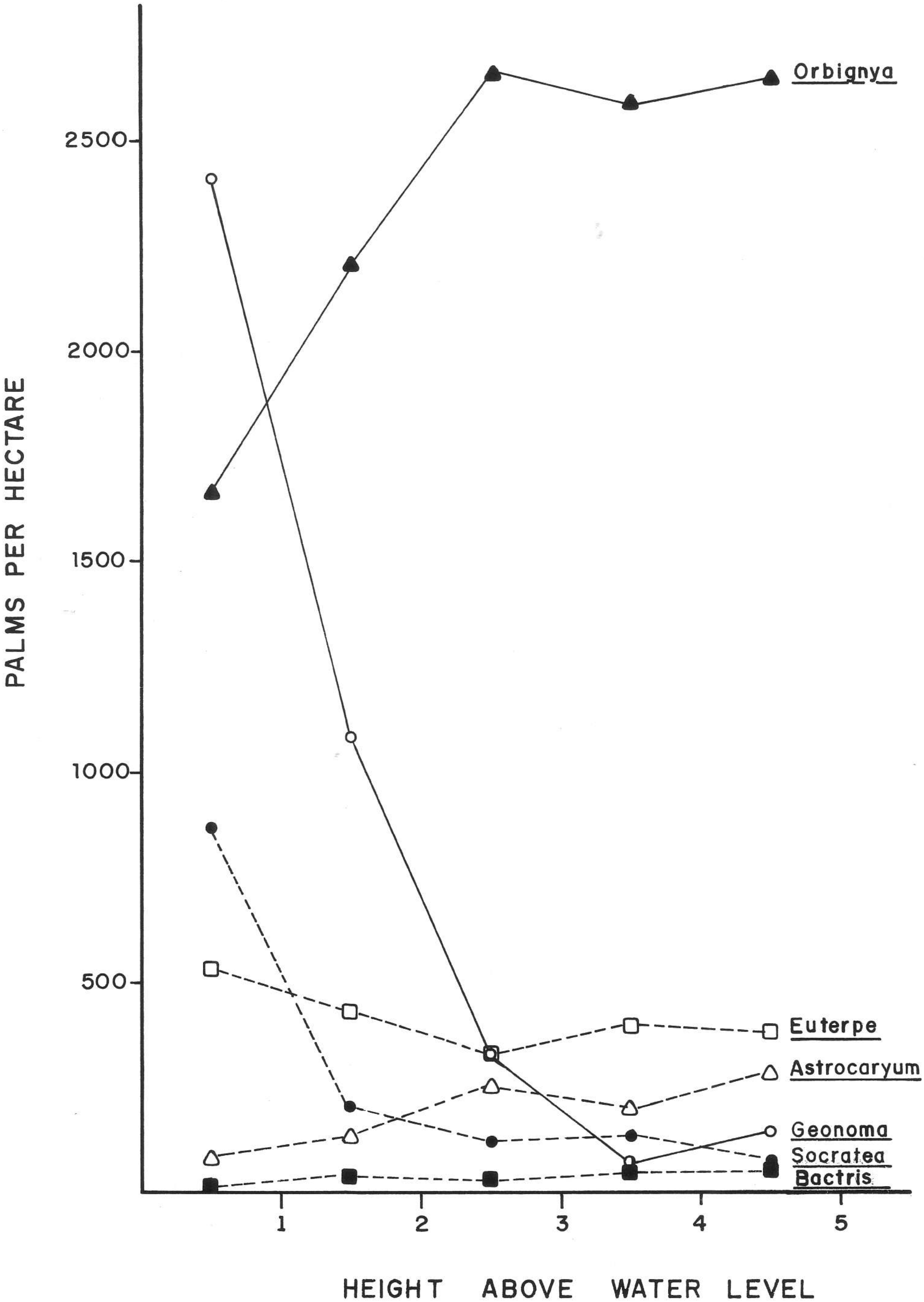


2. Number of palms at different distances from the stream. O, *Orbignya phalerata*; ☆, *Geonoma baculifera*; * *Euterpe oleracea*; ★, *Socratea exorrhiza*; ●, Total for all species, including *Astrocaryum munbaca* and *Bactris* sp.

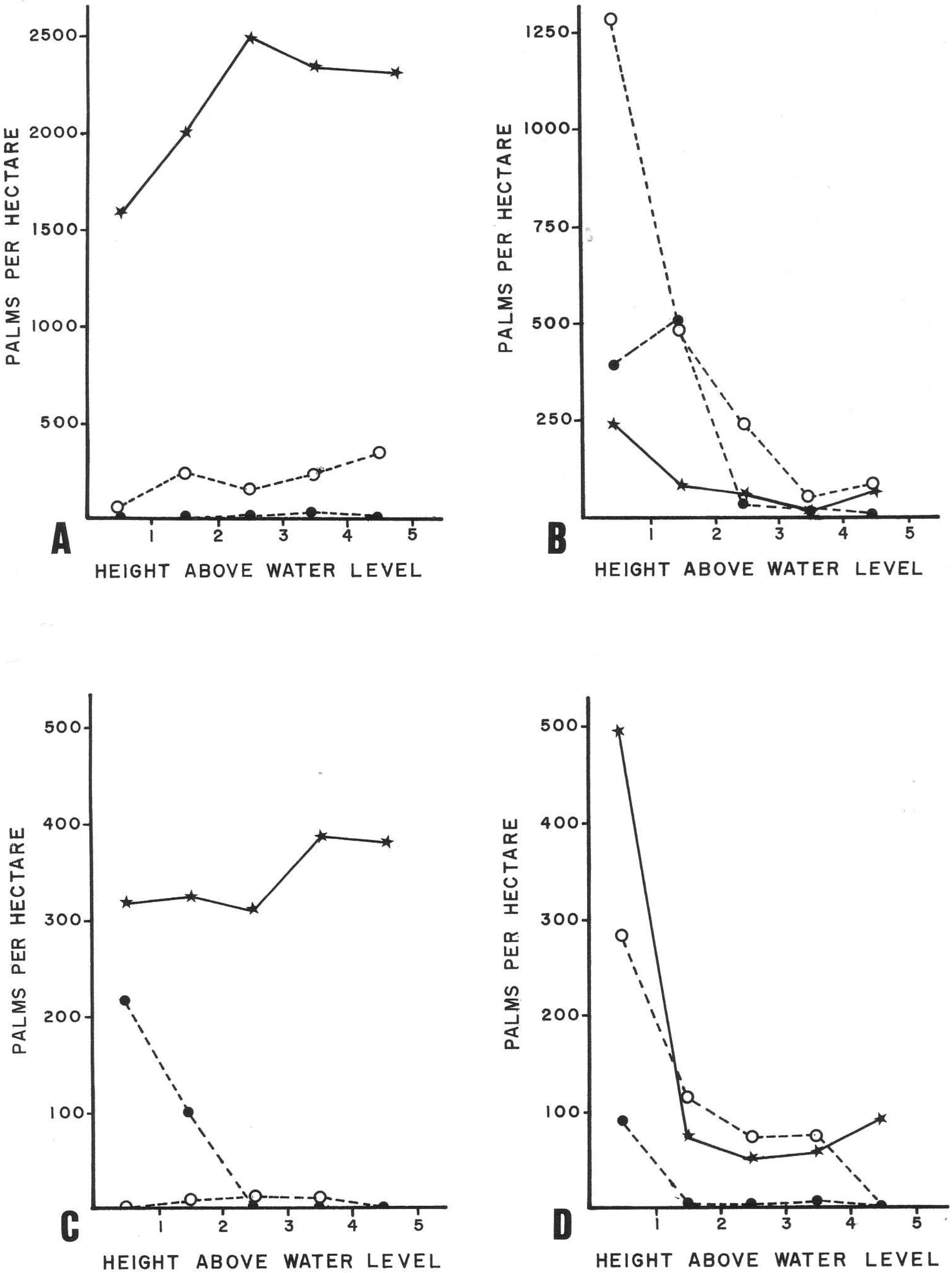
Figure 4 shows densities, along a vertical gradient, for the three size classes (adults, juveniles, and seedlings) of *Orbignya phalerata, Geonoma baculifera, Euterpe oleracea* and *Socratea exorrhiza.* In *Orbignya phalerata,* densities of juveniles and adults increased towards higher ground, with adults maintaining similar densities throughout. Both *Geonoma baculifera* and *Socratea exorrhiza* showed distinct preference for more humid soils for all three size classes, with the number of individuals decreasing drastically on higher soils. *Euterpe oleracea* behaved like these two with respect to juveniles and adults, while maintaining high densities of seedlings throughout the topographic gradient.

Discussion

Table 2 shows a comparison of species diversity and density for palms under varying soils and water conditions for several studies throughout the Amazon basin. In spite of the differences in size of the study areas involved, data are sufficient to support Kahn et al.'s (1988) claim that western Amazonia is richer in species than the eastern portion of the Basin, supporting the idea that western Amazonia is one of the richest regions in palm species diversity in the Americas (Lleras et al. 1983). Thus, it can be seen that, compared with other



3. Vertical distribution (densities) for the six most important species.



4. Vertical distribution (densities) for the three size classes. ●, Adults; ○, Juveniles; ★, Seedlings. A. *Orbignya phalerata*; B. *Geonoma baculifera*; C. *Euterpe oleracea*; D. *Socratea exorrhiza*.

Table 2. Comparison of species richness and density of palms under different soil-water conditions for several studies throughout the Amazon Basin.

Region	Soil Water	Size Classes Included	Number of Genera	Number of Species	Density/ha	Area Sampled (ha)	Source
Eastern Amazonia							
Tocantins Valley, Pará—Brazil	Diverse	All	9	21	2,224	10.56	Kahn (1986*a*)
Carajás, Pará—Brazil	Poorly drained	All	8	8	3,975	1.00	This paper
Central Amazonia							
Manaus, Amazonas—Brazil	Well drained	All	7	9	620–800	0.45	Takeuchi (1960)
Manaus, EEST/INPA, Amazonas—Brazil	Well drained	All	11	26	3,231	0.72	Kahn & Castro (1985)
Manaus, EEST/INPA, Amazonas—Brazil	Poorly drained	All	10	10	4,666	0.24	Kahn & Castro (1985)
Manaus, EEST/INPA, Amazonas—Brazil	Waterlogged	All	7	7	10.512	0.24	Kahn & Castro (1985)
Western Amazonia							
Jenaro Herrera, Rio Ucayali, Peru	Well drained	≥1, 2 m	—	—	3.500	0.7	Marmillod (1982)
Jenaro Herrera, Rio Ucayali, Peru	Well drained	All	16	29	9.860	0.71	Kahn et al. (1988)

areas, the area studied for this paper is relatively poor in species diversity.

Another salient point is that palm density is highest in the more humid (water logged or poorly drained) soils, decreasing toward higher ground. According to Kahn and Castro (1985), this may, in fact, not be related to water, but to light intensity in the understory, which is higher in seasonally flooded than in terra firme forests. Kahn et al. (1988) maintain that the higher density of palms in western Amazonia compared with the central and eastern portions of the Basin is due to the higher number of caespitose (multi-stemmed) species in the understory in the former, noting also that this also reflected a difference in dominant life forms for the western forests.

The higher density of palms found near the stream, in the present study, is due mainly to the large number of individuals of the caespitose species *Geonoma baculifera* and *Euterpe oleracea* and, to a lesser degree, the single-stemmed *Socratea exorrhiza.* Kahn (1986*a*) has already shown the preference of *Geonoma baculifera* for hydromorphic soils, which explains the abundance of this species near the stream margins, while Granville (1978) has shown that caespitose species are among the dominant life forms in seasonally flooded forests.

Euterpe oleracea occurs in highest density close to the creek. The species, which fits into Tomlinson's growth model (basal ramification with formation of clumps—Hallé et al. 1978) is under high selective pressure, as can be seen by the high number of seedlings throughout the study area (Fig. 4C). Small clearings are insufficient to accommodate the species, as lateral axes are shaded by the main axis and surrounding vegetation. Thus, adults predominantly grow in humid soils with high light intensity.

Species that have Corner's growth model (single-stemmed with lateral inflorescences, Hallé et al. (1978), such as *Orbignya phalerata* and *Socratea exorrhiza,* generally have high light requirements for shoot growth. This restricts growing conditions to two basic situations (Kahn and Castro 1985): a) open clearings in the interior of the forest, or b) sparse forest with well illuminated understory. Anderson (1983) and Anderson and May (1985) note that although shade favors seed germination in *Orbignya phalerata,* it inhibits stem growth. Thus, the low number of seedlings of this species near the water is probably due to high light intensity and humidity. However, occurrence of adults in similar densities throughout suggests that the limiting factor is not water but light.

Socratea exorrhiza seems to be unable to survive in the shade (but see Hogan 1986), while requiring high humidity. This limits its distribution to the fairly humid, well-lighted margins of watercourses, and gaps in the wetter portions of the forest.

In general, the present paper shows that two major environmental factors play key roles in determining palm density and distribution: humidity and light intensity.

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LETTERS

26 April 1989

Dear Natalie:

I have recently returned from Costa Rica where I had the privilege of revisiting the Robert and Catherine Wilson Botanical Garden (formerly known as the Las Cruces Tropical Botanical Garden) in the mountains around San Vito de Java, Costa Rica. As you recall, this is where I lived in 1974–75 after completing my undergraduate education. It was truly a joy to return to a place that I once called home.

While living in Las Cruces I had the chance to work intensively on the palm collection, consisting of native species as well as introduce plants that Bob Wilson's many friends and associates would send him from all over the world. It was remarkable see these specimens, now flowering and fruiting, like so many children having grown up over the last 15 years. I understand that the Garden suffered somewhat during the late 1970's and early 1980's but signs of this past struggle are certainly not evident today. Much of this is due to the hard work of the current Director, Dr. Luis Diego Gomez and his staff. The dream of Bob and Catherine Wilson, to build a botanical garden in a tropical paradise, still lives on and flourishes today.

I have had the chance to visit many of the other gardens in the Neotropics. It is always sad to observe the state of things at so many of these places. While many are founded by a person with a vision, after the founding person is gone the local economy is not always able to support a collection of ornamental and useful plants. There are simply too many more pressing priorities in the developing world.

The Wilson Garden is especially important because it is one of the few gardens focusing on palms, both native and exotic.

(*Continued on p. 190*)

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Principes, 33(4), 1989, pp. 181–190

The Rise and Fall of Vegetable Ivory

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People of the older generation who lived during the pre-World War II period may remember vegetable ivory or ivory nut. To younger generations this natural material remains largely unknown. Exploitation grew quickly at the beginning of the 20th century and improved considerably the trade balance of several South American countries. About $5,000,000.00 worth of vegetable ivory were exported from South America annually at the beginning of the century (Barrett unpubl.). In the twenties, 20 percent of all buttons produced in the United States were made of vegetable ivory (Acosta Solís 1944). The major producing countries were Ecuador, Colombia, Brazil, Peru, and Panama. World trade of vegetable ivory increased until the outbreak of World War II. During the war, the buying countries decreased their import and afterwards vegetable ivory never again regained its influence. The plastic age had begun while the knowledge of a unique natural material has become lost.

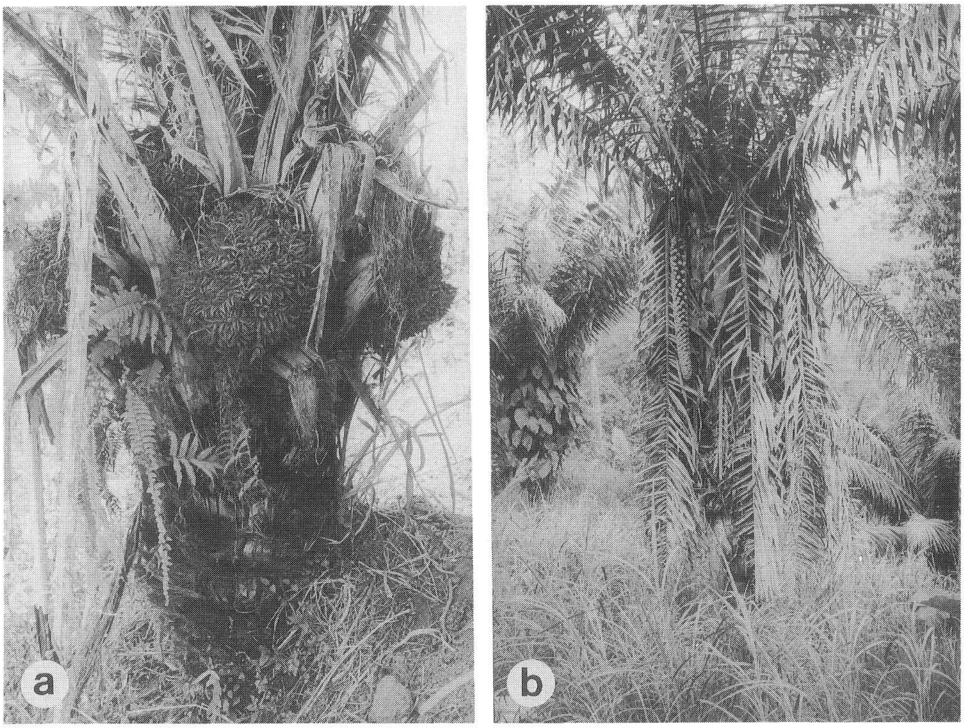
Vegetable Ivory Palms

The production of vegetable ivory has been based on five species of South American palms: *Phytelephas macrocarpa* distributed on the eastern Andean slopes of northern Peru, Ecuador, and southern Colombia, *Palandra aequatorialis* from the northern coastal plain of Ecuador (Fig. 1a, b), *Phytelephas schottii* distributed in the Río Magdalena Valley in Colombia, *Phytelephas tumacana* from Nariño in southern Colombia and finally *Phytelephas seemannii* which is found on both sides of the Panamanian-Colombian border. The genera, *Palandra* and *Phytelephas*, both belong to the phytelephantoid palms, which now have formal rank as subfamily of the palms according to Uhl and Dransfield (1987). This is a very distinct group of palms which, due to several unusual features and in particular the highly dimorphic flowers, have been placed in other more or less related families such as Pandanaceae, Typhaceae, and Cyclanthaceae. Today they are considered to represent a separate evolutionary line within the true palms.

The Ivory Nut

It is the seed or nut that is the source of vegetable ivory. The Spanish name "Tagua" refers specifically to this part of the palm, although in some places "Tagua" is also used as a name of the palm itself. In areas where it is used for roofing, *Palandra aequatorialis* is often called "Cadi," which is the Quichua name for thatch in Peru. Local names given to palms in Quichua often reflect their uses or describe the part of the palm used. "Antá," which is the local name *Phytelephas seemannii*, means metal or copper in Quichua and may refer to the hardness of the seeds (Cook 1927).

The infructescence of phytelephantoid palms (Fig. 1a) is a large spherical structure up to 35 cm in diam. The mature fruits are obpyramidal and 4–6 sided because of mutual pressure. The epicarp and outer mesocarp, is fibrous. Inside this, there is a thin and fleshy inner mesocarp. The seed is contained in a thin stony shell, which is the endocarp. In between the seed



1. The Ecuadorean Tagua palm, *Palandra aequatorialis.* a, Female plant with head-shaped spiny infructescences containing the vegetable ivory. b, Male plant showing the pendent male inflorescence.

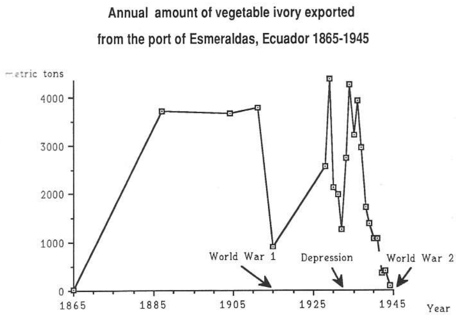
and this endocarp, a thin parchment-like brown seed testa is present which displays a conspicuous venation. The endosperm of immature seeds is fluid much like the milk of coconuts. This liquid gradually turns into a gelatinous substance and finally, in the mature seed, the endosperm is hard and white as ivory.

Chemical Composition

Ivory nut has been shown to be composed of two mannans. One is soluble in aqueous sodium hydroxide (mannan A), the other one is insoluble in this solution (mannan B) (Aspinall et al. 1953, 1958). In fact, vegetable ivory is the best source available for isolation of mannan polysaccharide, which constitutes 70 percent of the endosperm in the mature seed (Timell 1957). The mannans serve as storing material for the developing embryo. They are the major component of the thick walls of the endospermatic cells.

Other Ivory Nut Palms

According to Perez-Arbaleaz (1978) the seeds of *Mauritia flexuosa* have been a source of vegetable ivory. In Colombia, vegetable ivory is also obtained from *Dictyocaryum lamarckianum* Mart. This palm tree is also called "Tagua" in the northern parts of the eastern cordillera (Rodrigo Bernal, pers. comm.). In Africa, vegetable ivory is derived from the seeds of the Doum palms (*Hyphaene spp.*), and in Asia it is the hard endosperm of species of *Metroxylon* which is exploited.



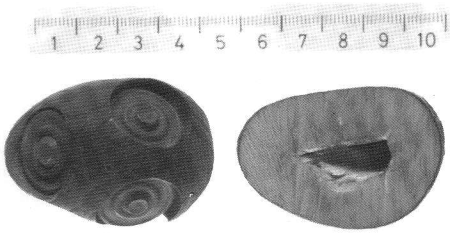
2. Years 1928–1944 based on figures compiled by Acosta Solís (1944). Years 1865–1928 based on Jácome B. and Martínez F. (1979).

Vegetable Ivory Versus True Ivory

The chemical composition of vegetable ivory makes it excellent for woodcrafts produced by hand or with a lathe. The term "vegetable ivory" suggests similarity to true ivory and it is correct that the two materials are much alike when they have been processed, however they differ in their basic properties. Vegetable ivory dissolves when soaked in water for long periods (more than a month), whereas true ivory does not. Moderate hydration will soften the vegetable ivory—a property that can be exploited in crafting—while drying will restore its hardness. Generally vegetable ivory is softer and much easier to craft than true ivory, provided that it has been harvested at the right time. If the seed is immature, it will crack when dried. The porosity of vegetable ivory makes it an excellent material to decorate, e.g., with drawing ink. Many ivory nuts have a cavity inside (Fig. 3) that makes using the entire seed difficult. However, seeds of *Palandra aequatorialis*, harvested at the right time, are usually solid, which is the reason they are considered to be of the highest quality.

The Golden Age of Vegetable Ivory in Ecuador

In 1944 the Ecuadorean botanist and naturalist Acosta Solís wrote a booklet on



3. Partly manufactured sample of ivory nut kept at the British Museum showing how the seed was placed on a lathe and buttons were carved out of the superficial layers. Note also the cavity inside the nut that prevented larger objects from being produced from this piece.

the vegetable ivory production in Ecuador. He compiled much valuable information on the production and trade of vegetable ivory, which was based on the exploitation of a single species, *Palandra aequatorialis.* Ecuador was the major exporting country of ivory nut when production was at its highest point in the late twenties and the early thirties. In 1931, 92 percent of the ivory nut imported by the United States came from Ecuador (Fig. 8).

The Beginning

Germany was the first country to start importing vegetable ivory from Ecuador. According to Acosta Solís (1944), the first shipment of Tagua from Ecuador was exported around the middle of the 1860s simply because a German cargo-steamer, on its way back to Hamburg, had room in its hold.

The Germans quickly became aware of the potentials of this new and interesting raw material. Vegetable ivory became a popular material for making, first of all, various types of buttons, but also toys, canehandles, jewelry, figurines, etc. In 1865 ivory nut first appeared in statistics and a few years later it had already become one of Ecuador's major export products, along with rubber and cacao. In 1887 the export of vegetable ivory from Esmeraldas amounted to 76.2 percent of the earnings of this port. At that time, the export from the port of Esmeraldas was worth about 3 percent of the total export of Ecuador (Jácome and Martínez 1979).

Harvesting

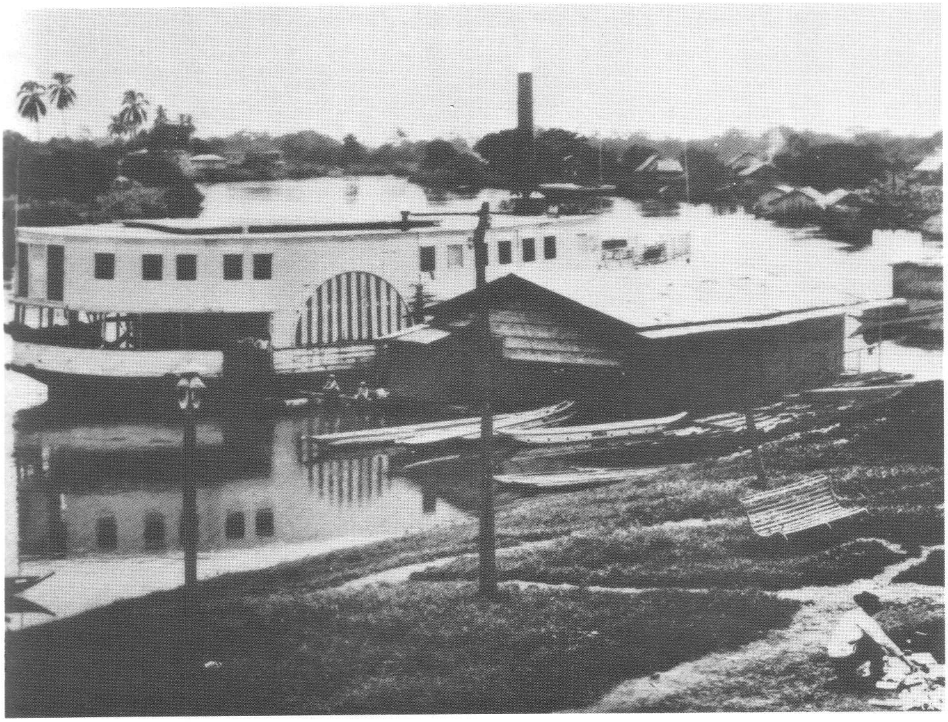
Production did not take place on plantations but was based on the harvesting of natural populations of palms by the rural inhabitants. Two species, *Palandra aequatorialis* and *Phytelephas seemannii,* were exploited more than any others. They combined two important qualities: large seed size and a usually solid endosperm. Seed size was an important criterion for determining the quality of the ivory nut when it was traded because small seeds limited the possibilities in crafting. Furthermore, both of the two species mentioned grew in dense populations adjacent to rivers on the coastal plains of Ecuador, Colombia, and Panama and could easily be reached by dugout canoe. Rich (1936) gave an account on the hard work which was done by the so-called "taguaros" gathering ivory-nut: "his outfit consists of a machete, an ax, gun and ammunition, a few cooking utensils, and such foods as rice, beans, flour. The taguaro may own his own canoe or raft. A few natives and, at times, several families work together. So after making ready, these diminutive expeditions proceed up-stream to the 'hunting grounds' or primeval solitudes. With their guns, the marksmen of the party shot a duck, hawk, squirrel or some other species of food; this together with supplies furnished by the merchant, may last for weeks or until the party returns with the first cargo of tagua." The biggest problem must have been transporting the heavy load. Rich estimated some of the rafts coming into the port of Guayaquil to have up to 10 tons of nuts aboard!

According to Acosta Solís (1944) one of the ways to harvest ivory nut was to collect the uppermost infructescences which contained seeds that were not yet mature. The seeds were then matured artificially by burying the fruits either below the ground, or below a pile of trash. The surrounding fibrous husk was later removed with a wooden hammer. The ivory nuts extracted in this manner were called "tagua rubia" or red ivory nut. If the trunks were tall, the palm trees were felled in order to facilitate collection and thus, harvesting often became very destructive. Another less destructive method produced "tagua negra" or black ivory nut. Here the seeds were allowed to mature naturally on the palm tree.

It is unclear from Acosta Solís' account which part of the seed the "black" and "red" relate to. He probably referred to the color of endosperm that varies according to the method of extraction. Acosta Solís wrote: "both red ivory nut and black ivory nut are in general sold and exported in a peeled condition ("Tagua pelada"), that is, with the shell or perisperm (=endocarp) removed."

It is interesting to read Acosta Solís' warnings in 1944 against the destructive exploitation of vegetable ivory and the ruining of an important natural resource. Decreasing trade later saved the vegetable ivory from being destroyed although today, deterioration of the habitat of the ivory nut palm, *Palandra aequatorialis,* represents a more serious threat.

Claès (1925) gave a rough estimate of the production of *Phytelephas schottii* of the Río Magdalena Valley in Colombia. The figures related to large and dense populations on alluvial sands in the lower parts of the valley. Some of these populations still exist today. Claès observed an average distance of 6 m between the mature individuals in fructification, which corresponds to about 250 individuals per hectare. He further calculated that a single individual produces at least 8 inflorescences every year and that one inflorescence yields a total of 250 to 300 ivory nuts, each weighing 35 grams on the average. Multiplying all these figures he deduced that the total annual production was 2.25 metric tons



4. General view of the Port of Babahoyo in 1900. The ivory nut was transported from this place to Guayaquil by cargo-steamers like the one in this photo. (Reproduced from Vásquez G. 1984)

of ivory nuts from one hectare of a natural population.

Transportation

From the sites of collection upstream along the rivers, the vegetable ivory was transported in dugout canoes or on rafts to centers of commerce on the coast, such as Babahoya in Ecuador (Fig. 4). Large cargo-steamers shipped the vegetable ivory from these ports to the buying countries along with cacao, rubber, and other products.

Transport to the United States was nearly monopolized by a British company named Pacific Steam Navigation Co. and by the Pacific Railroad Co. in Panama, who transported the cargo across the Isthmus of Panama by train (Fig. 5). The customers often protested about bad service and high prices and they seemed to have good reason. Transport costs in 1896 were more expensive from Ecuador to New York via Panama ($80 per metric ton) than to Europe via the Strait of Magellan ($30–60 per metric ton) (Dueñas de Anthalzer 1986). In 1914 transportation costs constituted nearly 30 percent of the price of the vegetable ivory sold in Hamburg, Germany (Fig. 6).

Still there was a lot of money to be earned from vegetable ivory and especially by the importing companies. Dueñas de Anthalzer (1986) estimates that the net profit of the dealers in Hamburg was around 40 percent of the final price (Fig. 6).

Prices depended on the quality of the ivory nuts and in particular on their size, their shape, and if they were solid. In New York in 1931 ivory nuts from Esmeraldas that were not peeled were quoted at $1.75

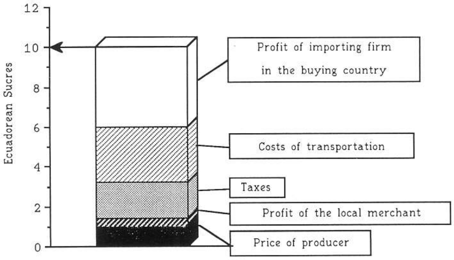
5. Very large amounts of vegetable ivory passed through the port of Panama City during the golden age of this material. Today, only 50 years later, there is no trace of vegetable ivory in the port of Panama City here photographed and the material is unknown to most inhabitants.

to $2.00 per quintal (=112 pounds) and ivory nut from Manta without the shell ("Tagua pelada") was quoted at $2.00 to $2.50 per quintal (Acosta Solís 1944) (Fig. 9).

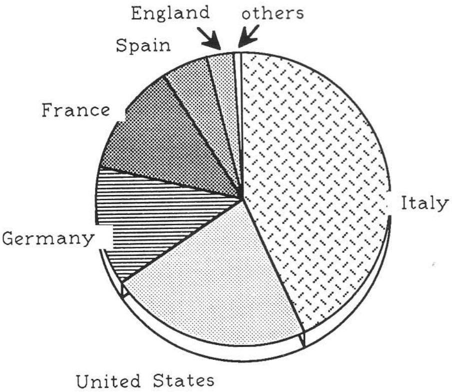
Button Production

A few years after Germany had started the import of vegetable ivory, it could be found all over Europe. The United States already imported great quantities of this item. When production was at its highest point in 1929 and 1930, just before the outbreak of the Depression, Italy and the United States bought more than ⅔ of the total annual production from Ecuador (Fig. 7, 8), which is a reflection of the distribution of the global textile industry at that time.

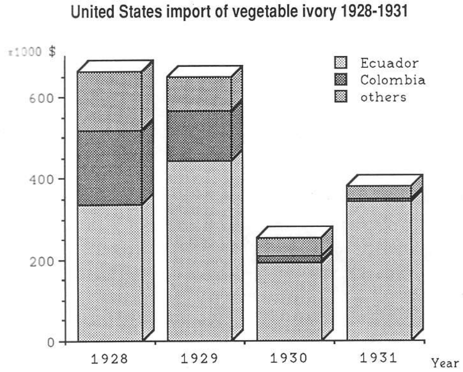
In the United States more than 25 factories manufacturing buttons from vegetable ivory were concentrated in the New York area (Acosta Solís 1944). Buttons of vegetable ivory were typically produced by hand using a lathe. A partially manufac-



6. Breakdown of the final price of 112 lbs. of vegetable ivory sold in Hamburg in 1914.



7. Destination of vegetable ivory exported from Ecuador in 1930.

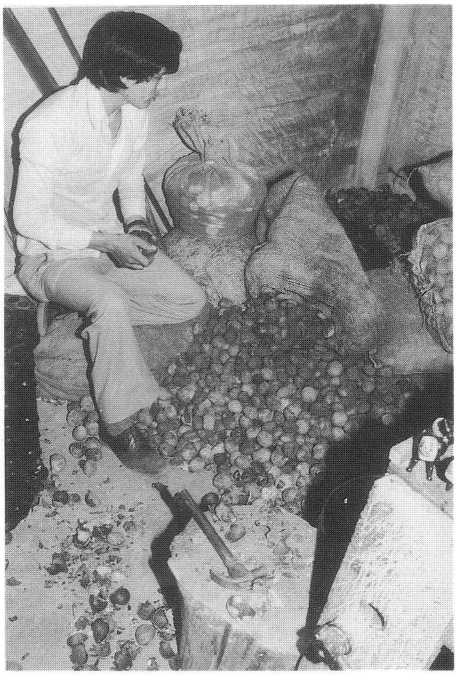


8. Based on Acosta Solís (1944).

tured ivory nut kept at the herbarium of the British Museum in London illustrates one way this could be done (Fig. 3). Several buttons from the same seed were carved with a profile cutter. Cheaper buttons were produced in great quantities at large factories, where the seeds where prepared for carving by a partly automatized process. Rich (1936) described how buttons were made in one of the largest factories in the United States. The entire endocarps were first dried at about 100° F. They were then separated mechanically from the nut in tumbling iron barrels with knockers inside. After removal of every vestige of endocarp, slices of vegetable ivory were cut from the sides by small circular saws leaving the hollow core. These pieces were dried on sieves for eight to ten days and subjected to a higher temperature than at the previous drying. After this treatment the slices of ivory nut are ready to be manufactured on a lathe. Rich continued: "Each piece of ivory is now as hard and dry as bone, and no matter how much it may be soaked or swollen in the subsequent processes of manufacture it always returns to its present state of hardness."

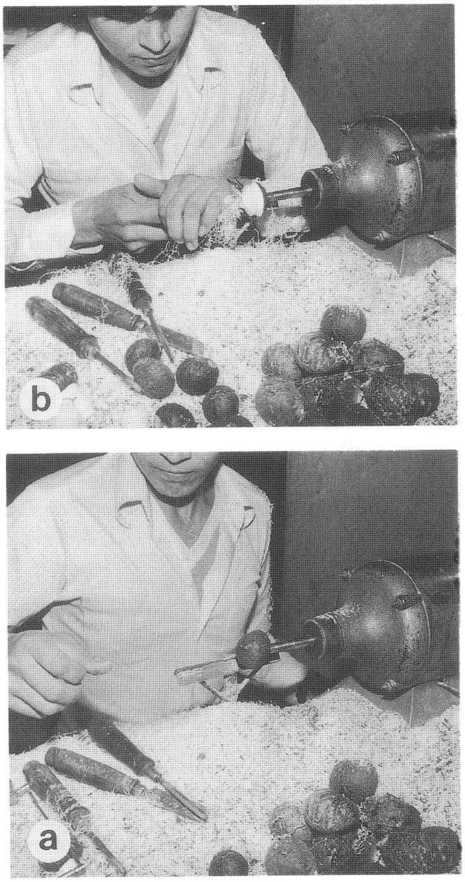
The Fall

By the beginning of World War II the demand for vegetable ivory had already started to decline (Fig. 2). The war resulted in many technical innovations and among others the invention of Bakelite and plastics. These new synthetic materials were inexpensive alternatives to vegetable ivory and were better suited to modern production modes involving fewer people and more machines. The raw material came from the petrochemical industry which meant relative independence from unstable supplies and oscillating prices.



9. Most ivory nut was delivered as "Tagua pelada." The endocarp was removed from the seed with a wooden hammer. In this souvenir factory it is removed with a steel hammer previous to manufacturing. Colombia, Dept. of Boyaca, Chiquinquirá.

Throughout World War II instability prevailed on the world market for raw materials. Trade with previously important products such as vegetable ivory declined rapidly whereas other products such as rubber and balsa were in great demand, compensating to some extent for the losses. However, after the war, world trade with both rubber and balsa decreased. Rubber was gradually replaced by plastics in west-



10. a, The ivory nut is placed on the lathe and b, carved into the foot of a salt shaker. Colombia, Dept. of Boyaca, Chiquinquirá.

ern countries and thus suffered the same destiny as vegetable ivory.

The economic situation in many of the raw material producing countries was critical. In Ecuador, a large part of the population was involved in the production of vegetable ivory and rubber. In 1938 about half of the export earnings from the province of Esmeraldas came from the production of vegetable ivory; one third of the earnings came from rubber production (Jácome B. and Martínez F. 1979). It was crucial to find new products to replace the ones that had been lost and banana production was attempted. The North American company, Standard Fruits, that had suffered severe lossees on their banana plantations in the Caribbean due to pest attacks, decided to stimulate the production of bananas in Ecuador. Only a few years after this initiative, a considerable export of bananas took place. Ecuador had found its successor to vegetable ivory and rubber. Enormous areas covered by forest were cleared in order to establish banana plantations. Many of the natural habitats of the vegetable ivory palms, *Palandra aequatorialis*, gave way to banana plantations. Within a few years this species was threatened more by banana cultivation than by the previously destructive exploitation of vegetable ivory that Acosta Solís had warned against in 1944.

Vegetable Ivory Today and in the Future

Today vegetable ivory is largely unknown to people in the industrialized part of the world. In the former major exporting countries, Ecuador and Colombia, small factories processing the material can still be found (Fig. 10). The objects made are mostly souvenirs that are sold locally and at a very low price.

In Ecuador figurines 4 to 6 inches tall and assembled from several pieces of ivory nut can be purchased in most souvenir ships in the capital Quito (Fig. 11). These are mainly produced in the small Andean town Riobamba. The ivory nut used in the production comes from *Palandra aequatorialis.* Near Manabí on the coastal plain of Ecuador, a few factories, founded before World War II, still produce buttons from vegetable ivory. The production is mainly exported to Japan, West Germany, and Italy where demand is steadily increasing. Wastes from the production are ground into a flour used as cattle or pig fodder.

In Colombia, small factories that manufacture souvenirs of vegetable ivory are situated in several villages in the department of Boyacá such as Ráquira and Chi-

11. Small statues ca. 15 cm tall made of ivory nut from *Palandra aequatorialis*. Due to the porous structure of the ivory nut they are very suitable for decoration with water stable colors and in particular drawing ink. Ecuador, Quito.

quinquirá. The ivory nut used in the production originates from different populations in the central part of the Río Magdalena Valley (Puerto Boyacá, San Vicente de Chucurí, Otanche and Belleza) and from the eastern part of Colombia. One metric ton of ivory nut is worth between $18 and $20 (Feb 1987). *Phytelephas schottii* and *P. seemannii* are probably the source of the ivory nut.

During the last five years the trade of souvenirs made from tagua has increased both in Colombia and Ecuador. It is too early to tell if this is the beginning of a renaissance for the ivory nut. Fashion is completely unpredictable but on the other hand many designers prefer natural materials to plastics. Another positive aspect is that it is a nondestructive exploitation of a renewable resource in contrast to the way the true ivory is obtained. In order to enhance the export of ivory nut, production should be based on elaborated objects such as jewelry (in particular necklaces and bracelets) chess pieces, dice, etc. In Bogotá, Colombia such refined craft-works are sold at a local market (G. Galeano-Garcés, pers. comm.).

Many uses of vegetable ivory probably remain to be discovered. The polymerized polysaccharides may eventually be used for their chemical and physical properties in products such as food additives.

Is there any future for the ivory nut? Ivory nut will probably never again regain its former position as one of South America's major products of export, but on a microeconomic level it may turn into an important raw material in the cottage industry, thus helping to stabilize the economy of small farmers.

Acknowledgments

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LETTERS (*Continued from p. 179*)

Bob Wilson, with the help of many others, carried out extensive explorations of Costa Rica and introduced new palm species into cultivation. Some of the original populations of these palms in the wild have been destroyed, and the Garden remains the ultimate repository for the natural variation found in these native species. Because of this, it seems to me that it is to the advantage of all members of the Palm Society to ensure that the Wilson collections flourish and expand. This facility is currently being operated by The Organization for Tropical Studies. Unfortunately, only about one-half the budget can be met with current funding—the rest must be raised each year from gifts and grants. An important consideration about funding facilities in the tropics is that each dollar obtained for that country goes 10–100 times as far as it would in the U.S. If a handful of palm devotees would donate funds to the Wilson Garden, this would have a tremendous impact on the palm and other native plant collections. I invite other Palm Society members to join me in sending a few dollars to the Wilson Garden (% Luis D. Gomez, Director, Jardin Botanico, Robert and Catherine Wilson, Apartado 35, San Vito de Java, Coto Brus, Costa Rica—make check payable to Organization for Tropical Studies, Inc.) to help with the maintenance and proliferation of the living collections. The OTS is a charitable organization, and donors will receive receipts documenting their tax-deductible contributions.

MIKE BALICK

Principes, 33(4), 1989, pp. 191–194

Influence of Temperature on Germination of Sabal causiarum Seed

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ABSTRACT

Sabal causiarum seeds have no dormancy when fruit are harvested at maturity, the pericarp removed, and seed cleaned and planted immediately. Temperature governs the length of the germination period and the total percent of germinated seeds. Constant 25°, 30°, 35° or alternating 20°–30°, 25°–35° or 30°–40° C promote 97% to 100% germination. Less favorable temperatures of 20° and 40° C gave 48% and 16% germination respectively. The number of days required to 50% of final germination varied greatly with germination temperature. Seeds at constant temperatures of 20°, 35° and 40° C require 52 to 87 days for germination while at constant 25°, 30° and alternating 20°–30°, 25°–35° or 30°–40° C only 12 to 22 days were required. Seed viability was unchanged after dehydration removed 13% to 73% of total water contents of freshly harvested seeds, but reducing seed water content to 7.2% significantly increased the days to 50% of final germination. Seed storage for 21 days at 5° to −20° C did not reduce viability, however −10° and −20° C hastened germination by reducing the number of days required to achieve final germination.

Sabal causiarum, Puerto Rican hat palm, native of Puerto Rico and the Virgin Islands, is a cold tolerant palm with massive trunk diameter and maximum height of 50 feet (Fig. 1). Its growing range in the U.S.A. includes the coastal areas of the Gulf of Mexico, the south Atlantic states and southern California. Propagation and plant production are increasing in Florida's nurseries as demand increases for cold tolerant palms. Limited propagation research has been conducted using this palm genus. Basu and Mukhernice (1972) reported that *Sabal blackburnia* and *S. mexicana* require 120 days to germinate, but gave no information regarding the temperature or the germination percentages. Sento (1976) found the optimum germination temperature for *Sabal minor* was 25° C and most seeds germinated between 20 and 60 days. He also reported *S. minor* seeds need a few months for after-ripening prior to germination. Both Brown (1976) and Carpenter (1987) reported best germination of *Sabal palmetto* seeds at a constant 25° and 30° C with germination within 28 to 35 days. Carpenter (1988) reported that 93% to 98% of *Sabal etonia* seeds germinated at 25°, 30° and 35° C constant temperatures and found 13 to 31 days required for 50% of final germination. This research was conducted to provide recommendations for the handling and germination of *S. causiarum* seeds.

Seeds of *S. causiarum* were collected from an established planting on the University of Florida campus in November 1987 and used in this series of studies. After removal of the pericarps and cleaning, seeds were soaked in deionized water for 48 hours, surface dried, and dusted with Captan before planting in moist Canadian peatmoss in 10-cm petri dishes. Four replications of 25 seeds each, were placed in incubators at constant 20°, 25°, 30°, 35°, 40° and variable 20°–30°, 25°–35°, or 30°–40° C. Variable temperatures were alternated at 12 hour intervals. Germination counts were made weekly of seeds with radicle emergence. Total germination percentages and days required to 50% of final germination were calculated, and data were statistically analyzed in this and subsequent studies by Tukey's honestly significant difference test at the 5% level.

1. *Sabal causiarum* palm on the campus of the University of Florida.

Table 1. Effect of alternating and constant temperatures on total seed germination and days to 50% of final germination of Sabal causiarum.

Temperature °C	Germination Total Percent	Germination Days to 50%
20	48	64
25	99	22
20–30	99	12
30	98	16
25–35	97	18
35	100	52
30–40	100	14
40	16	87
HSD,* 5% level	12	15

* Tukey's honestly significant difference test.

Germination of 97% to 100% resulted when temperatures were at constant 25°, 30°, 35° or alternating 20°–30°, 25°–35°, 30°–40° C (Table 1). Germination percentages were greatly reduced at 20° (48%) and 40° C (16%). The temperature treatments had large differences in the number of days to 50% of final germination (Table 1). Constant temperatures of 20°, 35° and 40° C required 52 to 87 days to 50% of final germination, while constant 25°, 30° and alternating 20°–30°, 25°–35° or 30°–40° C only required 12 to 22 days. These results indicate *S. causiarum* has a broad optimum temperature range from 25° to 35° for maximum germination, and a range of alternating daily temperatures promote germination. This agrees with Hartmann and Kester 1983 that alternating diurnal temperatures promotes increased germination.

A study was initiated in November 1987 to determine the effect of reduced seed moisture content on seed viability. Four replications of 50 seeds each, were weighed and placed in open petri dishes in 40° C forced-draft drying ovens for 0, 6, 12, 24, 48 or 72 hours. Immediately following dehydration, seeds were reweighed and sealed in screw-capped 25-ml glass vials, 50 seeds per vial. Following 3 weeks storage, the dehydrated 50 seed replicates were reweighed, soaked in deionized water for 24 hours, and germinated in constant 30° C incubators in 10-cm petri dishes containing moist peatmoss. Germination counts for treatment replicates were made weekly and data statistically analyzed. Three days following seed collection and cleaning, four 50 seed lots were weighed, dehydrated at 105° C for 48 hours, and reweighed after cooling to determine seed initial total moisture content.

Viability of *S. causiarum* seeds was unchanged by dehydration removing 13% to 73% of total moisture contents of freshly harvested seeds (Table 2). Seeds of all dehydration treatments had 96% to 100% germination. Reducing seed moisture contents from 26.6% to 10.5% had no effect on the numbers of days to 50% of final germination, but reducing the moisture

Table 2. Seed moisture content and total germination and days to 50% of final germination.

Dehydration Hours	Moisture Content %	Germination Total Percent	Germination Days to 50%
0	26.6 ± 1.9	100	17
6	23.1 ± 1.3	99	16
12	20.4 ± 1.4	99	19
24	14.8 ± 1.1	100	19
48	10.5 ± 0.7	98	23
72	7.2 ± 0.5	96	31
HSD,* 5% level		5	7

* Tukey's honestly significant difference test.

content to 7.2% delayed germination (Table 2). No visible signs of shriveling or damage to cells or tissues were found during microscopic examination of excised embryos from seeds dehydrated for 72 hours at 40° C.

A third study was initiated to determine the effects of temperature during seed storage on seed viability. Four replications of 50 seeds for each of 5 treatments were placed in 50 ml sealed glass vials. The vials were immersed in polyethylene glycol-water (v/v) in controlled temperature water baths (Guy and Carter 1984) for 21 days at 5°, 0°, −5°, −10° and −20° C. Following low temperature treatment, seeds were germinated in moist peatmoss in 10-cm petri dishes at 30° C. Germination counts were made weekly and data statistically analyzed.

S. causiarum seed germination was unaffected by storage for 21 days at 5° to −20° C and all treatments had 96% to 99% germination at 30° C (Table 3). The 12 or 13 days required for 50% of final germination following −10° or −20° C storage were similar to the germination period for seeds receiving alternating 20°–30° and 30°–40° C germination temperatures (Table 1). Prior to freezing, seeds in this study had 25% to 28% moisture contents. Hartmann and Kester (1983) report seeds must be in equilibrium with

Table 3. Effect of low temperature on seed storage of Sabal causiarum.

Temperature °C	Germination Total Percent	Germination Days to 50%
5	99	17
0	96	20
−5	98	16
−10	97	13
−20	97	12
HSD,* 5% level	4	4

* Tukey's honestly significant difference test.

70% RH or lower prior to storage at subfreezing temperatures or seed viability will rapidly be lost.

Seed quality, as affected by fruit maturity at harvest and postharvest handling, can greatly affect germination percentages of palm seed (Broschat and Donselman 1987, Caulfield 1976). Improper storage of palm seed prior to planting can greatly decrease germination percentages (Broschat and Donselman 1986). In this study, we found seeds of *S. causiarum* have no dormancy when harvested from mature fruits and pericarps are removed immediately following harvest. The mature embryos in seeds permit germination immediately following harvesting and cleaning. Almost 100% germination can be achieved at constant 25° to 35° C or alternating germination temperatures of 20°–30°, 25°–35° or 30°–40° C. This germination temperature range is much broader than for most palm species (Carpenter 1988, Sento 1976). Loomis (1958) reported seeds of many palm species lose viability when dehydrated. Loss of seed moisture content to 7.2% had no effect on the germination percent of *S. causiarum*, but seed moisture content at this level delayed germination. Seeds tolerated low temperature storage without losing viability. Seeds stored at −10° or −20° C for 3 weeks had faster germination after than before storage, and required fewer days then seeds stored at other temperatures. Our results indicate the long term storage of *S. causiarum* seeds may be possible since seeds retain viability at relatively low moisture percentages and $-10°$ or $-20°$ C storage temperatures promote germination in fewer days.

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Principes, 33(4), 1989, pp. 194–195

NEWS OF THE SOCIETY
Nominations and Elections

The Bylaws of the Society provide that:

ARTICLE IV, Sec. 2—The slate of candidates prepared by the Nominating Committee shall be made known to the membership in time to permit the nomination of additional candidates to appear on the final ballot. Such additional nominations must be made in writing to the Secretary of the Society (Lynn McKamey) by a member in good standing. The nomination must be accompanied by the written consent of the proposed candidate to serve if elected, and must be seconded, in writing, by another member. If the above conditions are met, the Secretary shall forward the candidate's name to the Nominating Committee for inclusion on the final ballot.

Sec. 3—Voting shall be by mail only. Ballots shall be mailed in time (with the January 1990 issue) for the results to be announced at the Biennial Meeting (June 1990 in Hawaii).

For Directors 1990–1994:

Mr. Paul Anderson, Australia
Dr. John Dransfield, U.K.
Mr. Bob Egge, Hawaii
Mr. Don Evans, Florida
Mr. Walter Frey, California
Mr. Jules Gervais, Hawaii
Mr. Edward Hall, Florida
Mr. Lynn Mier, California
Mrs. Tamar Myers, Pennsylvania
Mr. Richard Phillips, Fiji
Mr. David Tanswell, Australia
Dr. Natalie Uhl, New York

Properly qualified nominations from members must be sent to the Secretary LYNN MCKAMEY, P.O. Box 287, Gregory, Texas 78359 USA by December 15th, 1989.

Robert G. Egge, New Seed Bank Chairman

Robert G. Egge will be the new chairman of the IPS Seed Bank. Bob has a background in accounting and has served as treasurer of the local chapter for three years. As a volunteer seed collector for the Big Island and the Hawaian chain as well, he has been supplying the Seed Bank since 1980 and is exceptionally well qualified to serve as chairman.

The Seed Bank will be organized differently. Two regional divisions are being set up, one at Lyon Arboretum, Oahu and one in Florida by the South Florida Chapter of IPS in conjunction with Fairchild Tropical Garden. The divisions will gather, receive, and ship seed. The Director will take care of orders, payments, and bookkeeping. This is a preliminary announcement only. Members will receive a new Seed List when it is ready and more information as the organization proceeds. For the present all inquiries should be sent to: ROBERT G. EGGE, 65 Halaulani Place, Hilo, HI 96720.

Epiphyte Symposium

Marie Selby Botanical Gardens will hold an international symposium "The Biology and Conservation of Epiphytes" in Sarasota, FL on May 5–8, 1991. Invited and contributed papers. Contact DR. NALINI M. NADKARNI, The Marie Selby Botanical Gardens, 811 South Palm Avenue, Sarasota, FL 34236, USA.

Horticulturist Robert G. Wilson Dies

Robert G. Wilson died on the 8th of April 1989 at the age of 77. After several weeks of poor health and a short hospitalization, he returned to the Gardens near Coto Brus, Costa Rica for his last days. He was a valued friend to many of us and the fine collection of palms, established at Las Cruces by Bob and his late wife Catherine, has been enjoyed by many IPS members. See also letter p. 179.

Palms of Borneo Tour

A well established tour company (Borneo Adventure Co. Ltd.) that specializes in organizing holidays with a natural history bias is considering adding a 'Palm Tour Package' to its program. Participants would enjoy (in addition to Borneo's many other attractions) a holiday in one of the richest palm habitats in the world and see many of Borneo's most stunning palms.

If you would like more information regarding this and other tours in Borneo please contact MR. ROBERT BASIUK, Borneo Adventure, P.O. Box 2112, Kuching, Sarawak, East Malaysia. Tel. 082-245175. Fax 082-422626.

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Back Cover

The strange pistillate inflorescence of *Ammandra natalia* Balslev & Henderson, taken in Ecuador. See Front Cover for a tree with the very different staminate inflorescence of this dioecious genus. Photo by A. Henderson.