

Palms

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The International Palm Society

Founder: Dent Smith

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FRONT COVER

Trithrinax campestris in the wild in northwestern Argentina. Photo by M. Gibbons. See story, p. 74.

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CONTENTS

57 Germination of *Nypa fruticans* in Trinidad

PETER R. BACON

62 Observations and Pathogenicity Experiments on *Ganoderma zonatum* in Florida

M. L. ELLIOTT AND T. K. BROSCAT

74 *Trithrinax*: Trials and Tribulations

MARTIN GIBBONS

80 *Phoenix loureiri* var. *humilis*, a New Record for Bhutan

PHILLIP CRIBB, NICHOLAS PEARCE AND YESHEY DORJI

82 Maximizing Seed Production of *Linospadix monostachya*

JIM AND LISE WRIGHT

84 Hapaxanthic Axillary Shoots in Date Palm Plants Grown *in vivo* and *in vitro*

C. SUDHERSAN, M. ABO EL-NIL AND J. HUSSAIN

90 Variation on a Theme: Bonsai Palms

KATHERINE MAIDMAN

92 Why Lethal Yellowing has not Become Epidemic in the Dominican Republic

H. C. HARRIES, J. HERASME C. AND E. HICHEZ FRÍAS

97 Palmyrah Palms in Tamil Nadu, India

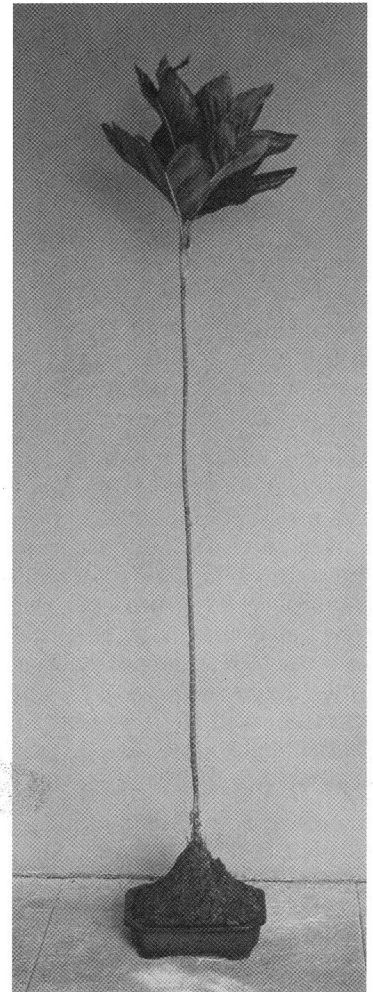
A. SANKARALINGAM AND H. HAMEED KHAN

BACK COVER

Healthy coconut palms in the Dominican Republic (Photo: J. Höppe). See related article by H. Harries, p. 92.

Features

News from the World of Palms	56
Classified	96
Palm Literature	73, 100
Horticulture Column	102



A bonsai *Chamaedorea metallica* from the collection of Ken Treister. See article by Katherine Maidman, p. 90. (Photo: K. Maidman)

NEWS FROM THE WORLD OF PALMS

Our member in New Caledonia, Jean Pierson, whom many of us met during the wonderful 2000 Biennial of the IPS, has sent us a sad story of the fruits of *Pritchardiopsis jeanneneyi*, endemic to New Caledonia and one of the world's rarest and most endangered palms. We have made a free translation of Jean's letter:

Pritchardiopsis jeanneneyi survives in the wild in New Caledonia as a single very old individual together with a few juveniles. It grows in a forest reserve situated in the south of the island, in an area rarely visited by people, although a nickel processing factory will shortly be constructed nearby. It is difficult to protect the palm, growing as it does so far from anywhere, and far from the relevant authorities, which do not have the resources to protect the palm. Because the palm is in such dire need of protection, the Association Chambeyronia, the local chapter of the IPS, several years ago obtained the necessary authorization to monitor this rare palm. Knowing that the infructescences of *Pritchardiopsis* are produced only once every two years and bear only about 30 fruits, we constructed cages around the infructescences to protect them from seed predators (rats). We did this on two separate years, and successfully collected about 50 seeds. The work was hard, as the adult palm has a trunk about 9 m tall and it grows on a steep slope. Moreover, we had to remove the cages numerous times to monitor the development and enlargement of the fruit, which, at maturity, have a diameter of about 5–6 cm. In this way we successfully collected about 50 seeds from two cycles of infructescence production.. The seeds that were collected were given to the administrative services of the forest reserve and to members of the Association. For my part, I successfully germinated the seeds I had been given each time in about seven or eight days, which is extraordinary when you consider the despairingly long time that is usually required to germinate seeds of most palms from New Caledonia. Despite these extraordinary powers of germination, most surprising in a species on the verge of extinction, a significant number of seedlings died within the first year. The seedlings seem to be very fragile during this period and need very special care and attention. The surviving plants that were under the care of the Association were distributed among a dozen or so members with suitable space and resources to look after them. One plant was offered to Kampon Tansacha of Nong Nooch Tropical Garden, Thailand, and another to Ray Baker at the Lyon Arboretum in Honolulu, Hawaii, USA. A few other plants are in private collections in Noumea. Three are in our family palm garden. We are very pleased to have been able to take part in the first step in saving this endemic genus from extinction.

About a year ago, the single infructescence of the third fruiting cycle suffered an unfortunate fate. The fruits had not yet reached maturity when they disappeared, the probable victims of vandals or ignorant and unscrupulous collectors. Several weeks after this event, which completely sickened us, someone outside the Association informed a journalist of the disappearance, telling him that there was trade in the seeds of *Pritchardiopsis* and that a single seed of the palm could be sold for \$10,000 to the major palm collectors of the world, giving the harvest a value of \$250,000! This news spread rapidly throughout New Caledonia. I may be mistaken but I am convinced that no seed was actually traded, all the more so as the seeds were not yet ripe, and that the disappearance of the seeds was an act of pure vandalism. Sadly, the journalist and his informant have been even more mischievous and stupid than the vandal who removed the seeds because they have now created dangerous publicity for this poor palm. *Pritchardiopsis* now risks becoming the prey of unscrupulous people attracted by the ridiculous value attributed to the seeds.

In order that the Association is not in anyway tainted by this sorry affair, we have informed the relevant authorities that we cannot continue to safeguard fruit production of without the means to protect the palm from vandals. There is nothing more that can be done at present. Despite our retreat, we are all affected by what has happened, and we know that *Pritchardiopsis* cannot in reality be protected. But we do not want to abandon it. I count on going soon to verify its state and the eventual presence of fruits.

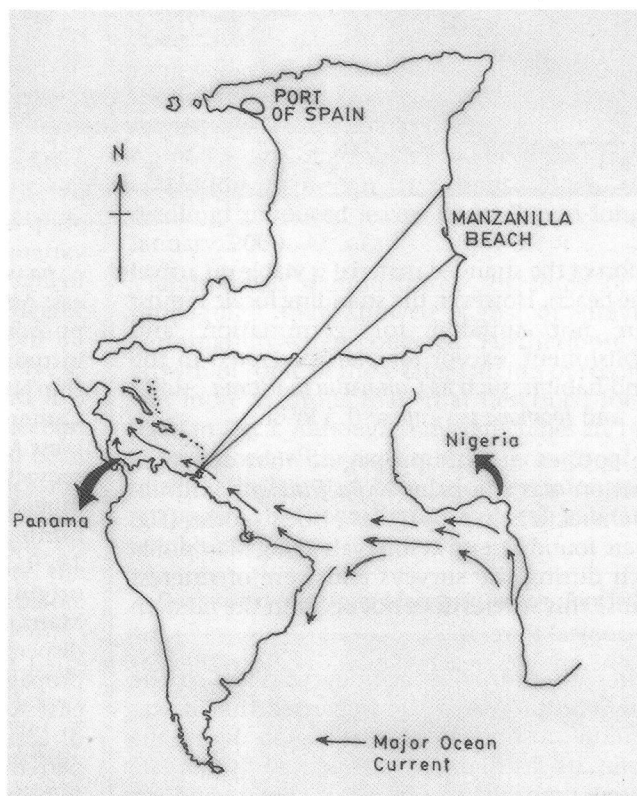
JEAN PIERSON

Germination of *Nypa* *fruticans* in Trinidad

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1. Map of Trinidad,
showing collecting
site.

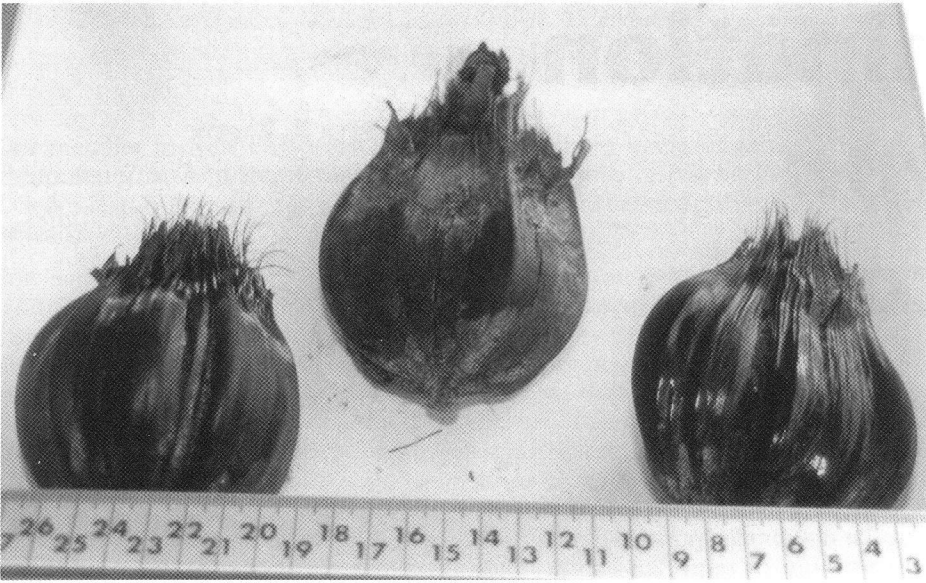


The first record of germination by beach-stranded propagules of the palm *Nypa* on a Caribbean shore is reported. Dispersal patterns indicate an origin from West Africa, and it is suggested that this might be evidence of the potential for recolonization of the western tropical Atlantic by this species.

Stranding by plant propagules on the windward east coast of the southern Caribbean island of Trinidad was reported many years ago by Guppy (1917). It was apparent from his collections that a high diversity of water-borne fruits and seeds is brought to the coast from the Atlantic Ocean annually, with centers of origin largely from rivers and coastal areas of northern South America but possibly also from the eastern Atlantic.

The degree of successful recruitment by these immigrant plant species has not been assessed. In any case, it would be disguised by the close similarity between the floras of the Guianas and Trinidad.

Observation by University of the West Indies student field classes on Manzanilla beach (Fig. 1) during 1998 and 1999 suggested that a significant



2. Beach-stranded propagules of *Nypa fruticans*.

portion of the stranded material is viable on arrival at the beach. However, the stranding locale is most often not suitable for germination and establishment, except for plants adapted to the strand habitat, such as *Canavalia maritima* (Aubl.) Urb. and *Ipomoea pes-caprae* (L.) R. Br.

One species of drift propagule that attracted attention was the palm *Nypa fruticans* Wurm. The characteristic propagules of this species (Fig. 2) were found cast up at intervals along Manzanilla beach during the surveys and were of interest because this species does not occur in the modern Neotropical flora.

Studies on the palaeoecology of *Nypa* in the western tropical Atlantic suggested that it was common on shorelines in this region during the Eocene. Its distribution was reduced by the late Tertiary, probably as a result of climate and sea level changes, and it was thought to have become extinct in the Neotropics well before the start of the Pleistocene (Dolaniiti 1955, Muller 1980).

Nypa is not mentioned in any of the numerous studies of modern tropical swamps along the coastal areas of northern South America (Gerlach 1958, Chapman 1977, Cintron & Schaeffer-Novelli 1983, Van Roosmalen 1989, Seeliger 1992, Lacerda 1993) and the insular Caribbean (Bacon 1990, 1993), while Myers (1990) clearly omitted it from his review of palm swamps in Central America. The only report is that of Duke (1991), who described a small stand of this species from the Atlantic coast of Panama, near the port of Colón. He considered it to have been introduced, probably in the 1960s.

Nypa was introduced into Nigeria from the South-east Asian region in the early 1900s for commercial purposes (Russell 1968, Zeven 1973). Since its introduction, it has become well established in the Niger Delta and in neighboring parts of Cameroon. It flowers and fruits abundantly in its West African naturalized habitat (Tuley 1995). The prevailing currents in the tropical Atlantic Ocean move from the West African coastal region towards northern South America and the Caribbean (IUCN 1979, The Times 1983). Thus, the most likely origin of the *Nypa* propagules stranded on Manzanilla was from a West African source, by dispersal across the Atlantic Ocean. The chance of propagules drifting to the Caribbean from South-east Asia is extremely low because of current directions in that region. Similarly, current patterns in the Caribbean Sea would be unlikely to bring propagules from the Panama population to Trinidad.

Germination of stranded *Nypa*

During a field visit to Manzanilla beach in September 1998, ten apparently viable *Nypa* propagules were collected from the strand line. Viability was assumed on vegetative appearance. The propagules selected all had a shoot protruding from the apex of the fibrous fruit and were firm to the touch. Despite their presence, all the roots were brown and shriveled, suggesting that the seeds had started to germinate while afloat but then died back.

The fruits were taken to the University in St. Augustine, where they were washed thoroughly in tap water and then soaked for two days by floating

in a bucket of freshwater. The fruits were then planted in a window box outside the Life Sciences Department. They were placed on the soil (soil not specially formulated) and pressed down gently rather than buried in order to mimic stranding conditions. The window box was located in a part of the building where it would be shaded throughout the day and the propagules were watered thoroughly once per day.

One plant put out a fresh green shoot in May 1999. Germination had started 7.5 months after collection from the beach. (Since the remains of a shoot were present when collected, it might be more correct to describe this development as re-growth). This first successfully germinated *N. fruticans*, collected from the Trinidad east coast and probably of African origin, is shown in Fig. 3.

Only one seed germinated from the batch of ten, despite the appearance of viability in the selected fruits. However, this simple experiment was quite revealing. It suggested either a long dormancy period or very slow growth. The very slow rate of germination may have been related to the degree of stress experienced prior to collection. Nonetheless, it appeared to have been effective as a strategy to aid long distance dispersal in this specimen. It should be remembered that collection from the beach occurred after the fruit had been floating for an unknown period while crossing the approximately 3000 km Atlantic Ocean and it was not known how long it had been lying on Manzanilla prior to collection. Furthermore, the primary shoot had sprouted and rotted back before the propagule was planted for the experiment.

The first shoot opened as a trifoliate leaf in June, after which second, third and fourth leaves emerged, but the plant had reached a height of only 11 cm by January, 2000. The successfully germinated palm was later transferred to a flower pot and placed in the author's home garden. Unfortunately it died following a heavy infection by white-fly (Aleyrodidae) in early February. The rapid growth rate reported by Zeven (1973) for this species in West Africa was not found in this Manzanilla specimen possibly because of the severe stress it had experienced.

Further studies on *Nypa* on Manzanilla

All *Nypa* propagules found in a series of 100 m transects parallel to the strand line on the Manzanilla beach were collected on 7 October 1999 and on 31 March 2000, in order to quantify the percentage viability in the stranded population. These were divided into the following three categories: (I) Non-viable = dried, empty or broken open, (ii) Apparently viable = solid, heavy,

apex closed, and (iii) Germinated = with roots or shoots present (even if brown and dried).

The distribution of propagules in these categories is shown in Table 1. The data indicate a similar large number of propagules per km of beach on both dates (estimated at 112 and 78). In the field it was estimated that some 20 to 25% of the stranded propagules were viable. However, additional planting experiments showed that only one third of the germinating propagules survived. These results suggested a true potential viability of only 6 to 8%.

Two groups of propagules identified as "Germinated" (i.e., with atrophied roots or shoots) were collected from Manzanilla and planted in the window box. From a collection made on 16 August 1999, three seedlings emerged with leaves up to 55 cm long by November, 1999. From a collection made on 10 August 1999, three seedlings produced leaves up to 24 cm long by January, 2000.

Viability was demonstrated for some of the propagules that showed signs of previous germination when collected. Furthermore, the growth of some of these later batches of seedlings was more vigorous than that described for the plant in Fig. 3. Although some difficulties are being experienced with maintaining growth of the seedlings in Trinidad, because of pest infestations, it appears that recruitment to local habitats is feasible.

3. Germinated *Nypa* from Manzanilla beach, Trinidad.



Table 1. Viability of stranded *Nypa* propagules on Manzanilla beach, estimated in the field.

100 m transect	Non viable	Apparently viable	Germinated
October, 1999			
1	9	1	0
2	7	2	0
3	12	4	2
4	5	4	1
5	8	2	0
Total 500 m	41	12	3
Est. 1 km	82	24	6
March, 2000			
1	13	1	1
2	6	1	0
3	3	1	1
4	5	0	0
5	5	2	0
Total 500 m	32	5	2
Est. 1 km	64	10	4

Manzanilla beach is approximately 20 km in extent. By extrapolation, this would give at least 1500 propagules on this section of the Trinidad coast. (This is a measure only of the standing crop at time of observation, as no study has been done on the daily rate of arrival of *Nypa* fruits or the seasonality of their stranding). Even if less than 10% of stranded propagules remain viable, as suggested above, this would give some 150 propagules on Manzanilla beach on any one day with a chance of survival, assuming that suitable habitat can be found.

Discussion

Noting the recorded date of first establishment in Nigeria, West Africa, as 1906 (Russell 1968, Zeven 1973) and allowing about 10 years for development of a regularly fruiting palm population, I calculate that *Nypa* propagules have been available for dispersal across the Atlantic for nearly 90 years. It is understandable that Guppy (1917) did not record *Nypa* in Caribbean beach

drift, as his collections were made too soon after the initial introduction of this palm to West Africa.

Why is it that *Nypa* has not become established on the Atlantic coast of Trinidad, perhaps in one of the many river mouths, given that its seeds may have been stranding for decades? The answer may perhaps be that a much longer time period may be required before this species becomes established in any part of the eastern Neotropics.

Duke's (1991) suggestion that *Nypa* was introduced to the Atlantic coast of Panama is of interest in this regard, since an alternative explanation is provided by the stranding evidence presented above. He thought the Colón stands seen in 1989 were about 30 years old, which means that *Nypa* had already been in Africa about 50 years before the Panama population became established. It is possible, therefore, that floating propagules released from the Nigerian stands after 1906 could have seeded the Panama coast by the 1960s. Certainly, the location within an estuarine area of the Río

Majugual would have provided a more suitable habitat for colonization by ocean borne *Nypa* propagules than the strand line of Manzanilla beach in Trinidad.

It would be of interest from the perspective of biogeography to follow the routes and rates of dispersal of *Nypa* propagules from both the Nigerian and Panamanian populations. This would give a better indication of the likelihood of this palm species recolonizing a region from which it has been absent for a few million years.

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Observations and Pathogenicity Experiments on *Ganoderma zonatum* in Florida

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Ganoderma butt rot of palms, caused by *Ganoderma zonatum*, is a widespread and serious disease in Florida, USA. The means by which the fungus invades healthy palm trunks is not known. However, infection appears to begin at the center of the base of palm trunks and spreads outward and upwards from there, eventually producing a hard, shelf-like structure that is the basidiocarp (conk). Basidiospores produced within the conk may be the primary method for spreading the fungus in the urban landscape. Wilt symptoms are caused by the fungus rotting the xylem, as well as other trunk tissue, in the lowest 1.5 m of trunk. It is believed that most, if not all, woody palms are susceptible to this disease. Experimental attempts to inoculate healthy trees with this fungus have generally been unsuccessful.

Palms are found throughout Florida (USA) in both natural and landscaped settings. They are not grown for agronomic purposes, but are important as ornamental plants. When a list of the top ten diseases of Florida ornamentals was compiled in 1997, *Ganoderma* butt rot of palms was listed as number two (Schubert et al. 1997). The fungal genus *Ganoderma* is a group of wood-decaying

basidiomycete fungi that are found throughout the world on all types of wood – gymnosperms, hard- and softwood dicots, and palms (Gilbertson & Ryvarden 1986). The genus is greatly debated at the species level; Miller et al. (1999) described it as “currently chaotic.” This has been due to species names being added and then dropped, an inconsistency in criteria used for identification



1 (above). *Sabal palmetto* (sabal palm) with wilted and desiccated leaves due to *Ganoderma zonatum* infection.



2 (right). *Syagrus romanzoffiana* (queen palm) dying from *Ganoderma zonatum*. Only the spear and one other leaf remain green.



3. Basidiocarp (conk) of *Ganoderma zonatum*. Note glazed reddish-brown top surface and white undersurface. The "straight" side of the conk is directly attached to the trunk. There is no "stem" or "stalk" that attaches the conk to the trunk.

purposes at the species level, and the fact that morphological characteristics change based on environment (Moncalvo et al. 1995).

In Florida, *Ganoderma* butt rot is a lethal disease that appears to be caused by the fungus *Ganoderma zonatum* Murrill. Another fungal name that was associated with this disease in the first half of the 20th century was *Ganoderma sulcatum* Murrill (Murrill 1902, 1908; Childs & West 1953). Murrill indicated in his papers that both species were associated with dead wood in Florida, and that they were very similar in appearance. Recently, these two species have been grouped together as one, *G. zonatum* (Gilbertson & Ryvarden 1986). Although *G. zonatum* is often referred to as a member of the *G. lucidum* complex, it is a distinct species from *G. lucidum* (Adaskaveg & Gilbertson 1989). Information is available regarding the morphological and cultural characteristics of *G. zonatum* (e.g., Adaskaveg and Gilbertson 1989; Adaskaveg and Gilbertson 1988; Gilbertson & Ryvarden 1986), but little is known about the disease it causes. A similar basal stem rot of oil palms is widespread, but is caused by a different *Ganoderma* species, presumed to be *G. boninense* (Miller et al. 1999). This pathogen does not occur in North America. Considerable information is available on this disease in Southeast Asia, so we have relied heavily on this information as a basis for initiating research in Florida. This article is a compilation of our personal observations and pathogenicity research results obtained since 1994.

I. OBSERVATIONS

Symptoms and Signs

Ganoderma zonatum is a white rot fungus that produces numerous enzymes that allow it to degrade (rot) woody tissue, primarily lignin and cellulose (Adaskaveg et al. 1991). As the fungus destroys the palm wood internally, the xylem (water-conducting tissue) will eventually be affected. Therefore, the primary symptom that may be observed is a wilting, mild to severe, of all leaves but the spear leaf (Figs. 1 and 2). Other symptoms can best be described as a general decline – slower growth and off-color foliage. However, these symptoms alone should not be used for diagnosis of *Ganoderma* butt rot, since other disorders or diseases may also cause these symptoms. Only when these symptoms are accompanied by the development of the basidiocarp (conk) (Fig. 3) can the palm be confirmed as affected by *G. zonatum*. Also, it is commonly observed that basidiocarps will form prior to any obvious wilting or decline symptoms.

It should be emphasized that this fungus is not restricted to vascular tissue. The palm wilts because

the vascular tissue as well as the surrounding tissue has been degraded by the fungus. This becomes evident when a palm that has died or is dying from *Ganoderma* butt rot is cut down and cross-sections made of the trunk. Figs 4 and 5 are examples of the wood rotting and disease progression pattern observed. The fungus colonizes and degrades the palm trunk tissue closest to the soil line first, expands in diameter at the base and moves up the center or near-center of the trunk. Therefore, the disease progression pattern within the trunk is best described as cone-shaped, widest at the soil line and narrowing to a pinpoint. In general, we do not see the fungus extend more than 1.5 m (~5 ft) up into the palm trunk. Although roots may eventually rot, especially after the palm dies, the lethal damage from the fungus appears to be associated with the trunk degradation. *Ganoderma* butt rot is a disease of mature palms (i.e., palms with trunks) and has not been observed to affect seedling or juvenile palms in natural or landscape settings.

It was previously thought that the location of the initial basidiocarp formation was the entry point for the fungus, perhaps from a wound to the trunk. We do not believe that is true. The location of the basidiocarp is where the fungus is emerging from the trunk. This means the degradation is occurring internally as the fungus moves from the lower center of the palm to the outside. This is especially evident when a palm suspected of being infected with *G. zonatum*, based on wilt symptoms and proximity to other diseased palms, but without basidiocarps is examined. This means that wounds are not a likely factor in disease initiation. Other external environmental factors associated with the trunk are probably not associated with disease development either, such as too much mulch around the trunk, irrigation heads striking the trunk, flowers or shrubs too close to the trunk, or painting the trunk.

Life Cycle of the Fungus

The basidiocarp or conk is the most easily identifiable structure associated with the fungus. The conk is a specialized mass of fungal growth that originates from mycelia in the palm trunk. Fig. 6 illustrates different stages in the development of the basidiocarp. When the fungus first starts to grow on the side of a palm trunk or palm stump, it is a solid white mass that is relatively soft when touched. It will have an irregular to circular shape and is relatively flat on the trunk or stump.

As the conk matures, a small shelf or bracket will start to form as the basidiocarp begins to protrude from the trunk. It will still be white, both on the

Table 1. Palms documented to have been infected with *Ganoderma zonatum*.

Palm	Source ^z		
		<i>Nannorrhops ritchiana</i>	FTG
		<i>Phoenix canariensis</i>	DPI, FTG
		<i>Phoenix dactylifera</i>	FLREC
		<i>Phoenix reclinata</i>	DPI, FTG
		<i>Phoenix roebelenii</i>	FTG
		<i>Phoenix sylvestris</i>	FLREC
		<i>Ptychosperma elegans</i>	TREC
		<i>Ptychosperma macarthurii</i>	DPI, FTG
		<i>Ptychosperma salomonense</i>	FTG
		<i>Roystonea altissima</i>	FTG
		<i>Roystonea oleracea</i>	FTG
		<i>Roystonea regia</i>	DPI, FTG
		<i>Sabal causiarum</i>	FTG, TREC
		<i>Sabal mauritiiiformis</i>	FTG
		<i>Sabal palmetto</i>	DPI, FLREC, FTG
		<i>Sabal uresana</i>	FTG
		<i>Satakentia liukuensis</i>	FLREC
		<i>Serenoa repens</i>	FTG
		<i>Syagrus oleracea</i>	FTG
		<i>Syagrus picrophylla</i>	FTG
		<i>Syagrus romanzoffiana</i>	DPI, FLREC, FTG
		<i>Syagrus sancona</i>	FTG
		<i>Syagrus schizophylla</i>	FTG
		<i>Syagrus × costae</i>	FTG
		<i>Washingtonia robusta</i>	DPI, FTG
<i>Acoelorrhaphe wrightii</i>	FTG		
<i>Acrocomia aculeata</i>	FTG		
<i>Adonidia merrillii</i>	FTG		
<i>Aiphanes</i> sp.	DPI		
<i>Arenga engleri</i>	FTG		
<i>Arenga tremula</i>	FTG		
<i>Arenga undulatifolia</i>	FTG		
<i>Attalea</i> sp.	FTG		
<i>Bactris major</i>	FTG		
<i>Brahea berlandieri</i>	FTG		
<i>Brahea brandegeei</i>	FTG		
<i>Brahea dulcis</i>	FTG		
<i>Brahea edulis × brandegeei</i>	FTG		
<i>Butia eriospatha</i>	FTG		
<i>Butia capitata</i>	DPI		
<i>Carpentaria acuminata</i>	FLREC		
<i>Caryota mitis</i>	DPI		
<i>Chamaerops humilis</i>	FTG		
<i>Coccothrinax</i> sp.	FTG		
<i>Cocos nucifera</i>	DPI		
<i>Copernicia curtisii</i>	FTG		
<i>Dictyosperma album</i>	DPI		
<i>Dypsis cabadae</i>	FTG		
<i>Dypsis lutescens</i>	DPI, FTG		
<i>Elaeis guineensis</i>	TREC		
<i>Euterpe edulis</i>	DPI		
<i>Gastrococos crispa</i>	FTG		
<i>Hyophorbe indica</i>	TREC		
<i>Livistona benthamii</i>	FTG		
<i>Livistona chinensis</i>	DPI, FTG		
<i>Livistona merrillii</i>	FTG		
<i>Livistona muelleri</i>	FTG		
<i>Livistona saribus</i>	Forestry		

^zDPI = Diseases and Disorders of Plants in Florida (Alfieri et al., 1994); FTG = Fairchild Tropical Garden, Miami, FL; TREC = University of Florida's Tropical Research and Education Center, Homestead, FL; FLREC = University of Florida's Fort Lauderdale Research and Education Center, Fort Lauderdale, FL; Forestry = Florida's Department of Forestry, Miami, FL.

top and bottom surfaces. Eventually, it will form a very distinct shelf-like structure that is quite hard with a glazed reddish-brown top surface and a white undersurface (Fig. 3). A mature conk will have distinct zones, hence the name *G. zonatum*. The basidiocarp will have a half-moon shape with the "straight" side directly attached to the trunk. This is referred to as a sessile basidiocarp as opposed to one that has a stalk or stipe (Figs 3 and 6). Conks can be up to 20 cm (8 in) at their widest point and 5 cm (2 in) thick. Microscopic basidiospores will be produced in the "pores" present on the underside of the conk. When basidiospores are dropped en masse on a white surface, they will appear brownish-red in color.

The conk is considered an annual conk. Once it stops growing, it does not begin growing and

expanding in size at a later date. In southern, subtropical Florida, conks can be produced throughout the year. In northern, temperate Florida, conks are normally only produced during the warmer months of May through October. We have observed that mature, viable basidiospores are produced very early in the formation of the basidiocarp. Spores were produced shortly after the conk began to protrude (form a shelf) from the trunk, while it was still white, and long before the top turned a reddish-brown color. We believe that the spores are the primary means of spread of the fungus, but that has yet to be proven. Recent research with *Ganoderma* in Malaysia determined that *G. boninense* may spread in oil palm plantings through basidiospore dispersal or through contact with long-term residual inoculum (mycelia, etc.) in soil debris (Miller et al. 1999). The genetic



Fig. 4 (top). Cross-sections of lower trunk of *Syagrus romanzoffiana* infested with *Ganoderma zonatum*. Top-left section is bottom section (section 1) and remaining sections progress up the trunk. Note darkening of wood due to fungal degradation (rot). Fig. 5 (bottom). Sections 5 and 6 of Fig. 4 (bottom row, middle) after incubation in a moist chamber for 4 days. White growth is mycelia of *Ganoderma zonatum* and corresponds with the discolored area of the cross-sections.



Fig. 6 (top). Three phases of basidiocarp (conk) development of *Ganoderma zonatum*. The white "button" near the top of picture is the beginning stage of the conk. The lower-right structure is a mature conk. The lower-left structure is also a mature conk, but it is an old one; the underside of the conk is no longer white. Fig. 7 (bottom). Cut palm stump with numerous basidiocarps of *Ganoderma zonatum* forming on it.

information obtained by this research group suggests that the fungus does not spread by direct root-to-root contact between palms.

The diversity and isolation of locations in Florida where *Ganoderma* butt rot has occurred would support the concept of spores as a primary method of spread. Palms are not a plantation crop in Florida, but are found in two distinct settings. One would include natural groves of non-transplanted sabal palms (*Sabal palmetto*). The other is the urban landscape, where the majority of palms are transplanted from either natural settings in Florida, date groves from south-western USA, or plant nurseries. In urbanized southern Florida, the "soil" upon which developments are built, and in which palms are transplanted, is dredged from man-made lakes. It is devoid of any possible plant debris harboring *G. zonatum*. However, only genetic studies will definitively demonstrate how *G. zonatum* spreads.

After spores are released, it is unclear exactly what happens next. We do not know if the spores become dormant in nature. In a laboratory setting, the spores do not show any dormancy and germinate readily on media after being dropped from the basidiocarp. However, in the real world, they may indeed become dormant or need specific substrates, temperature, relative humidity and so forth for germination to occur. We do know that at some point in time multiple spores do germinate, mate and produce mycelia that will go through three distinct stages of development – primary, secondary and tertiary. The basidiocarp or conk is composed of the tertiary mycelia.

Host and Geographic Range

In the *Diseases and Disorders of Plants in Florida* (Alfieri et al. 1994), five non-palm species are listed under *G. zonatum*. It is quite possible that *G. zonatum* was not a pathogen of these non-palm species, but rather a saprobe that grew on the wood after the tree had died. According to Adaskaveg et al. (1991), the only authenticated reports of *G. zonatum* are from palms. However, there has been one report in Florida of *G. zonatum* associated with a cycad. Still, palms should be considered the primary hosts of this fungus. Table 1 lists all of the palms known to have died from *Ganoderma* butt rot in Florida. This list was compiled with information obtained from numerous sources in Florida, as indicated in the table. Although not all palm species known to be growing in Florida have succumbed to this disease, the majority of those species not on this list are relatively uncommon in Florida. Therefore, just because a palm is not listed in this table, it is not safe to assume that the palm is resistant to the

disease. In fact, it is probably more logical to assume that all palms are susceptible to *G. zonatum*. The only possible exceptions would be palm species that do not form woody trunks – e.g., *Sabal minor*, some *Chamaedorea* spp. Since *G. zonatum* kills by degrading wood, these palm species may not have any suitable tissue to serve as a substrate for the fungus.

The distribution of *G. zonatum* in Florida is shown in Fig. 8. This information was obtained from many of the same sources as listed for the palm host range and by contacting University of Florida Cooperative Extension Service faculty in each county. While the disease is more prevalent in the southern half of the state where palms are in greatest abundance, it is certainly not restricted to that area.

Environments or Practices that Encourage Disease Development

To date, we have observed no common environmental conditions or landscape management practices that favor the development of *Ganoderma* butt rot. The disease has been observed in natural settings (palms never transplanted) and in highly-maintained, transplanted landscapes. It has been observed on palms that have been maintained very well nutritionally (no nutrient deficiencies) and on palms that were severely stressed by deficiencies. The disease has been observed in well-drained settings and in swamps. The fungus has killed trees that had no apparent mechanical injuries and those that had been severely damaged by weed trimmers. Soil type appears to have no relationship with disease either as diseased palms have been observed on deep sands (both silica and calcareous), muck (peat), and limestone rock. There has been no simple discernible pattern to provide clues as to why palms become infected and die from *G. zonatum*.

Management Considerations

In general, the fungus will be located in the lower 1.5 m of trunk. This has two implications. First, this means that only this lower trunk portion should not be chipped and used for mulch. If possible, the diseased section should be placed in a legal landfill or incinerated. The remaining portion of the palm trunk could be immediately chipped and used for mulch in the landscape.

Secondly, only the lower 1.5 m of trunk will need to be protected from the fungus. However, typical xylem-limited, systemic fungicides will not be effective unless they are capable of spreading beyond the vascular tissue and protecting all the wood in the lower portion of the trunk. No

fungicide will be effective once the basidiocarps have formed, since a large percentage of the trunk is already destroyed. Since we have no means of predicting or determining which palms are infected with *G. zonatum*, this effectively eliminates the use of fungicides as a control method, either preventively or curatively, for the present time.

Since basidiospores are probably the primary method of spreading the fungus, we urge people to monitor their palms closely, especially after a palm has died or been removed for any reason. The fungus will readily colonize and degrade palm stumps or dead palm trunks (Fig. 7). Once it becomes established on this dead wood, it will normally produce basidiocarps with millions of basidiospores. We had never observed *G. zonatum* as a pathogen on the Fort Lauderdale Research and Education Center (FLREC) property until March 1993 when it first killed a *Sabal palmetto*. Interestingly, this palm was only ~ 30 cm away from a sabal palm stump, left when a healthy palm had been cut down 5 years earlier for research purposes. However, we had observed *G. zonatum* basidiocarps on this stump as early as August 1991. More recently at the FLREC, we observed *G. zonatum* basidiocarps on dead *Carpentaria acuminata* trunks. These palms had died from other causes. We also noticed that there was a *Carpentaria* palm in this same planting, ~ 1 m away, that appeared wilted. When it was cut down, the center of the basal trunk area was already rotted from *G. zonatum*. We have also observed and been told on numerous occasions of *Ganoderma* butt rot occurring on *Dypsis lutescens* (areca palm) after some of the mature canes had been removed. In all probability, the fungus moves in on the dead stumps of these palms and spreads from there to living canes.

Therefore, monitor your palms in Florida, and other areas of the south-eastern USA where the fungus has been documented, for the basidiocarps. Remove the basidiocarp (conk) and place in a trash receptacle that will be incinerated or delivered to a landfill. Do not place in trash that will be recycled in the landscape. The earlier the basidiocarp is removed (i.e., before it becomes a distinct shelf-like structure), the less likely that spores will be released into the environment. If you have never observed *Ganoderma* butt rot on the property, monitoring the palms once every six months will be adequate. Once you have observed the basidiocarps on palms or have a palm cut or fall down for any reason, monitor the palms at least once a month.

It has been observed repeatedly that a replacement palm planted into the same site where a palm died

from *Ganoderma* butt rot also eventually succumbs to this disease. This would indicate that the fungus does survive in the soil, either as infected plant material or spores. Therefore, it is never recommended to plant another palm in the same location as the previous *Ganoderma*-infested palm. In general, no other plant tree species grown in Florida (pines, oaks, woody shrubs, etc.) are affected by *G. zonatum*. Therefore, these would be acceptable replacements. We have no definitive information on the length of time for *G. zonatum* survival in the soil, but it should be measured in multiple years, not months. It may be as long as 10 to 30 years. It is certainly not less.

If an infested site must be replanted with a palm, follow these guidelines. Remove the stump and all roots from the site, and then fumigate the soil. This can be done by a professional pesticide applicator using a legally registered fumigant for the landscape. An example would be the product dazomet (trade name = Basamid). If the palm was located in a site surrounded by concrete (e.g., a street median), remove all of the old soil, bring in new soil and then fumigate. However, none of these procedures guarantees the new palms will remain free of *Ganoderma zonatum*.

II. RESEARCH

Introduction

Although it may appear obvious that *G. zonatum* is a pathogen of palms in Florida, a fungal pathologist would like to have this confirmed. The term used for the process that confirms pathogenicity is "Koch's Postulates." This requires isolating the fungus from a host with typical symptoms, obtaining a pure culture of the fungus, using this culture to inoculate a healthy host, and then observing the development of typical symptoms and re-isolating the same fungus. While this may be a simple task when dealing with small annual plants, it is not simple when dealing with mature palms. Furthermore, we would like to have a system that would consistently provide us with a method for artificially inducing the disease in healthy palms in order to conduct experiments relative to control tactics, fungal life cycle and disease cycle.

Researchers working with the *Ganoderma* disease on oil palms in Southeast Asia have examined pathogenicity of *G. boninense* using *Elaeis guineensis* (African oil palm) seedlings. Both natural inoculum (Navaratnam & Leong 1965) and artificial inoculum (Hashim et al. 1993; Sariah et al. 1994) were used and were successful in inducing disease. However, as Hashim et al. (1993) point out, reproducing these experiments has not always been possible.

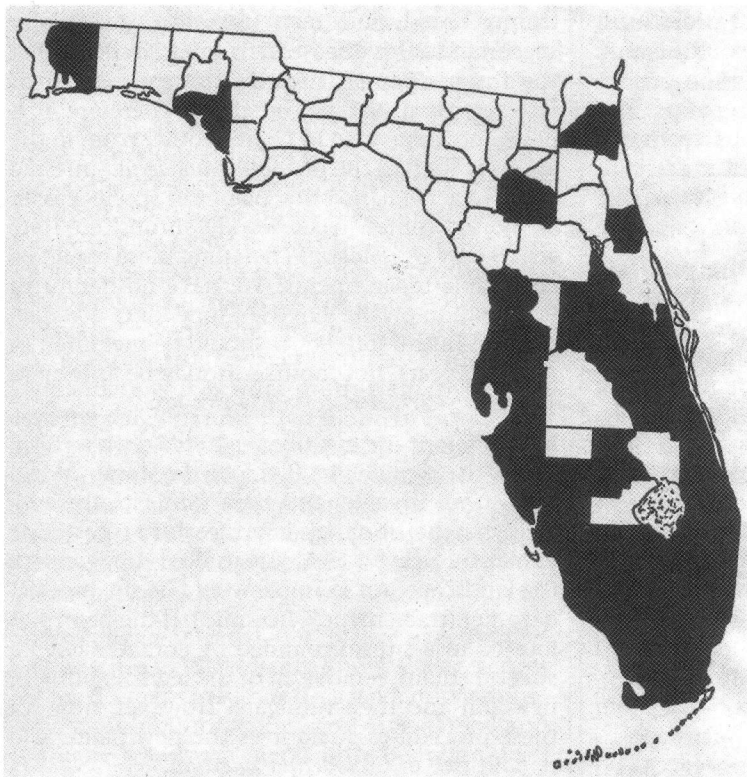


Fig. 8. This map illustrates those Florida counties where *Ganoderma* butt rot, caused by *Ganoderma zonatum*, has been reported on palms. Information was obtained from the Florida Department of Plant Industry, University of Florida's Plant Disease Clinics and County Extension Faculty.

Materials and Methods

Field experiments with natural inoculum and mature palms

A *Syagrus romanzoffiana* (queen palm) with *Ganoderma* butt rot was obtained in Palm Beach County, Florida, USA. This palm had basidiocarps present on the lower trunk that were confirmed as *G. zonatum*. The lower portion of the trunk was rotted. This section (~ 0.5 m) was cut into 10–15 cm cross-sections with a chainsaw, and then broken into different size pieces (chunks, splinters, etc.) by hand. These pieces were mixed with the sawdust in a large garbage can and the lid replaced. This inoculum remained at air temperature in a shade-house for 14 days. A pure culture of the pathogen was obtained from the basidiocarp and the wood.

A block of 28 *Syagrus romanzoffiana*, 20–25 years old, were used for the experiment. Half of the palms were transplanted on 28 September 1994, on 6 m centers, to a site adjacent to the original block. Half (7) of each palm group, transplanted vs. non-transplanted, was inoculated with the infested palm trunk material on 10 October 1994. The inoculum was divided into 14 equal portions (~ 2 L volume per tree). For each inoculated transplanted palm, 3 equidistant holes were dug 15 cm from the trunk base and about 8–10 cm

deep (until roots were contacted). The inoculum was divided among the holes and recovered with soil. For inoculated non-transplanted palms, the inoculation procedure was similar except that we avoided contacting or damaging any roots. The non-inoculated palms were not disturbed. Transplanted palms were maintained using standard procedures. Once they were established, no extra care (fertilizer or water) was provided these palms or the non-transplanted palms.

Shade-house experiments with natural and artificial inoculum and seedling palms

Two experiments were initiated to determine the best method for inducing disease by *G. zonatum* on seedling palms. The use of artificial and natural inoculum was examined as well as size, amount and location of inoculum. These experiments were initiated in June 1995.

For Experiment I, three palm species in the seedling phase, *S. romanzoffiana* (queen palm), *Phoenix roebelenii* (pygmy date palm), and *Elaeis guineensis* (African oil palm), were inoculated with either artificial or natural inoculum. Artificial inoculum was made following the method of Sariah et al. (1994). Two isolates of *G. zonatum* were used, one from *P. reclinata* (GAN-9) and the other from *S. romanzoffiana* (GAN-10). *Bischofia javanica* wood was obtained and cut into 5 × 7.5

cm pieces, with the bark removed. These pieces were sterilized for 90 min. Individual pieces were then placed separately in heat-sealable pouches and sterilized again for 90 min. Three days later, 25 ml of sterile, cooled, but not yet solidified, malt extract agar (1.5% malt extract plus 2% Bacto agar) was added to each pouch. Pouches were rotated to evenly coat the wood pieces as the agar solidified. The next day half the pouches were inoculated with GAN-9 and the other half with GAN-10. The *G. zonatum* isolates had been grown on potato dextrose agar in petri plates for 15 days. Fungal growth in each plate was cut into 5 × 5 mm pieces, and one-quarter of the pieces were added to each pouch. Pouches were incubated at 28–32 °C for 4 weeks. Natural inoculum was obtained from a *G. zonatum*-infested *Sabal palmetto* trunk. The wood was cut into 12.5 × 25 × 50 mm pieces.

The *E. guineensis* and *S. romanzoffiana* seedlings were transplanted from 1 L containers into 10 L plastic containers, while the *P. roebelenii* palms were transplanted into 6 L plastic containers. The potting substrate was 50% pine bark, 40% sedge peat and 10% sand. Roots were separated and as much potting mix as possible was removed prior to transplanting into containers with inoculum. All three palm species had the following treatments: 1) artificial inoculum infested with GAN-9, placed below the root ball; 2) artificial inoculum infested with GAN-10, placed below the root ball; 3) natural inoculum placed below the root ball; 4) natural inoculum placed on top of the root ball; 5) uninfested *Bischofia* wood placed on top of root ball; 6) uninfested palm pieces placed on top of the root ball; and 7) no wood pieces. Only one piece of artificial inoculum was placed in the container. Twenty pieces of natural inoculum were placed in each container to obtain a total inoculum volume of 15.5 cm³. There were 10 replicate containers for each inoculum × palm species treatment.

Palms were examined at 6-month intervals for visible symptoms or signs of the disease. After 19 months, roots and crowns of *P. roebelenii* and *S. romanzoffiana* from each treatment were examined, two replicates per treatment. After visual examination, roots were cut from the crown, washed, surface sterilized, blotted dry and placed on a semi-selective medium for *G. zonatum*.

For Experiment II, five different size pieces of natural inoculum were produced from a *G. zonatum*-infested *Sabal palmetto* trunk: a) 50 × 50 × 50 mm; b) 25 × 25 × 50 mm; c) 12.5 × 25 × 50 mm; d) 12.5 × 25 × 25-mm; and e) 6.25 × 25 × 25 mm. Only *P. roebelenii* palms were used with the same potting substrate as described previously.

There were 13 treatments. Each size of inoculum was used as either a single piece per container or as multiple pieces per container to obtain an inoculum volume of 125 cm³. The remaining 3 treatments were controls with either no inoculum, 1 piece of uninfested palm wood (50 × 50 × 50 mm), or 8 pieces of uninfested palm wood (12.5 × 25 × 25 mm for a 125 cm³ volume). There were 10 replicate containers for each inoculum volume × size treatment.

Palms were examined at 6-month intervals for visible symptoms or signs of disease. After 24 months, inoculum pieces that were still present were removed, scrubbed clean, surface sterilized, blotted dry and placed on a semi-selective medium for *G. zonatum*.

Shade-house experiment with natural and artificial inoculum and mature or juvenile palms

For Experiment III, nine palm species were transplanted into 38 L plastic containers using the same potting substrate as described previously. Holes, 0.5 cm diam. × 5 cm deep, were drilled into the palm trunk or stem at the soil line (root-trunk interface) or 15 cm above the soil surface. The five *G. zonatum* inoculum treatments were: 1) no inoculum; 2) 1 cm³ of infested palm wood from *Sabal causiarum*; 3) 1 cm³ of oat kernel inoculum, made by growing *G. zonatum* on sterilized oat kernels for 4 weeks; 4) 1 cm³ of basidiospores; and 5) 1 cm³ of basidiocarp tissue. The palm species were *Phoenix roebelenii*, *Roystonea regia*, *Dypsis lutescens*, *Archontophoenix alexandrae*, *Veitchia arecina*, *Ptychosperma elegans*, *Thrinax radiata*, *Syagrus amara*, and *Ravenea rivularis*. The *P. roebelenii* palms were mature (9-yr old) and had developed at least 90 cm of clear trunk. The *A. alexandrae*, *V. arecina*, and *P. elegans* had begun to form a woody trunk, but all other species were without trunk tissue at the time of inoculation. There were six replicates of each palm species × hole location × inoculum type treatment. Palms were examined at 6 month intervals for visible symptoms or signs of disease.

Results

Field experiments with natural inoculum

After 24 months, we observed that two of the seven inoculated, transplanted *Syagrus romanzoffiana* had basidiocarps present on their trunks. Until this point, all of the palms had a similar appearance. Basidiocarps were removed and confirmed as *G. zonatum*. Pure cultures of the pathogen were obtained. These palms were removed with as many roots as possible and

replaced with *S. romanzoffiana* juveniles. To date, no other palms in this experiment have died or produced basidiocarps of *G. zonatum*.

Shade-house experiments

No palm was killed by *G. zonatum* or ever exhibited symptoms of the disease in any of the three experiments. The fungus was not detected in the roots examined in Experiment I, nor was it detected in the inoculum examined in Experiment II. We observed that the center of the *Bischofia* wood pieces used in Experiment I were completely degraded leaving a hollow core.

Discussion

The only time *Ganoderma* butt rot was induced was when natural inoculum was used on mature palms. Even then, only 2 of 14 inoculated palms exhibited symptoms and signs (basidiocarps) of the fungus. However, inoculation of field-grown palms is not a good system for completing Koch's postulates. First, working with palms with tall trunks is difficult and expensive. Second, there is no way of definitely determining if these palms were already infected with *G. zonatum*. Our attempts to use seedling palms (i.e., palms without woody trunk tissue) for pathogenicity assays were not successful, whether we used artificial or natural inoculum. We also saw no evidence of root rot or root infection as has been observed with oil palm seedlings inoculated with *G. boninense* (Navaratnam & Leong 1965; Hashim et al. 1993; Sariah et al. 1994). Even the experiments that inoculated mature *Phoenix roebelenii* and various species of juvenile palms with different forms of inoculum placed directly into the trunks were unsuccessful in inducing the disease. However, the observed infection of clumping palms (e.g., *Dypsis lutescens*) that have mature canes removed, the infection of two of the seven transplanted *Syagrus romanzoffiana*, and the pattern of disease development within the trunk suggests that *G. zonatum* probably enters palm trunks via dead palm tissue (dead roots or palm stumps) as a saprophyte and spreads from there into adjacent living woody trunk tissue. Additional experiments are planned to test this hypothesis.

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PALM LITERATURE

ORNAMENTAL PALM HORTICULTURE. By Timothy K. Broschat and Alan W. Meerow. University Press of Florida, Gainesville, Florida. 2000. ISBN 0-8130-1804-8. US \$39.95, hard bound. pp. 255. Available from IPS Bookstore.

Many of the currently available, popular books on palms contain a chapter or a section dealing with growing palms; this new book fills a longstanding need for a work devoted solely to palm horticulture. The authors names are familiar to palm growers and enthusiasts. Since 1979 Timothy K. Broschat and his associates have conducted research on all aspects of palm horticulture at the University of Florida Fort Lauderdale Research and Education Center, while Alan W. Meerow is well known to palm enthusiasts as the author of *Betrock's Guide to Landscape Palms*. Meerow was formerly one of Broschat's colleagues at the Fort Lauderdale Center and now works as a research geneticist for the US Department of Agriculture.

This book is not a recounting of the time honored practices of generations of palm growers; instead it is based on research, most of which was done by the authors and their colleagues at the Fort Lauderdale Center but the work of others is frequently cited as well. Many of these research articles first appeared in *Principes* and *PALMS*, a fact which will make some portions of the book seem familiar to International Palm Society members.

Nurserymen, landscapers, arborists and serious palm collectors will find this book a valuable reference, and will want to use the table of contents and the index to find solutions to specific problems that they may encounter, but I would recommend reading it through first. The first chapter, entitled: "Palm Biology in Relation to Horticulture" familiarizes the reader with palm anatomy and reproductive characteristics and taxonomic classification as well as palm evolution, ecology and conservation. In appropriate places in the discussion of palm biology attention is called to points of importance for horticulturists; for instance, we learn that some palms (*Bismarckia* and *Sabal* are given as examples) do not develop a visible trunk or as extensive a root system as quickly as others and are therefore more difficult to transplant until they are more mature.

The second chapter deals with palm propagation and is thorough to the extent that it includes discussions of seed sources, the effects of seed maturity on germination success, seed cleaning,

viability testing, seed storage and much more. I was surprised, however, that the "Plastic Bag Method" of germination, which is frequently used by many growers and hobbyists, was not mentioned in this chapter.

This book will probably not be found on the coffee table with those palm books that contain many pages of beautiful photographs of palms in their natural habitat; the place for this book will be close at hand in the nursery, backyard garden or even a landscaper or interiorscaper's truck; it is a tool. Black and white photographs along with graphs and tables appear throughout the book. There is a separate fifty-six page section of high quality color photographs at the back of the text; most of these illustrate palm problems, and when used with the three chapters dealing with palm nutrition and pests and diseases, they constitute an effective troubleshooting guide.

There is a chapter covering nursery production in containers and another for field or in-ground production, which even gives suggestions for a nursery layout. The information in the chapter on transplanting is very important for anyone who moves palms for a living or who may wish to rearrange his or her in-ground collection. The landscape use of palms and their maintenance is discussed in Chapter 10. The final chapter entitled "Interiorscape Use and Maintenance of Palms" was one I found particularly interesting. As I have little experience with this field of horticulture, I quickly learned the reason for the poor performance of the palms that I have tried as houseplants: they were not properly acclimatized. Especially useful are lists of species that can survive for extended periods at various light levels.

It is difficult to say anything negative about this book; the few errors in nomenclature that I spotted are not important enough to mention. The first impression I had upon receiving my copy was that it was expensive considering its modest size, but the usefulness of its content fully justifies the cost. Some may find that the language of the book is too technical – the chapter on mineral nutrition may be the most difficult – but it should be kept in mind that it is based on research and that the reward of healthier palms and maybe even reduced costs are worth the modest effort needed to understand and use the information presented.

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Trithrinax: Trials and Tribulations

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1. A particularly good silver-blue form of *Trithrinax campestris* in the wild.

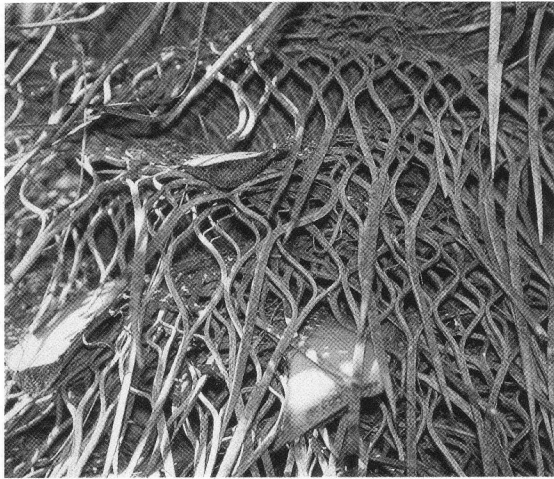


Buenos Aires is a terrific city! Modern, cultured and exciting, it can stand alongside any European metropolis and hold up its head with pride! Forget "third world." Forget "South America." Here you can rub shoulders with the rich and famous in La Recoleta; you can watch polo played by some of the best horses and riders in the world. And you can dance the Tango! A thousand kilometres to the west, however, it's a different story. Here the landscape has hardly changed since the time of the dinosaurs.

With all this in mind, west is the direction in which we are heading this bright March morning. We have left the lovely sunlit city of Cordoba and are heading towards the Sierra de Cordoba mountain range that divides Argentina north to

south and runs parallel with the Andes, which separate Argentina from Chile. Raul is at the wheel of his Cherokee Jeep. He is a big, larger-than-life character with silver hair and moustache. He talks loudly and animatedly, waving his arms about





2. Close-up of the fierce armature formed by the leaf sheaths of *Trithrinax campestris*.

and not letting his less-than-perfect command of English get in the way. Sometimes, to stress a particular point, he breaks off into French, but with an accent that would scarcely be understood in Paris – testament to his years in the Ivory Coast of West Africa. He talks about the weather, Argentina's history, the Falklands/Malvinas conflict and a thousand and one other things, chain-smoking his way through a packet of Marlboro in a morning.

By the time the conversation has come around to palms, we are in the mountains themselves. At 800 m we are not particularly high, but high enough for the sun to be blotted out by mist and low cloud and for visibility to be reduced to a few meters. We crawl along, Raul peering into the gloom. The Caranday palm, he tells me, lighting up yet another cigarette and referring to *Trithrinax campestris*, grows all over the central north of Argentina, and there are hundreds of thousands of them. It has no natural enemies, only man and his machines. He goes on to explain that for the first time ever, this beautiful, tough, armed-and-dangerous palm is under threat from land clearance. This is what we have come to see. Huge areas are being bulldozed for agriculture, and palms are among the victims of the farmers' insatiable appetite for land. Raul is talking non-

previous page

3 (top). Fire, deliberately set to aid land preparation for agriculture, sweeps through a population of *Trithrinax campestris*.

4(bottom). Charred trunks of *Trithrinax campestris* lie uprooted, victims of land clearance.

stop in his broken English, the car full of cigarette smoke. At that moment we break out of the mist, the sun is shining once again and from our high vantage point we can see for 80 km in every direction, across a huge flat plain where we will find our palms.

We stop in a village for a quick lunch: a huge plateful of meat, at least half a cow it seems (it's a brave man who declares himself a vegetarian in macho Argentina), and a foaming pint of Quilmes beer to wash it down, and soon we are on our way again. Before long we see our first *Caranday*. First one, then a hundred and one, then a thousand and one (Front Cover, Centerfold). Singles, doubles and in groups of up to four or five trunks, the tallest no less than 6 or 7 meters. Many are covered with the old leaves which form a skirt in the manner of *Washingtonia*. There are palms everywhere. We are surrounded by them, and stop to examine them more closely.

The fan leaves, surely the stiffest of any palm's, are a beautiful blue color, their tips sharp as needles (Fig. 1). There are up to 20 or 30 leaves per tree, and they radiate their spiny tips outwards in a sphere of stilettos. Where the old leaves have died, the armament is no less fierce, and the trunk is covered with an intricate network of interwoven spines and fibers, countless downward-pointing pairs of scissors (Fig. 2). The tree can scarcely be touched. Only on very old trees is the weaponry absent and the lower meter or so of trunk is bare.

At this time of the year, the palms are in flower, small yellow puffs of color, slightly fragrant and swarming with bees. Noisy parrots are landing in the trees, apparently nesting in the thick layers of old leaves. It's a magic landscape, prehistoric, as old, one feels, as time itself.

We walk back to the Jeep and continue down the same road. For many kilometers we see little but *Trithrinax*. It is baffling why this beautiful palm, so common in the wild, is so rare in cultivation. The land itself is rather flat, a huge flat plain that we had seen from the mountain pass. But now we are climbing a gentle rise and from the top, suddenly we get a different picture. To the left of the road, the scene is what we had become used to, palms as far as the eye can see. To the right however, there is not a palm to be seen, instead millions and millions of sunflowers are pointing at the sun and following its direction with their gaze as the day progresses. While the palms are wild and free, the sunflowers, genetically modified, are, symbolically perhaps, behind barbed wire, hung with placards promoting the chemicals and the manufacturers thereof that have been used to keep these vast numbers of plants weed free.



5. Refugee *Trithrinax campestris*, established in the Palm Centre, Ham, UK, none the worse for their ordeal.

Argentina is the largest producer of genetically-modified foods in the world.

Pretty as the flowers are, their very numbers are daunting (is it *us* their stares are following?), and we move on, constantly comparing the contrasting views to the right and left of this ruler-straight road. A couple of kilometers further on we come across farming in action. There is a smudge of smoke in the sky, rapidly becoming thicker as we approach and finally blotting out the sun. Here is the graveyard of the palms, felled by the hundred by huge bulldozers that care not for their ancient beauty but see them simply as obstacles in the path of progress. The armament that surely would have defeated the *Saltasaurus* that roamed these plains millions of years ago is nothing more than grist to the bulldozers' mill, and over they go, without sympathy or comment. Then they are unceremoniously piled into heaps, doused with diesel and torched, decades of growth reduced to ash and smoke, disappearing up into the evening sky as from a crematorium chimney (Figs. 3, 4).

Saddened and sobered, we drive back to the town where we had lunch, stopping at the same small hotel for the night. We have the other half of the

cow that we missed earlier, more Quilmes to wash the dust – and the smoke – away, and talk about our day. Raul became interested in the palms and their fate some years back. His business was in essential oils, and for him the palms were a sideline. Now, however, they are daily increasing in importance; they are, he readily admits, a lot more exciting than marigold and evening primrose. Now his business and indeed his mission in life is to get in before the bulldozers, dig up the palms, ferry them away to safety and, after a short period of recuperation, to export them by the container-load to Europe where they are beginning to grace the gardens of well-heeled palm enthusiasts.

They adapt remarkably well, tolerating the unavoidable damage to their roots, and what must be a terrible shock to the system. Remarkably they don't turn a hair and continue growing as though they were still back at home. We talk late into the night, Raul well into his third pack of cigarettes of the day, and Argentinean brandy having taken the place of beer.

A knock at my door tells me that morning has broken, and we must be on our way. *Jugo de naranja* and *café con leche* serve for breakfast, and we drive off into the cool sunrise, Cordoba-bound. It has been an eye-opener of a trip and a reminder that little is sacred in this world. My memories of the stately palms, falling like ninepins, will remain with me for a long time.

A month or so after I arrive back in the UK, a container-load of refugees arrives at my nursery. They look a little flustered, but after a week or two in the ground they are as good as new and seem to have suffered little from their ordeal. I do not pretend that I am saving them from extinction – there are far too many to be endangered as a species just yet, but 'rescued' certainly seems the appropriate word, at least for a few of the thousands of individuals which would otherwise have been incinerated on that distant plain (Fig. 5).

Centerfold (overleaf, pp. 78, 79).

Trithrinax campestris in great abundance in the wild.





Phoenix loureiri var. *humilis*, a New Record for Bhutan

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1. *Phoenix loureiri* var. *humilis*, growing near Wangdi Phodrang, Bhutan (Photo: P. Cribb).

Phoenix loureiri Kunth var. *humilis* (Becc.) Barrow is newly reported from Bhutan. Sightings of two other *Phoenix* species are also reported from Bhutan.

Wangdi Phodrang lies at the junction of two tumultuous rivers, the Mo Chu and the Mara Chu, which arise in the high Himalayas of central Bhutan. The town occupies a ridge overlooking

the junction of the rivers and is dominated at its southern end by the imposing fortress monastery (dzong), of Wangdi. Running south from the town is a deep rather dry valley that gradually falls to



2. *Phoenix loureiri* var. *humilis*, with immature fruit (Photo: P. Cribb).

the plains that border the Bramaputra River in north-west India. The relative dryness of the valley is surprising in a country that is dominated by the monsoon that arrives in June and lasts until September, but dry valleys are not uncommon in the Himalayas where they lie in the rain shadow of mountains to their south. The aridity is compounded by the south winds that blow strongly and persistently nearly every afternoon. Driving down this spectacular valley, we encountered groves of a small pinnate-leaved palm in fruit on the valley sides. The stems reached about a meter tall in the larger specimens (Fig. 1). The leaves were about 1.5 m long and the erect inflorescences had yellow flattened stems topped by several short suberect branches, bearing fruits similar to those of wild olives in size and color (Fig. 2).

We tried to key it out in the *Flora of Bhutan*, a rare Flora that is handy enough to carry into the field. It keyed out to *Phoenix loureiri*, a palm not previously recorded from Bhutan. John Dransfield subsequently confirmed the identification as *P. loureiri* var. *humilis* (Becc.) Barrow (1998). The *Flora* reports it from nearby Duars of India and from the Darjeeling area.

The palm is distributed for several kilometers down the valley from about 1100 to 900 m elevation, higher than the elevation range given in the *Flora* account but within the range, up to 1700 m, given

by Barrow (1998). This region is sparsely populated but grazed by nomadic herds of cattle and other livestock. The palm grows in small to large colonies on steep dry grassy slopes with scattered *Pinus roxburghii*, usually on slopes that face east or south-east. They were fruiting at the start of the monsoon season in early June. On the opposite side of the valley, in a hanging meadow, *P. loureiri* seemed to be absent.

Further to the south-east and north-east of Gaylephug, two larger *Phoenix* species were seen growing on steep cliffs and in subtropical forest, often near waterfalls, at between 500 and 900 m elevation. One of these, with a slender elegant trunk and just coming into flower, was *P. rupicola* T. Anderson. It formed small colonies on almost vertical rocks, probably gneiss (Fig. 3). It has been reported previously from Samchi, Sankosh, Gaylephug and Deothang districts of Bhutan. The other we were unable to identify certainly because we could not get close enough to it, but it may have been *P. sylvestris* (L.) Roxb., which is common in the nearby Darjeeling area.

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3. *Phoenix rupicola* is well named; near Gaylephug, Bhutan, it grows on vertical cliffs (Photo: P. Cribb).



Maximizing Seed Production of *Linospadix monostachya*

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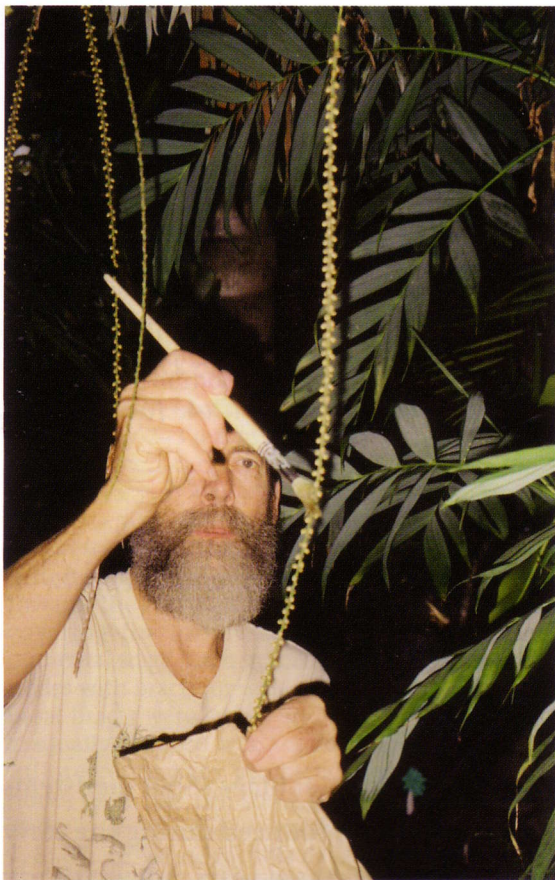


1. *Linospadix monostachya* with inflorescences bagged for pollen collection.

For years we watched our *Linospadix monostachya* palms in hopes of seeing beautiful strings of red infructescences. If luck prevailed, a total of 30 or 40 seeds would develop from multiple inflorescences; this certainly was not the spectacular seed display that had entranced us in photographs and at other gardens.

We decided to get serious about increasing seed production and began observing the flowering habit of *Linospadix monostachya*. At first

observation, using a hand lens, we were able to differentiate male from female flowers. The flowers appear in a triad formation; a single female



2. Jim Wright applies pollen to receptive pistillate flowers.



3. The results of hand pollination, infructescences with full loads of ripe fruits.

'pistillate' bud is located between two male 'staminate' buds. The staminate buds open three to four weeks before the pistillate buds, yielding plentiful quantities of pollen. Unfortunately, most of this pollen has dispersed by the time the female flowers are receptive.

Our solution (Fig. 1) is to place a paper bag over the full length of the inflorescence. After the male flowers have finished producing pollen, the bags are removed, closed, and stored in a dry place. When the pistillate flowers are receptive, we use an artist's paint brush, (Fig. 2), frequently dipping the brush into the pollen at the bottom of the

bag, painting the pollen up and down the entire length of the inflorescence. We do this once or twice a day for 7 to 10 days, or as long as the female flowers appear to be receptive. This has been truly rewarding (Fig. 3), as each of the inflorescences that we hand-pollinated produces a full length of seeds. We employ the same technique on *L. minor*, with the same productive results.

If you have a palm from which you desperately want seeds, try out this technique; it may be just the answer.

Hapaxanthic Axillary Shoots in Date Palm Plants Grown *in vivo* and *in vitro*

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Date palm (*Phoenix dactylifera* L.) produces axillary shoots from axillary shoot meristems and inflorescences from floral meristems. Axillary shoots are produced during the early vegetative growth period and cease when flowering starts after three years. A few axillary shoots produce terminal inflorescences and die. These flowering shoots are termed hapaxanthic axillary shoots and appear in seedling palms and tissue culture palms during the second or third year of vegetative growth. The production of hapaxanthic shoots does not affect the normal growth of the mother tree.

Date palms are propagated sexually by seeds and vegetatively by offshoots or tissue culture plantlets. Both the tissue culture plantlets and the seedling palms resemble each other in growth and development in the field except that seedlings start with juvenile leaves while the offshoot-derived palms start with adult leaves. Axillary shoots are produced during the early vegetative phase prior to the onset of flowering in the fourth year. However, axillary shoots may develop during the reproductive phase in certain cultivars. These axillary shoots are called *racoobs*, and they develop higher up on the tree.

During our 15 years of experience with *in vitro* and *in vivo* date palm growth and development, we observed a third type of axillary shoot in addition to the offshoots and *racoobs*. These peculiar axillary shoots are morpho-logically different from the normal offshoots and *racoobs*. These axillary

shoots are hapaxanthic, i.e., they produce terminal inflorescences after one or two years of growth and die. This phenomenon is common in both tissue culture palms and seedling palms during their second or third year of growth in the field.

Vegetative proliferations from inflorescences or from floral sites has been reported in many palms: *Cocos* (Davis 1948, 1967; Balaga 1975; Sudasrip et al. 1978), *Elaeis* (Henry & Scheidecker 1953), *Areca catechu* (Davis 1968) and *Borassus* (Davis & Basu 1969). In rare instances, the apical meristem of the flower bud proliferates to form floral or vegetative organs (Eames 1961; Padmanabhan et al. 1987). Recently Mohamed (1997) reported on axillary shoots that terminated in inflorescences in the date palm cultivar 'Mishring wad-khatib.' We observed hapaxanthic shoots of several date palm cultivars *in vitro* and *in vivo*. The details of our observations are presented in this paper.

Observations

Hapaxanthic axillary shoots (HAS) were observed in tissue culture date palm (Figs. 1, 2) cultivars 'Maktoomi,' 'Nebut-seif,' 'Succari,' 'Barhi,' 'Munifi' and 'Sheshi' (Table 1). The same phenomenon was also observed in several seedling palms (both male and female) grown for landscaping. These hapaxanthic axillary shoots (Fig. 3) were periodically removed from the mother plant and dissected out in the laboratory for observation (Figs. 3–12).

Morphologically, these axillary shoots were distinct from offshoots and *racoobs*. They produced 2–8 basal leaves with a full complement of leaflets, followed by 2–3 leaves with few leaflets at the tip followed by 3–5 cataphylls (Fig. 5). These shoots grew for a year or two and produced terminal inflorescences (Figs. 7, 8). Some of them produced inflorescences at their basal leaf axils (Fig. 9). The inflorescence axis was cylindrical and tapering towards the end (Figs. 7, 8). There was no prophyll covering the inflorescence at the early developmental stage. Each inflorescence axis had several nodes with bracts or scale leaves (Figs. 10–12). The basal bracts were larger, and the upper ones were gradually reduced to a smaller size. Some of the inflorescence axes produced flowers at all the nodes (Figs. 11, 12), some flowered only at basal nodes and some did not produce any flowers (Figs. 7, 8). There was no rachilla development, but some inflorescences showed small branches with flower buds at the basal nodes (Fig. 10). The inflorescences emerged with 4–15 flowers. The flowers were normal and produced parthenocarpic fruits. Some of the pollinated ones produced normal fruits with seeds.

Terminal inflorescences were induced to form on date palm seedlings *in vitro*, when cultures were supplemented with indole acetic acid (IAA), benzyl aminopurine (BAP) and sucrose (Ammar et al. 1987). The same growth regulators (IAA and BAP) and sucrose did not induce floral bud formation in plantlets induced via embryogenesis in callus cultures (personal observations). Among the date palm plantlets produced in culture, 0.1% produced flowers (Fig. 13). Some of the *in vitro* flowered plantlets were hapaxanthic (Figs. 14, 15). A few plantlets produced terminal inflorescences and

some with axillary shoots terminated in inflorescences. After producing flowers the plantlets lived for a month or two and then died.

Discussion

Hapaxanthic axillary shoots (HAS) were observed as a common phenomenon among seedlings and tissue culture derived palms growing under regularly irrigated soil conditions. None of the plants that we observed produced this type of shoot during the reproductive phase. Occurrence of HAS during the juvenile stage in both tissue cultured and seedling palms indicated that it is highly related to the juvenile stage. Each palm produced one or two such shoots during the second or third year of the vegetative growth. HAS were rare among the palms developed from the offshoots.

The developmental pattern of HAS was similar to the development of terminal inflorescences in banana. After one year of vegetative growth, the number of leaflets per leaf diminished, and the leaflets finally became cataphylls (without leaflets). Later the meristem terminated in an inflorescence without bracts or rachillae. Since the earlier growth was similar to the normal offshoot growth, it is clear that the shoot meristem later converted into a floral meristem. This developmental pattern was also confirmed by the plantlets growing in culture showing the similar HAS phenomenon. Our present study confirmed that HAS production occurs not only in tissue culture plants but also in seedling palms. These shoots died after the development of terminal inflorescences without affecting the growth of the mother plant. Further detailed study is needed to find out the real cause of the development of hapaxanthic axillary shoots in date palm.

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Table 1. Different date palm cultivars and percentage of hapaxanthic axillary shoots (HAS).

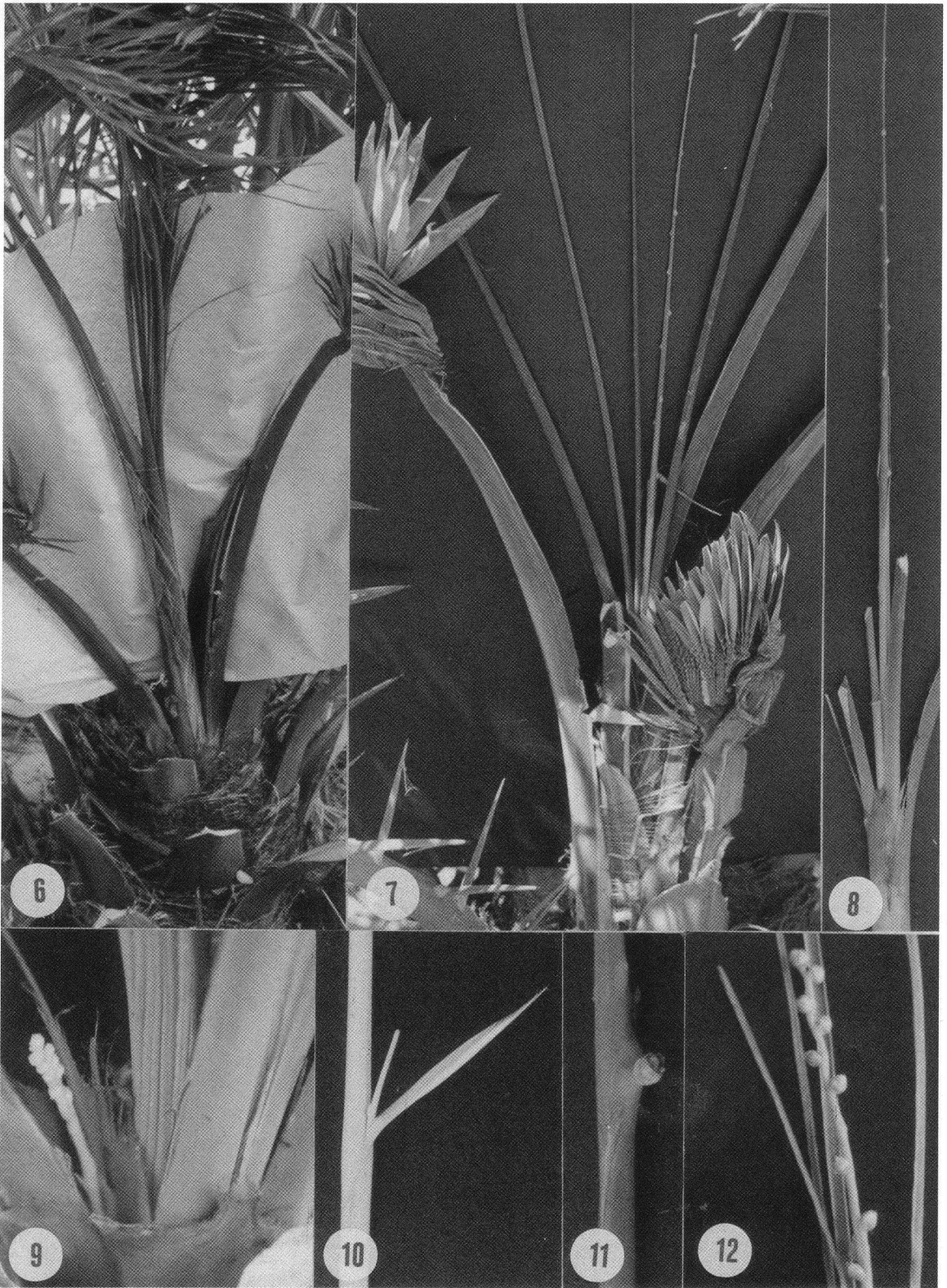
Cultivar	No. of plants observed	No. of plants with HAS	% of plants with HAS
'Maktoomi'	30	27	90
'Nebut-seif'	30	24	80
'Barhi'	20	12	60
'Shesi'	20	20	100
'Munifi'	12	8	66.7
Seedling palms	170	78	45.9



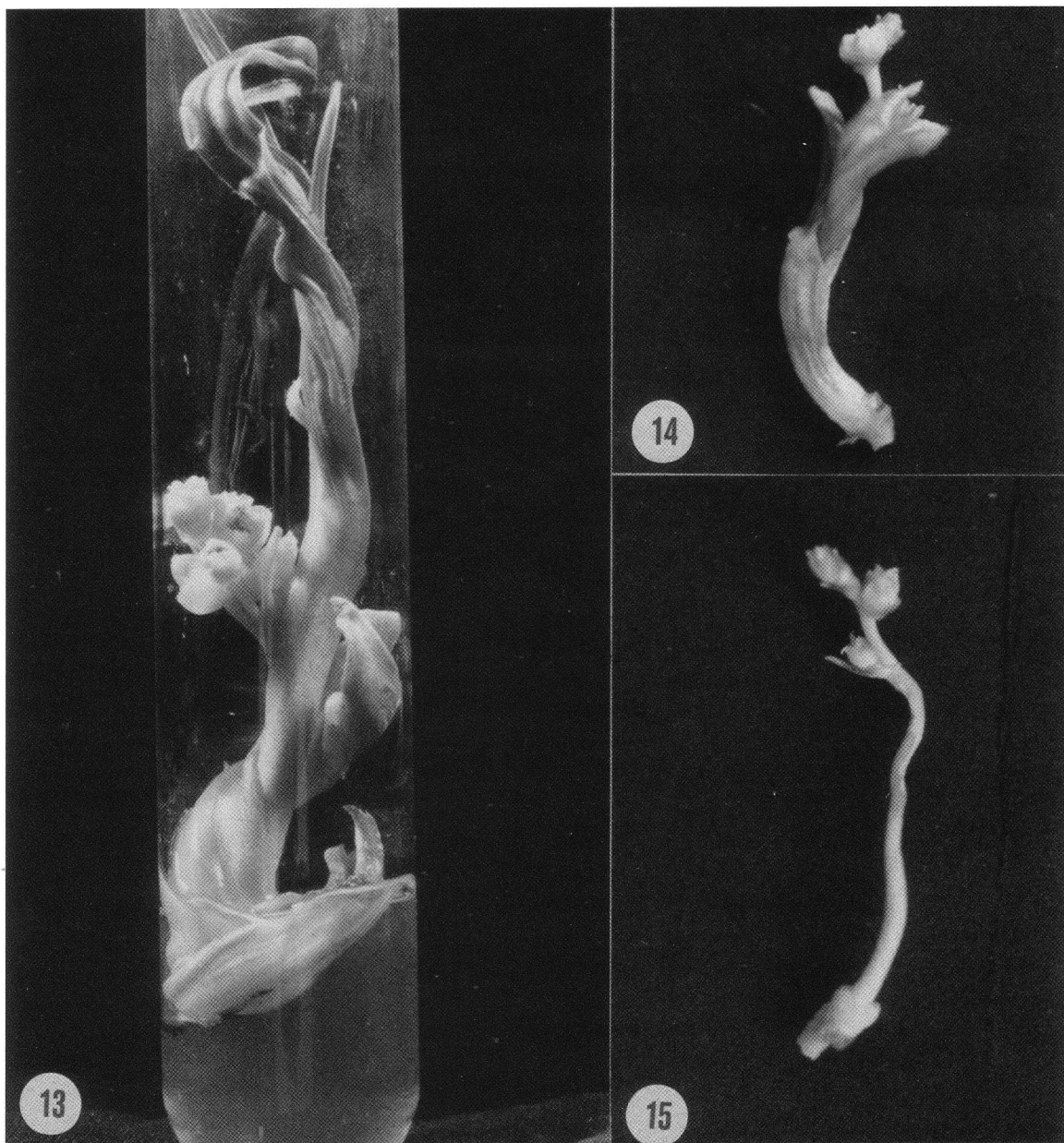
1. Tissue culture date palm showing hapaxanthic axillary shoot. 2. Hapaxanthic axillary shoot showing inflorescence produced at the basal leaf axil.



3. Isolated hapaxanthic axillary shoot. 4. Partly dissected out hapaxanthic shoot. 5. Dissected out leaves.



6. Seedling date palm with hapaxanthic axillary shoot. 7. Hapaxanthic axillary shoot with terminal inflorescence. 8. Dissected out shoot with terminal inflorescence. 9. Hapaxanthic axillary shoot with inflorescence at its basal leaf axil. 10. Inflorescence axis scale leaf and a small inflorescence branch with flower bud. 11. Inflorescence axis showing female flower at its basal swollen node. 12. Terminal inflorescence with flowers.



13. Date palm plantlet showing normal inflorescence produced in culture. 14. *In vitro* grown plantlet with terminal inflorescence. 15. Dissected out *in vitro* plantlet showing terminal inflorescence with flowers.

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Variation on a Theme: Bonsai Palms

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1. Two *Hyophorbe verschaffeltii* with miniature mondo grass (*Ophiopogon* sp.) as ground-cover.

South Florida architect Ken Treister grows an extensive collection of palms in bonsai containers, and it is a viable practice, judging by the health and age of his palms.

"Could you call it bonsai?" might be the only question raised about this palm growing technique. While the palm's growth and form cannot be manipulated to the extent of traditional bonsai, the essence of the older plant or larger scene can be suggested in miniature form and this, says one expert, makes it bonsai. Depending on the species, palms can be grown as solitary

specimens or groups of one species in a container to suggest mature trees or a whole forest. The unique features of each palm are enhanced in this small scale setting. One of Treister's most dramatic creations is six 70 cm (27 inches) tall *Hyophorbe verschaffeltii* in a rectangular, blue-glazed pot, where their strong forms and red leaf stems are beautifully displayed. A 1.5 m (4.5 ft) tall

Chamaedorea metallica looms over its small container home of four years making a daring new statement as well (see p. 55). While some might consider this an odd or inappropriate treatment of palms, it does make for a new way to admire them. Treister has made bonsai palms a hobby for 20 years and has more than onehundred containers arranged along shelves on a patio. He points out that he enjoys a large collection of palms in a rather small area and here is an outlet for frustrated palm lovers in apartments.

With close attention to watering and regular liquid fertilizing, palms can be grown for years in bonsai containers. Pure long-fiber sphagnum moss is the recommended potting medium since frequent watering flushes soil media out of these containers. Seedlings or small plants cleaned of all soil are carefully arranged in the container with sphagnum moss packed in around them. Moss and even miniature mondo grass can be placed over the

sphagnum moss as a groundcover (Fig. 1). Due to the rootbound state of the palms, watering is a nearly daily ritual, and fertilizing typically consists of a weekly liquid 20-20-20 drench. Treister rootprunes as often as twice a year to keep the plants within their containers, and this involves cutting large emerging roots of single specimens or sawing a bottom portion off multiple plant roots, and then repotting with sphagnum moss around the cut areas.

Palms cannot match the longevity of traditional bonsai, but many species remain an appropriate size in bonsai containers for 5–10 years. Faster growing palms such as *Roystonea* spp. have been retired as early as four years when they reached 1 m (3 ft) in height. Some of the best subjects for bonsai include species of *Arenga*, *Rhapis* (Fig. 2), *Livistona*, *Hyophorbe*, *Chamaedorea*, and *Dypsis*. Some named varieties of *Rhapis excelsa*, such as *R. excelsa* 'Kodaruma' can stay in the same pot for decades, only reaching 1 m (3 ft) in height.



2. Ideal for bonsai: slow growing *Rhapis* sp.

Why Lethal Yellowing Has Not Become Epidemic in the Dominican Republic

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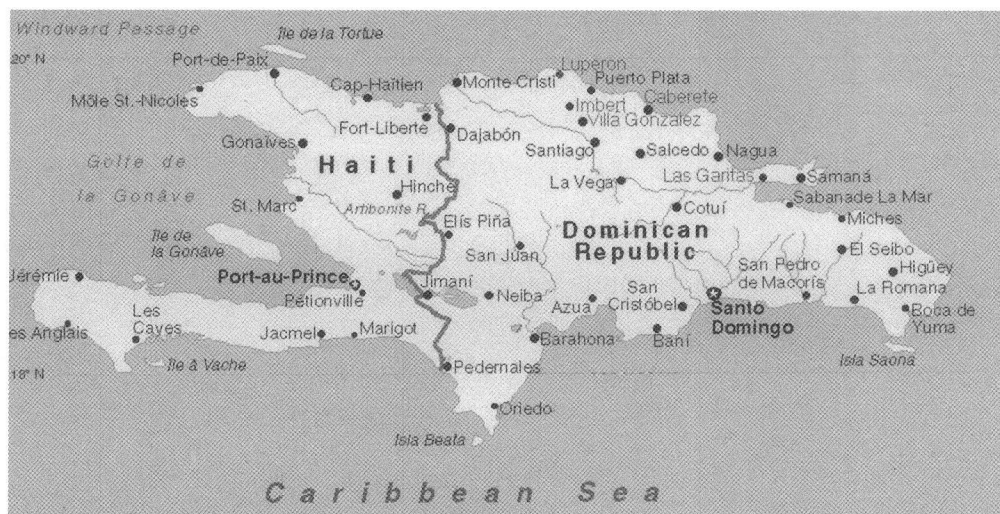
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1. Map of Hispaniola (Haiti and Dominican Republic) showing locations mentioned in the text.



Lethal yellowing disease of coconut palm (LY) in Dominican Republic is sporadic, not epidemic. No evidence exists for the spread of lethal yellowing disease out of previously diseased areas to any other part of the Dominican Republic. The risk of transmitting the disease by carrying infected vectors on grass or other planting material is very high, particularly in tourist areas where hotels are being landscaped. The establishment of a lethal yellowing quarantine control area in seven provinces may contain the disease and prevent an epidemic. The rest of the country where the disease is not present and from where it must be excluded comprises a lethal yellowing pest free area.

In 1962 lethal yellowing was reported from Dominican Republic (Carter 1962) having previously been identified in Haiti (Ollagnier & Weststeijn 1961). Further sightings in Dominican Republic were reported by other specialists (Schieber 1969, Romney 1970; Schieber 1970, Schieber & Hichez Frias 1970). Another report (Maramorosch 1972) was made when samples were taken to identify the causal organism (then known as an MLO) by electron microscopy. The MLO were visualised (Karl Maramorosch, pers. comm.) but the results were not published. Nor was tetracycline treatment attempted, to identify LY by giving temporary remission of symptoms (McCoy *et al.* 1976).

From 1969 to 1986 an eradication programme was operated in seven provinces of the affected area of Dominican Republic. During that period one visiting specialist was unable to find cases of lethal yellowing (Howard *et al.* 1981), but a photograph taken in 1983 (Carlos Vargas, pers. comm.) shows a palm with typical symptoms that was recognised by visiting Jamaican and West African coconut specialists (who unfortunately did not publish any reports). In that same period, the disease continued to spread in Haiti (Timyan 1996) and was epidemic in Jamaica and Florida, where active research supported effective rehabilitation programmes based on resistant varieties and (in USA only) tetracycline therapy. The fact that LY failed to become epidemic in Dominican Republic was overlooked. This led to the assumption, locally, that the disease had either been eradicated by the quarantine measures or, more controversially, that the initial identifications by up to seven independent specialists had been wrong.

The issue came to a head when the Brazilian government placed an embargo on imports of coconut products from Dominican Republic, because quarantine regulations routinely include Dominican Republic as one of the countries in which lethal yellowing occurs. Brazil, as the ninth largest producer of coconuts in the world, was extremely anxious not to allow LY to enter that country. The entire native coconut (criollo) population of Brazil is known to be highly susceptible because it has a common origin with other named, susceptible varieties in Caribbean and Atlantic countries (Harries 1977).

Findings

During a recent mission for FAO (Harries 1999), the presence of lethal yellowing was recognised, on the basis of visual symptoms, at Villa Gonzalez (Santiago), Dajabon (Dajabon), Luperon and Cabarete (Puerto Plata). Four samples were taken

for PCR (polymerase chain reaction) analysis at Centro de Investigación Científica de Yucatán AC, Mérida, Yucatán, México and gave positive results for LY phytoplasma (Ivan Cordova, pers. comm.). A non-LY infected control sample was also taken from a palm growing in an LY-free area at Las Garitas (Samana), which had a yellow leaf because it was touching an electric power line. This sample had a negative PCR result (Ivan Cordova, pers. comm.). Tests made on duplicate samples sent to the University of Florida, Fort Lauderdale, confirmed the four positive and one negative result (Nigel Harrison, pers. comm.).

These observations support the earlier findings of the phytopathologists and coconut palm specialists who previously identified lethal yellowing in these locations. The fact that the first case in Dominican Republic was reported at Imbert may be explainable because there is a sugar cane growing area there where Haitian field workers may have unwittingly transported vectors on fresh plant material. The provinces of Santiago, Dajabon, Puerto Plata, Santiago Rodriguez, Monte Cristi, Valverde and Espaillat, which made up a quarantine control area from 1974 to 1986, should once more be considered as potentially LY-infected areas for quarantine purposes. Symptoms of LY were not seen in other provinces visited during this mission from either the road or aerial surveys. As far as can be determined, LY symptoms have never been reported from any other provinces. Thus 23 provinces can be considered as being LY free (see Back Cover).

The other findings, one reported here for the first time, account for why lethal yellowing has not become epidemic in Dominican Republic. There is no epidemic of LY because there has been no "jump-spread" from the area of the original outbreaks into the areas where there are extensive commercial coconut plantations. This can be compared and contrasted with the situation that occurred in Jamaica when the disease appeared in the commercial coconut growing area in the east of the country after having previously been known for many years as "West End Bud Rot." When jump spread occurred, the outbreak was in a public works yard, and it was subsequently assumed to have been caused by infected insect vectors being transported by trucks carrying soil or plants across the intervening low rainfall area where comparatively few coconuts grew. This separation of the two areas by climatic and topographic conditions that restricted the natural movement of the vector, and hence the natural spread of the

2 (p. 94). Royal palms in Dominican Republic (photo J. Höppe).



disease, can also be seen in Dominican Republic. The dry region near Monte Cristi effectively isolates Dajabon. The steep hills and deep valleys around Puerto Plata could also limit insect movement. The prevailing NE trade wind blows from the healthy to the diseased areas and hurricanes, which generally move from east to west, have yet to be implicated in any dispersal of the disease or of the leafhopper vector.

The second, and new, finding became apparent when making a survey by helicopter. At first, the survey merely confirmed the previous idea on topographic separation. For instance, there is a considerable stretch of land without any coconut palms between the infected palms near Cabarete and other coconut palms growing around Puerto Plata. As the flight continued, over the Cordillera Septentrional, it was also seen that the coconut palms growing near properties or on boundary lines were separated by ridges and valleys. However, what had not been evident, until then, was the very high number of Royal palms that grow everywhere in Dominican Republic. The Royal palm (*Roystonea* spp), along with many other indigenous American palms, are not included on lists of LY susceptible palms and may be considered to be immune to LY. [Of twenty-seven palm species that grow where coconuts may be found in DR (Jurgen Höpfe, pers. comm.), only one species from the fourteen genera listed has been recorded as susceptible (in Florida). This is the rain palm (palma de lluvia – *Gaussia attenuata*) from Puerto Rico, but not only is its relative susceptibility unknown but it is also found only in small populations in the East National Park, southeast DR]. It is suggested here that if the insect vectors acquire LY from an infected coconut palm they will spread the disease only if the next palm that they feed on is also a (susceptible) coconut. In the situation described, the next palm is much more likely to be a Royal palm (or a *Sabal* palm, or other immune indigenous palm species).

It may be that the topographic and edaphic isolation and the Royal palm "buffer effect" will continue to protect the Dominican Republic from an epidemic lethal yellowing outbreak. However, a lesson can also be learned from the situation in Mexico, where infected LY vectors are thought to have been introduced on planting material, specifically on grass, brought into Cozumel from Florida for hotel landscaping. The tourist industry in Dominican Republic is expanding rapidly, and during the consultancy visit, when in or near tourist centers, pick-up trucks were frequently seen to be carrying turf grass, young palms and other growing plants. If infected planting material has already been carried from, say Cabarete to Rio San

Juan (a journey of only about 60 km) then palms with symptoms of LY could occur within less than a year (the incubation period, during which the palm appears healthy but acts as a source of further infection is about 7 to 11 months, depending on the size of the palm and the season). Unfortunately, but not unexpectedly, the helicopter survey over Samana showed that coconuts outnumber Royal palm in that province. Under those circumstances, as in the coconut growing areas of Jamaica, any outbreak of LY disease will surely become epidemic. It is therefore essential to prevent the movement of plant material carrying potential vectors out of the lethal yellowing quarantine control area. It is also important to plant LY resistant varieties or hybrids because resistance is known to be the best, and indeed the only economically practical, form of control.

Acknowledgments

The mission in which the authors participated was part of the FAO Project TCP/DOM/8823. Thanks are due to the staff of the FAO office in Santo Domingo; to the staff of Sanidad Vegetal, Secretaria de Estado de Agricultura, Republica Dominicana; to Centro de Investigación Científica de Yucatán AC; Ivan Cordova and Nigel Harrison for PCR analyses; Jurgen Höpfe, Bill Howard, Dennis Johnson, Dave Romney, Karl Maramorosch, Simon Eden-Green and Carlos Vargas for various items of background information. The authors are particularly grateful to Jurgen Hoppe for providing the pictures of coconut and Royal palm in Dominican Republic.

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Palmyrah Palms in Tamil Nadu, India

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1. *Borassus flabellifer*
in a dry landscape,
Tamil Nadu.

India stands first in the world in terms of its wealth of palmyrah palms (*Borassus flabellifer*) with a population estimated to be nearly 102 million palms. Of this, 50% of the palms are concentrated in the southernmost state of Tamil Nadu, where palmyrah is honored as the State Tree.

In Tamil Nadu, the districts of Tuticorin, Tirunelveli, Ramnad and Kanyakumari, adjacent to the Indian Ocean, are endowed with 10 million palmyrah palms (Sankaralingam et al. 1999) (Fig.1). In these tracts the palm is cultivated and exploited in the wild, and referred to as 'The Tree of Life' with 801 uses, including food, beverage, fiber, fodder, timber and medicines. Among the various edible uses of the palm, the sweet sap tapped from the inflorescence for making palm

sugar is of prime importance. The endosperm of the young fruit, like tender coconut, is a delicacy in summer. The petiole fiber and leaf blade are used to make products such as brushes and handicrafts. The tree serves as a source of raw material for several cottage industries.

Palmyrah prefers a dry climate, growing naturally in sandy plains adjacent to seashores (Fig. 2). The mean annual rainfall in this area ranges from

600–700 mm with temperatures in summer (April, May) ranging from 35–40° C. However, the palm is not suited only to dry climates. It flourishes well under wetter conditions such as on the banks of the perennial River Tambiraparani that runs through the two districts of Tirunelveli and Tuticorin. On the riverbanks in fertile soils, the groves take on the appearance of rain forest (Fig. 3). The palm is so closely woven into the lifestyles of the people of the region that palmyrah fruits are hung as decoration in marriage ceremonies as a symbol of prosperity and happiness.

Palmyrah has separate male and female trees. Sex cannot be differentiated until flowering. The palm is a slow grower compared to the coconut, which is cultivated in areas with good irrigation. The stem of palmyrah is visible only after 4–5 years. In contrast, some dwarf cultivars of the coconut begin bearing at 4–5 years. Palmyrah needs minimum care, and if protected by fencing from stray cattle feeding on its foliage, the palm can come into flower and fruit within 10–12 years. Otherwise, it may take 20–25 years for the palm to flower.

Fig. 2. Palmyrah palms flourishing on sandy soil with a female tree in the foreground.



The palmyrah stem is unbranched, usually growing to a height of 15–20 m, topped by 25–30 large fan-shaped leaves. However, there are dwarf palms that come into bearing even at a height of 4 m. The male palm produces 5–10 inflorescences each year. The male inflorescence is heavily branched with each branch having 2–3 spikes. Each spike has 800–1000 flower clusters, which in turn bear 15–20 little flowers. As a whole, a male inflorescence may have 200,000–250,000 florets. In contrast, the female inflorescence has only 2–3 branches, with each branch bearing 10–12 large, globose flowers. Normally a female palm produces 5–8 inflorescences with a total of 100–150 fruits. However, trees close to water sources may bear nearly 300–400 fruits (Fig. 4). The fruits are generally black-skinned, but red-skinned types also occur.

These palmyrah-growing tracts receive one heavy monsoon during October–November. Flowering is seasonal, and fruiting occurs in September–October. In nature, the fully-ripe, heavy fruits fall down and become buried in the soil. The rainfall received during the season facilitates germination. The fruits are normally 3-seeded and when all of them germinate from a single fruit, they give rise to three palms. Clumps of 2–3 palms are a common sight in the area.

Palmyrah is one of the major sources of palm sugar in Asian countries. The palm is planted on reservoir and lake banks to stabilize them. It is also planted on rice field margins to demarcate them. The palm does not need much water, requires very little maintenance and it is highly disease resistant. It stabilizes unproductive, erosion-prone soils. It can be planted in any type of soil to increase soil fertility and water conservation. It is used as a wind-break in sandy plains to stabilize dunes. Palmyrah is truly a multipurpose palm.

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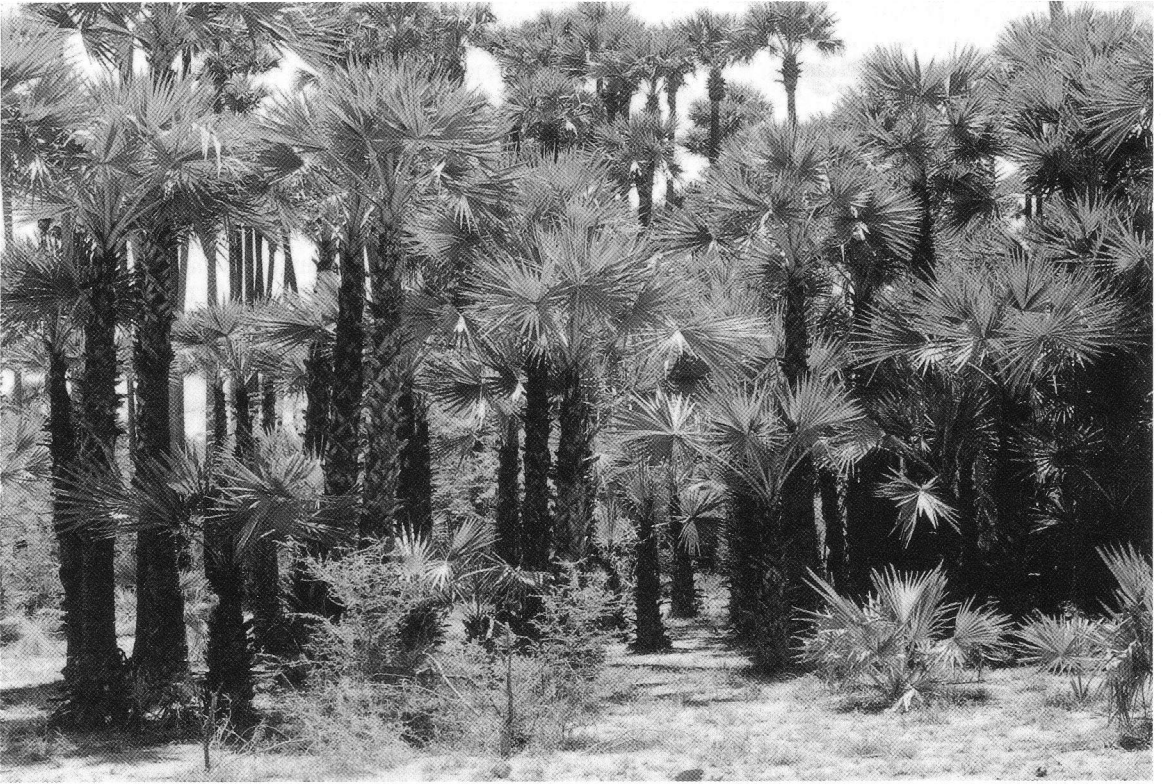


Fig. 3 (top) Palms of different ages growing wild on the banks of the River Tambiraparani. Fig. 4 (bottom). A female palm bearing 300–400 fruits at maturity.

PALM LITERATURE

Response to Dransfield's Review of *The Palms and Cycads of Thailand*

When we present our work in a public forum we take the risk of someone being critical of our work. We also expect our work to be reviewed in a fair, unbiased, and objective manner. I am not at all adverse to fair, unbiased, objective and constructive critique. Although some of the comments in John Dransfield's review (PALMS 44: 98-100. 2000) of my book, *The Palms and Cycads of Thailand*, are fair, I believe most are factually incorrect, and the remaining are rather petty and of no consequence.

Readers of Dransfield's review should be aware of his early involvement with the project. At the 1996 IPS Biennial, Kampon Tansacha asked me to write a popular, illustrated book on Thai palms in time for the 1998 Biennial. I accepted his offer and invited Dransfield and Dr. Anders Barfod to participate, as they had been working toward a scientific account of the Thai palms for some time. They declined my invitation to join the project as junior authors when Kampon backed me as senior author.

Kampon did not commission me to do the project and write the book as Dransfield falsely asserted. I received no payment from Kampon for directing the project and writing *The Palms and Cycads of Thailand*, and I receive no revenue from sales of this book.

"Work on just the historic collections in the herbaria at Kasetsart University (BK) and the Royal Forest Department (BKF) in Bangkok would have added further species to his list. It is surprising that these, at least, are not included." [Dransfield's statements from the published review are given in bold.]

That Dransfield criticized me for not apparently examining available herbarium specimens is remarkable on two accounts. First, I am surprised that a popular treatment of palms requires an examination of herbarium specimens. Second, I actually did examine all available palm specimens at these two herbaria as well as those at the herbarium in Surattani. I spent an entire day at BKF since it was said to have the largest number of palm specimens; however, I was greatly surprised and disappointed at the dearth of specimens available for study. There were not more than 100 specimens of Thai palms at BKF, a surprisingly small amount considering that

researchers, Dransfield included, have been periodically working on Thai palms for over 20 years. The herbarium cases holding the palm collections were mostly empty, with few specimens scattered here and there.

It was obvious these cases had held many more specimens at one time. What had happened to them? Under the most unusual, suspicious and mysterious of circumstances, the herbarium officer at BKF told me that he had been ordered to place the herbarium specimens off limits and made unavailable specifically to me. Another person independently corroborated these incredible circumstances. Perhaps I should have gone to Europe or elsewhere and examined Thai palm specimens there although by then I doubted I would have been received in any more of a cooperative spirit than I had been at BKF in Thailand. Besides, the expense and time to visit European herbaria were not warranted, especially for a popular (not scientific or technical monograph) book. Dransfield has since told me that he was and is unaware of any conspiracy to deny me access to palm collections in Thai herbaria.

"That it gives equal treatment to all the palms, all confidently identified and named ... gives a superficial air of completeness to the book-as if it purported to be a complete monograph of the palms of Thailand."

I clearly and unequivocally stated in the preface of the book that, "It must be stressed this book is a popular account, not a monographic treatment". Later in the preface I added, "This work is not intended to be the final word on Thai cycads and, especially, the palms." Past reviewers and others, Dransfield included, have written glowing words of praise about other popular palm books, but never did they criticize or discount them because the authors did not examine herbarium specimens.

"Perhaps the most unfortunate aspect of the book is that it appears to have been written without any contact being made with the very active palm botanists Saw Leng Guan and Lim Chong Keat who live just over the border in Malaysia."

In fact, I relied heavily on Saw's excellent 1997 monograph of *Licuala* of the Malay Peninsula in making determinations, and I still stand behind my work. As for Lim, he had co-authored a short article with Dransfield in *Principes* in 1992 about a species of *Areca* from northern Malaysia that extends just across the border into far southern Thailand. Dransfield called this article to my attention. I agreed with him and was able to

incorporate the name of the palm in the book in time to include it before going to press. Dransfield did not, however, indicate to me that Lim would have been such a critical resource for the project as he purported in the review. For one who thought Lim or Saw was such a critical resource for the project, Dransfield did not show it. Certainly Dransfield could have simply told me of their possible contributions to the project in 1996.

Nevertheless, since the book was printed, Lim and Saw (including Barfod) have weighed in with their opinion and interpretation of *Pinanga*, *Iguanura*, *Areca*, and *Licuala* in Thailand. They accepted some of my species boundaries and rejected others. They are entitled to their opinion. Where to draw the line between species has been and always will be a source of healthy, contentious debate of opinions and interpretations.

"...the authors follow the latest monograph of the genus (*Phoenix*) by Barrow, whose work predates the book. . . [yet] there are no explicit references to her monograph."

I did not reference Sasha Barrow's *Phoenix* monograph simply because I did not use it. It was not published until after *The Palms and Cycads of Thailand* went to press. Sasha herself, through personal communication, was one of the sources of information I used for *Phoenix*, and I noted her contributions in the Acknowledgments, as I did for other researchers with whom I had communicated.

"The authors have not seen for themselves all the taxa included in the book. For example, *Calamus spectatissimus*... Unfortunately, no source of information is cited..."

It is correct that I did not see all the taxa. I saw only 150 of the 162 (93%) species, as my photographs indicate. The remaining 12 species I included without photographs. I made no citations in the book because it is a popular account, as I clearly stated in the Preface. Instead, I relied on the literature listed in the Selected

References, several of which are Dransfield's own works, including *A Manual of the Rattans of the Malay Peninsula*, published in 1979. Although not without its own errors and omissions, this work was still the best, most up-to-date treatment on the rattans. In this work, six of the 12 remaining species I did not see are noted as also occurring in Thailand, so I included them.

There are positive aspects of the book that another reviewer might have mentioned. *The Palms and Cycads of Thailand* is the only handsomely-illustrated account of Thai palms, and I believe it can be a starting point for a future scientific and technical taxonomic monograph, the need for which Dransfield noted in his review. Since the book is written in a popular style and format, the information is accessible to everyone, no matter his or her level of interest or expertise. Also, *The Palms and Cycads of Thailand* is the only modern, colorfully and extensively-illustrated account of numerous Old World palms, many of which are poorly known and rarely or never illustrated. The rattans, a group of palms mostly ignored in popular palm literature, are especially well illustrated. In many respects, the book is a badly-needed introduction and guide to Old World palms. The project resulted in new species and new published records of palm species for Thailand, the latter including 25 *Calamus*, 10 *Daemonorops*, and four *Korthalsia*, among others, and the collection of over 200 herbarium specimen vouchers, which are now accessible to Dransfield and his co-workers.

Phrases such as "The authors...show a certain irresponsibility and disregard of taxonomic convention" and "It could have been written honestly and rapidly without compromising taxonomic convention" question my integrity. I was honest and sincere in all my work for this book, as I have been in all my other work.

DONALD R. HODEL
Senior Author and Editor
The Palms and Cycads of Thailand

Horticulture Column

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Q. We have a foxtail palm, *Wodyetia bifurcata*, planted in a prominent spot in our retail nursery. It grew well for several years but began to decline about six months ago. About two months ago, we noticed that the lower part of the trunk was oozing a thick sap (Fig. 1) and now it really looks like it is dying. Although this palm is planted in well drained soil, it is situated in a nursery area with containerized plants that receive irrigation on a nightly basis, so perhaps the soil is too wet. We would like to plant another if we can avoid losing it again. Kevin Riley, Florida.

A. To begin, I must confess that this palm was planted at the nursery where I am employed, and that I am the one who planted it. Close examination of the lower trunk of the dying palm and a little research led my colleagues and me to conclude that it was infested with ambrosia beetles. A wire 1 mm in diameter could be inserted into the tunnels or galleries made by these insects. Also, we were able to see the plugs of chewed up trunk material called frass that they push out of their galleries. In Florida, ambrosia beetles are members of the genus *Platypus*. Similar insects are found in many parts of the world, mostly in warmer regions. Ambrosia beetles can be economically important pests of recently cut, untreated timber, but they usually do not infest dried lumber or healthy living trees. Likewise with palms, they seek trees that are already dying from root, trunk or bud rot diseases. It might be possible to kill ambrosia beetles by spraying the trunk at the entrances to their galleries, but this action would not save the palm. The insects do not eat the wood of the palm trunk; rather, they feed on a fungus that they introduce and grow within the galleries they have created. This fungus is not pathogenic and is different from the fungus that may have been killing the palm.

After removing our dying foxtail palm we sawed the lower portion of the trunk into halves, lengthwise. This task was easier than it sounds since the trunk was nearly rotted through. We were fairly certain that the actual cause of death was a trunk-rotting fungal disease. By covering and sealing one of the trunk sections in a large

plastic bag for four days we could see the fluffy white mycelium of the fungus advancing on the last bit of unrotted tissue near the base of the trunk. This disease could be any of several that can cause the death of a palm by rotting through its trunk.

In our experience, plants are often made susceptible to disease by one or more cultural conditions. Often these conditions are different than those which the species, in this case *Wodyetia bifurcata*, would experience in its natural habitat. The daily irrigation that our foxtail palm received was likely a contributing factor to its disease susceptibility, but a quick look at the base of the trunk revealed the simple and avoidable mistake that led to its death. In Figure 4 the lower finger indicates the point on the trunk that would be considered the correct planting depth, while the upper finger shows the actual level of the soil and mulch around the palm. Our palm was about 10 cm (4 in.) too deep. Particles clinging to the trunk showed that the palm was originally planted 5 cm too deep in the sandy soil, and another 5 cm of gravel mulch were added later.

We hope this palm "post mortem" will help others avoid making the serious mistake of planting too deeply or of piling mulch up close to the trunks of their palms. It is a difficult lesson to learn by trial and error. Our foxtail palm was small when it was planted. It grew very nicely for several years and increased in size rapidly. It is very easy in such a case to blame the palm's death on insects or disease rather than improper planting and maintenance. We plan to plant another foxtail palm in our nursery, but in a place which is not so heavily irrigated.

Q. At the base of our four-trunked *Chamaerops humilis* there are suckers (new shoots). Is it possible to divide and transplant them successfully, even though there are no roots on them? Sam Edwards, California.

A. Theoretically, I suppose, it is possible to separate successfully and grow an offshoot or sucker from any multi-trunked palm. The degree of difficulty might range from that of *Pinanga coronata*,



1 (left). An early indication of trouble with this *Wodyetia bifurcata* was the presence of thick, gummy sap on the lower trunk. 2 (right). The lower finger indicates the base of the trunk which is the correct planting depth; the upper finger shows how deep the palm actually was, a difference of 10 cm (4 in.).

which is very easy to divide, to *Allagoptera arenaria*, which I have tried to divide a few times but always without success. Other familiar palms that one may propagate by division include species of *Areca*, *Dypsis*, *Cyrtostachys* and *Chamaedorea*. Since there may be some risk to the parent plant, you should consider carefully whether it is worth trying to divide a rare or valuable palm.

Those species that produce additional stems some distance from the parent plant by means of stolons, such *Chamaedorea stolonifera*, are especially easy to divide. Simply cut the stolon, dig up the young plant and plant it in a pot. In this case, there is little risk to the parent, and chances for success are good.

It will be a difficult task to make a new plant from an unrooted sucker of *C. humilis*, but with time and patience perhaps you can do it. It will not be possible simply to remove and plant the unrooted sucker; it must be encouraged to produce some roots first. To begin, select a sucker the diameter at the base of which is close to that of a mature trunk, then carefully dig to try to expose the point at which the sucker is connected to the parent

plant. Tools that will be helpful aside from a shovel might include a brush to sweep away soil, a hand trowel for digging in tight spots and a water hose to rinse dirt away from the area where the sucker joins the parent plant. Once this area is located and exposed use a thin saw to cut halfway through the point of connection. You may wish to dust this cut area with sulfur to prevent fungal diseases. Replace the soil around the base of the partially severed sucker. In about six weeks you can carefully re-excavate the base of the sucker to see if any roots have formed, being careful not to injure them. If a number of roots are present, use a saw to cut through the remainder of the connection between parent plant and sucker and once again replace the soil. Wait another six weeks or so for additional roots to form and then dig and remove the plant, again, trying to avoid injuring the roots. It would be best to establish the new plant in a container before planting it in a permanent site. This really is a lot of work to make a new plant of such a common species. You may wish to purchase a young *C. humilis* instead.

