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PRINCIPES

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Contents for January

Cover Picture

Cocos nucifera, the coconut, towers above fruit trees in the village orchards of Kandy, Sri Lanka. Photo by J. Dransfield. See editorial.

PRINCIPES

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Editorial

The first issue of *Principes* 1989 has two new features. Color covers, resulting largely from the efforts of Pauleen Sullivan, do better justice to the beauty of palms and should make our journal much more attractive. The most important palm, the coconut, also a romantic symbol of the tropics, seems appropriate for *Principes'* first front cover in color, and for the back cover, *Corypha*, renowned among other things for having the largest inflorescence among seed plants, also deserves special recognition. The second feature, a new editorial page, allows us to comment on our authors and the importance of their articles and to bring other items of interest to your attention.

The International Palm Society has some 3,000 members from all parts of the world. Members are of many professions, ranging from those with an amateur or professional interest in growing palms to scientists of many kinds. What unites us is our common love of palms. Now that The Society has become so large, we must all be aware that *Principes* is the organ of a diverse membership, and furthermore is the one journal that reaches every Society member. From time to time at meetings of The Board of Directors, the contents of *Principes* have been reviewed and recommendations made. As editors, our primary concerns are that the articles should be of excellent quality and should mostly represent new information about palms. We also feel very strongly that whether the article is scientific or popular, the palm names and information in it must be accurate. Readers should realize that scientific articles need not be read word for word; they serve as sources to be consulted for desired information—such as the appearance and size of a new palm or its soil and temperature requirements.

When content is considered, we would like *Principes* to represent what is perhaps the most fascinating feature of palms—their remarkable diversity. It is because of their diversity that palms touch so many parts of our lives. If *Principes* includes articles on all the facets of life where palms are represented, certainly every Society member will find something of interest in its pages.

Recently we have been making special efforts to have each issue of *Principes* include a mix of articles ranging from the scientific to the popular. Our most serious problem has been a dearth of good quality popular articles. We encourage all of you out there with your wonderful palm collections to write about them. At every Biennial meeting we encounter members with interesting palm anecdotes or observations—on unusual growth, flowering behavior, or just stories about the particularly splendid palms in their collections. We always urge, "Write it up for *Principes*," but we very very rarely receive such articles. In this issue we announce a new contest. Please write about your experiences; we'll assist by typing, editing, or in any other way we can. Let's make *Principes* what you want it to be.

Some Comments on the Papers in This Issue

The articles in this issue provide new information on a large variety of subjects.

A serious problem faced by coconut breeders is the difficulty of propagating elite strains vegetatively. Some palms occasionally produce bulbil-shoots instead of inflorescences and these shoots could in theory be used for propagation. Jack Fisher of Fairchild Tropical Garden and Bill Theobald of the Florida Forest Division have investigated the possibility of inducing bulbil-shoots in mature coconuts by applying growth substances.

Some diseases of the oil palm and coconut are spread by bugs belonging to the genus *Lincus*, but the natural habitats of these vectors have not been known. Guy Couturier and Francis Kahn report that in Peruvian rain forest their natural habitat is on species of *Astrocaryum*. It's interesting that these bugs live naturally on a palm but a most important question is whether the bugs on the cultivated palms originate from the forest.

A different relationship of bugs and palms is presented by James Herrera of Sevilla, Spain. James has studied pollination in wild populations of the well known and widely cultivated European fan palm, *Chamaerops humilis*. Information on pollination is needed for many palms and is useful in seed production as well as in evolutionary studies.

Bradford Hicks discusses the very early development and dispersal of another familiar fan palm, *Washingtonia filifera*. We suspect that some palms are very ancient plants; unraveling their prehistory leads to fascinating conclusions and requires input from many disciplines.

For those who like to travel, Rolf Kyburz introduces the diversity of palms to be encountered in some long established gardens of Italy and Switzerland. For growers, Ralph Velez describes an ingenious method of water treatment and Hershell Womble comments on growing palms in Florida. Finally we have a short feature by Chuck Hubbard on the flowering of *Corypha* last year in Florida and we introduce a new feature: "Palmy Extracts" by Bill Gunther.

JOHN DRANSFIELD
NATALIE W. UHL

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Long Term Effects of Gibberellin and Cytokinin on Coconut Trees

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ABSTRACT

Mature coconut (*Cocos nucifera* L.) trees were treated with a cytokinin, 6-benzyladenine (BA), or a gibberellin mixture of $GA_4 + GA_7$. Trunks were injected for up to six months, and each treated tree received a total of 0.2 to 1.2 g of growth substance. Trees were observed for up to 43 months after the start of treatments. BA had no visible effect. GA caused an initial precocious opening of flowers and abnormal elongation of seedless fruits. A series of elongated inflorescences and leaves followed. Inflorescences associated with the longest leaves aborted. The oldest expanding leaves at the start of treatment produced blades with undivided regions to varying degrees. The youngest or primordial leaves and inflorescences present at the start of treatment that grew out long after treatment showed no structural modification from BA or GA.

To date, coconut palms cannot be cloned, although tissue culture techniques have shown promise. The existence of rare individual trees of coconut and of other palms which produce vegetative shoots or bulbils in place of flowers or whole inflorescences (Davis 1967, 1968*b*, Padmanabhan 1976) demonstrate that various palms have the potential to change normally reproductive meristems into vegetative meristems. However, the cause of such unusual development is either unknown or presumed to be physiologically based (Henry and Schneidecker 1983). We attempted to modify the normal development of inflorescences of coconut by prolonged treatment with plant growth substances to produce vegetative structures, either side shoots or plantlets, in place of the usual flower-bearing structures. We chose two growth substances for our experiments. Gibberellins are known to affect growth of reproductive structures and leaves in other palms (Fisher 1980). Cytokinins are known to stimulate growth of lateral buds and modify meristems in general (Horgan 1984). If successful, such treatments would offer a way to vegetatively propagate desirable coconut trees by the possibility of air layering sideshoots (Davis 1968*a*, Davis et al. 1981, Sudasrip et al. 1978).

Our treatments did not induce vegetative proliferations, but the effects of the regulators on shoot development are of theoretical interest. Our findings of unusual leaf structure may also shed light on the mechanisms involved in the production of distorted leaves in palms infected by pathogens or deficient in some minerals. To our knowledge, this is the first report on the effects of prolonged treatment of mature coconut trees with either gibberellin or a cytokinin, although coconut seedlings have been previously treated with growth substances (Remison 1984, Schwabe 1976). We used a widely used synthetic cytokinin, benzyladeneine, and a mixture of two natural gibberellins, $GA_4 + GA_7$. Both of these growth substances are available commercially.

Materials and Methods

Experiments were carried out at the Division of Forestry, Coconut Seed Orchard located at the USDA-ARS Subtropical

Horticulture Experiment Station, Miami, Florida. Trees of *Cocos nucifera* L. var. Red Malayan Dwarf with 3–4 m of trunk were used. These were the tallest trees scattered randomly throughout the orchard. Two experiments were set up.

The first experiment used 23 trees. Injection treatments began in May 1984. For each injection a 7 cm-deep hole was drilled into the trunk 1–2 m above soil level, and the plastic tube of a Mauget Injector (J. J. Mauget Inc., Burbank, California) was driven into the hole. The injector unit was filled with 10 ml solution and pushed onto the tube. The solution was taken up within a few hours. After two days the tube was removed from the trunk, and the hole was filled with a wooden rod. Holes were drilled elsewhere in the trunk for subsequent injections. A similar injection method has been used with oxytetracycline solutions in treatment of lethal yellowing disease of coconut. Four treatment solutions were used. These were as follows:

1) High GA = 0.21 g $GA_{4/7}$ (a mixture of gibberellins 4 and 7) every 4 wk for 6 mo for a total dosage of 1.26 g per tree. This was the stock solution ABG-3035 (Lot 67-001BR) from Abbott Laboratories, North Chicago, IL 60064. Seven trees were treated.
2) Low GA = 0.021 g $GA_{4/7}$ every 2 wk for 5 mo for a total dosage of 0.21 g per tree. This was a 1:10 dilution of the stock solution with 50% ethanol. Six trees were treated.
3) High BA = 0.2 g 6-benzyladenine (=6-(benzylamino)purine) every 4 wk for 6 mo for a total dosage of 1.2 g per tree. This was the stock solution ABG-3034 (Lot 63-001BRC) from Abbott Laboratories. Five trees were treated.
4) Low BA = 0.02 g 6-benzyladenine every 2 wk for 5 mo for a total dosage of 0.2 g per tree. This was a 1:10 dilution of the stock solution with 50% ethanol. Five trees were treated.

A plastic ribbon marked the fifth visible green leaf (=fourth leaf after the spear) at the start of the experiment. This ribbon was lost in most trees because the tagged leaf abscised or broke off below the tag at times between observations. Although the edges of the injection holes darkened, no internal darkening or rot was seen in the treated trunks when the trees were cut two years after the holes were made. Adjacent trees in the Coconut Seed Orchard were controls and received no treatment.

The second experiment used eight trees, all of which received a high GA treatment consisting of a short but intense dose starting in May 1985. These received injections of 0.21 g $GA_{4/7}$ every week for 3 wk for a total dosage of 0.63 g per tree. Because of tree height, leaves could not be marked at the start of this experiment.

During the two year period of these experiments there was an outbreak of lethal yellowing disease in the coconut orchard. Some controls and seven treated trees in the first experiment died. There was no apparent relationship between susceptible trees and treatment. Location within the orchard, however, was significant. One tree in the second experiment died from bud rot. Selected trees were felled, dissected, and measured in October and November 1986. Young inflorescences and apical buds were fixed in FAA and later observed and measured using a Wild M5 dissecting microscope. Final observations of surviving trees were made in November 1987, 43 months after the start of experiment 1 and 31 months after the start of experiment 2.

A representative control tree was dissected and measured (November 1986) in order to understand the pattern of leaf and inflorescence development under local growing conditions.

Results

Untreated Control.—For all the following descriptions, leaf positions (=nodes) were numbered sequentially starting with the lowest attached leaf. Thus, the oldest leaf on a tree = 1. The spear leaf (or oldest if more than one spear) = sp. Inflorescences were numbered by their node (=number of the subtending leaf). Because the ends of many inflorescences were removed as part of the coconut breeding program, only the length of the peduncle, the lowest internode between the spathe and lowest rachilla or branch, was measured. Total leaf length and sheath length (=total − blade) were measured. Complete data for one tree is presented in Figure 1.

The control tree (Fig. 1) had 30 expanded leaves, the spear, plus two visible unexpanded leaves, and 26 leaf primordia within the bud. Leaf 31 was the spear leaf (=sp), defined by an essentially folded blade with little or no pinna separation. Leaves 32 and 33 (sp + 1 and 2 younger leaves) were also folded and visible. Leaf 29 (sp + 2 older leaves) appeared to have the youngest fully elongated sheath, and leaf 32 (sp + 1 younger leaf) had the youngest elongated blade. Leaf 30 (sp + 1 older leaf) had unfolded but still soft pinnae, and leaf 29 had a stiff blade flattened in one plane. The youngest fully elongated peduncle was number 21 or 22. Inflorescence 20 was fully exserted from the spathe. Some variation in leaf and peduncle lengths may be related to the season of their expansion, but the preceding year (1985–86) had a mild winter and thus a minimum climatic effect on growth. We have observed a noticeable shortening of leaves and inflorescences which expand after severe winter cold in other years. Plication of the blade occurs at about leaf 51 (sp + 20 younger leaves). Rachillae (=inflorescence branches) are first visible in inflorescence 36 or 37 (sp + 5 or 6 younger leaves). The bracts that subtend the first rachillae and that form after the spathe were first visible in inflorescence 40 (sp + 9 younger leaves). The youngest inflorescence bud was first visible as a meristematic ridge in the axil of leaf ca. 56 or 57 (sp + 25 or 26 younger leaves). The earliest evidence of the ridge was unclear in this specimen because the youngest four leaf primordia were damaged during dissection. However, sectioned apical buds from other coconut trees showed a clearly staining meristem in the axil of the second or third leaf primordium from the apex.

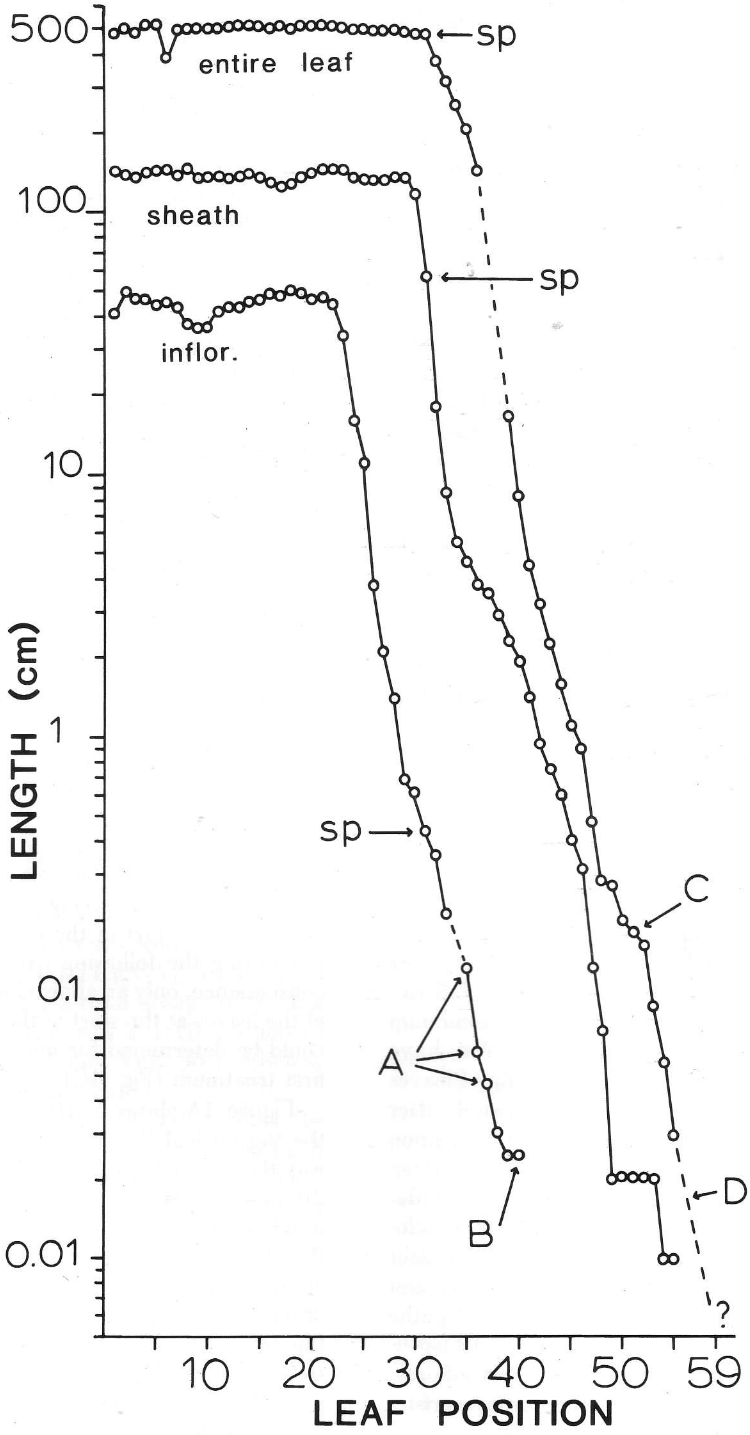
Gibberellin Treatment.—The first visible effect was a noticeable elongation of the upper inflorescences that broke through their spathes during the 6 month period of treatment, beginning 8 wk after the first injection. Both staminate and pistillate flowers prematurely opened before the peduncular bract split. Ovaries were abnormally elongated. These affected ovaries developed into small elongated fruits that lacked seeds (Fig. 2).

The second result of gibberellin treatment was a failure of pinnae (=leaflets) to separate. Undivided regions were seen first at the blade base of leaves several months after initial treatment (Fig. 3B).

The third result, visible only after all the original leaves of the crown fell more than two years after the start, was an elongation of stem tissues. This was seen in a region where leaf scars and internodes were longer than normal (Fig. 3A).

In all but two trees (Fig. 4A,B), the leaf tagged at the start of the experiment was lost during the following two years. As a consequence, only an approximate position of the leaves at the start of the experiment could be determined for most trees in the first treatment (Fig. 4C).

Figure 4A shows a tree which still had the tag on leaf 9, indicating that leaf 13 was the original spear and that a total of 20 new leaves had expanded in the 29 months since the start of treatment. From this graph (in comparison with the untreated control trees as in Figure 1) the following observations can be made with respect to the original leaf numbering *at the start* of treatment: 1) Inflorescences aborted at positions sp + 7 to 10 older; 2) Older inflorescences (sp + 11 and 12 older) were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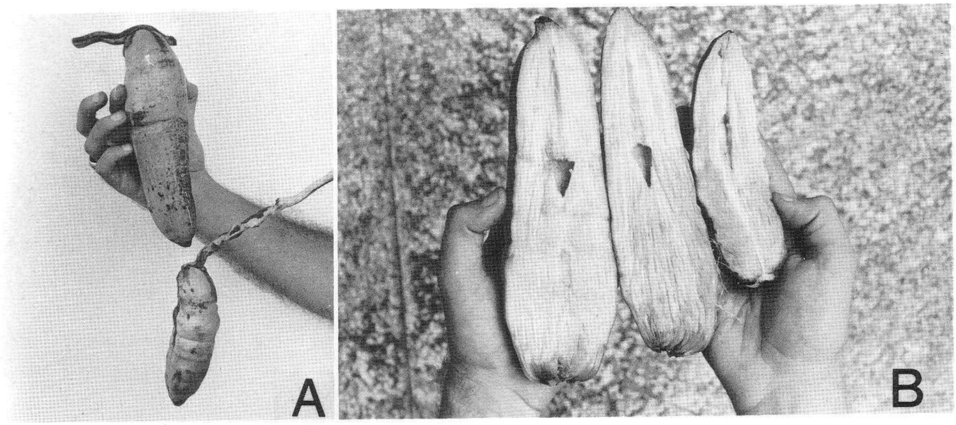

2. A. Intact fruits from high gibberellin-treated tree. B. Same fruits cut longitudinally.

elongated; 3) Total leaf lengths in sp + 4 older to sp + 11 younger were greater than control leaves; 4) Sheaths were elongated in sp + 11 older to sp + 1 younger; 5) Undivided regions occurred in the blades of sp to sp + 10 younger and followed a pattern described in the next paragraph; 6) Youngest leaves with undivided regions (sp to sp + 10 younger) and normally shaped new leaves (sp + 11 to 33 older) were shorter than control leaves; and 7) Internodes in the region of the undivided leaves were elongated (not shown in Fig. 4A, but similar to those in Fig. 7C).

Representative leaves with undivided regions (those indicated by solid dots in Figs. 4,7) are shown in Figures 5,6. The illustrated sequence approximates the pattern of these undivided blades which occurred in a single crown. The first elongated leaves had normal blades and elongated sheaths which frequently broke between the blade and the node. This is why so many tags were lost. The last-formed, elongated leaves had more of the lower blade region undivided (Fig. 5A–C) with less pinna separation in older leaves (Fig. 5D–F). Later leaves had both the middle and tip of the blade remaining undivided (Figs. 3B and 6A,B). The undivided regions were always plicated but varied in having the blade continuously attached to the rachis (= midrib) as in Figure 6C or having only the distal ends of the pinnae joined with separated pinna bases attached to the rachis (Fig. 5C,E) similar to normal leaf. In all the last-formed leaves with undivided regions only the blade tip had joined pinnae.

Trees treated with low GA (Fig. 4C) had fewer elongated undivided leaves and, as a consequence, had more normal leaves produced after the treatment effects showed themselves. Rate of leaf production was not obviously different between high and low GA, since total leaf production per tree varied as seen in Figure 4. The number of leaves that had expanded (after the tagged leaf) was 23 in A, 18 in B, and ca. 24 in C. However, because of the loss of

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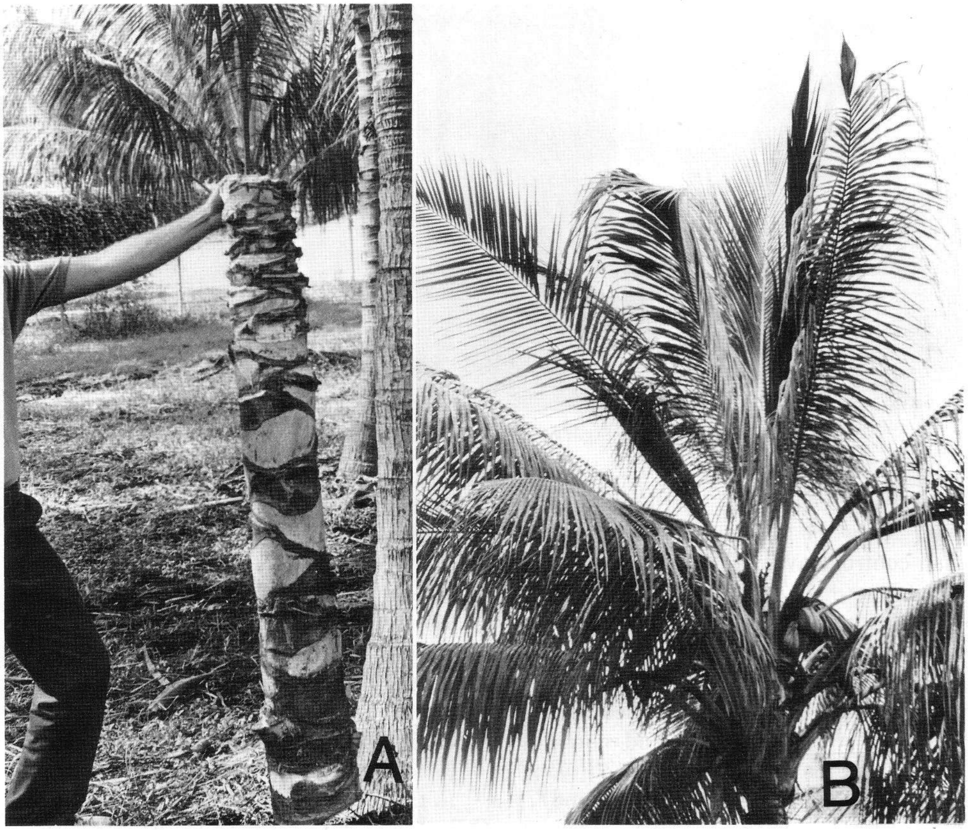
←
1. Length (on logarithmic scale) of entire leaf, sheath only, and inflorescence peduncle for successive leaf positions of an untreated, control tree. Leaf positions begin with the lowest attached leaf. sp = position of spear leaf (no. 31). A = earliest indication of rachillae (nos. 36–37). B = sign of first rachilla bracts after the prophyll and peduncular bract (no. 40). C = first sign of leaf plications (no. 51). D = leaf primordia nos. 56–69 damaged during dissection. ? = position of shoot apex (no. 60). Broken connecting lines indicate intervening missing or incomplete data.



3. High gibberellin-treated tree. A. Trunk with leaves cut off to show the region of stem elongation. B. Crown of tree with pinna fusion on new leaves 16 months after start of second experiment.

tags, the number of new leaves produced per tree could not be accurately determined for each treatment.

In both high and low GA trees, the expanded inflorescences had normal peduncle lengths and were not structurally different from those of the controls. Dissected, unexpanded inflorescence buds also appeared to be normal. In three trees treated with low GA, which were still growing 3½ years after the start of treatment, all leaves and inflorescences were normal.

The second experiment was a shorter but more frequent treatment with high GA. Since trees in the second experiment were cut and measured 17 months after the start (compared to 29 months in the first experiment), the tree crowns lost fewer original leaves and showed a more complete sequence of GA effect on leaves and

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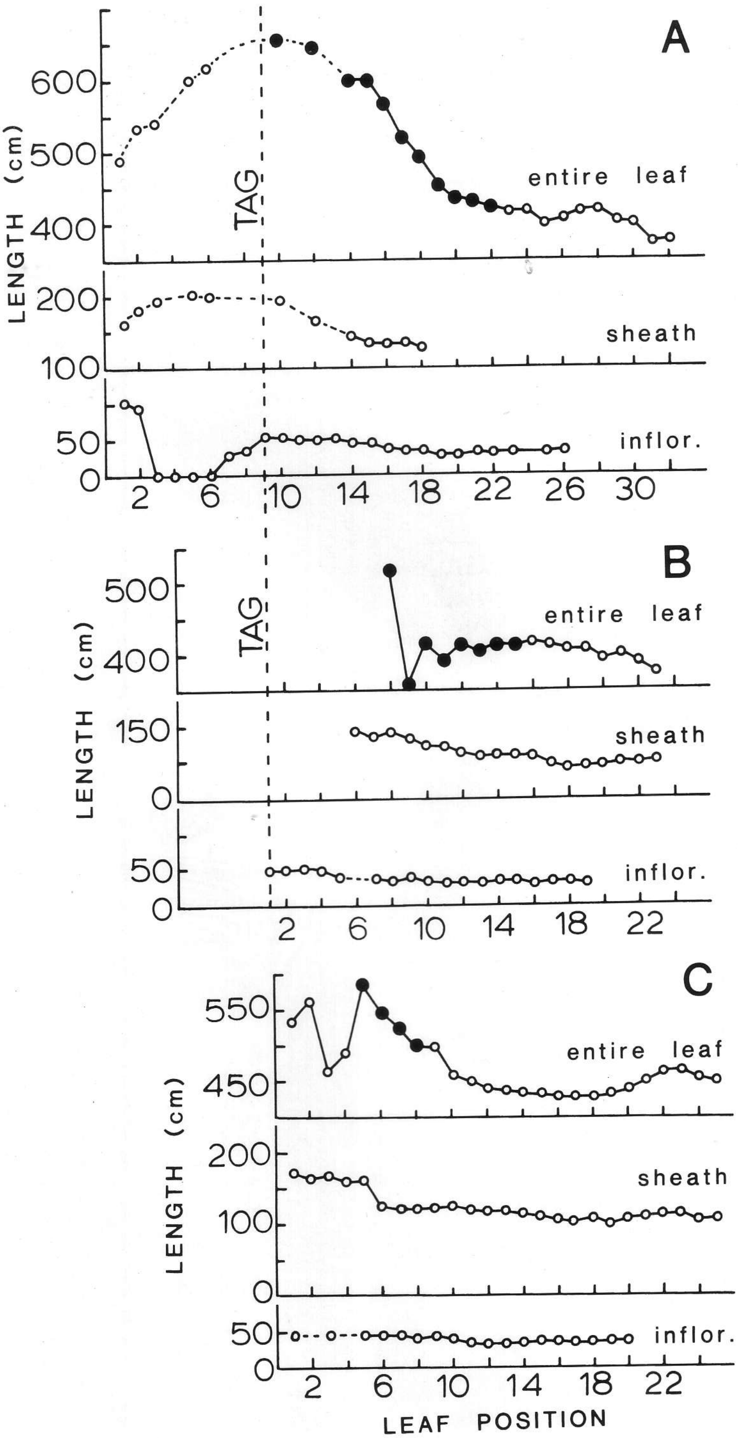
4. Length (on arithmetic scale) of entire leaf, sheath only, and inflorescence peduncle for successive leaf positions on high gibberellin-treated trees of first experiment. Trees A and B were high GA; tree C was low GA. In trees A and B the original tagged leaf was still present = vertical broken line. Thus, in tree A, leaf 13 was the spear at the start of treatment 29 months earlier. In tree B, leaf 5 was the spear but leaves 1–5 were broken off in their sheath regions. Tree C lost its tag but is shown in its estimated relationship to A and B. Open dots = normal leaves; solid dots = blades with pinna fusion. Broken connecting lines indicate intervening missing or incomplete data. Leaf position starts with the oldest and ends with the youngest expanded leaf.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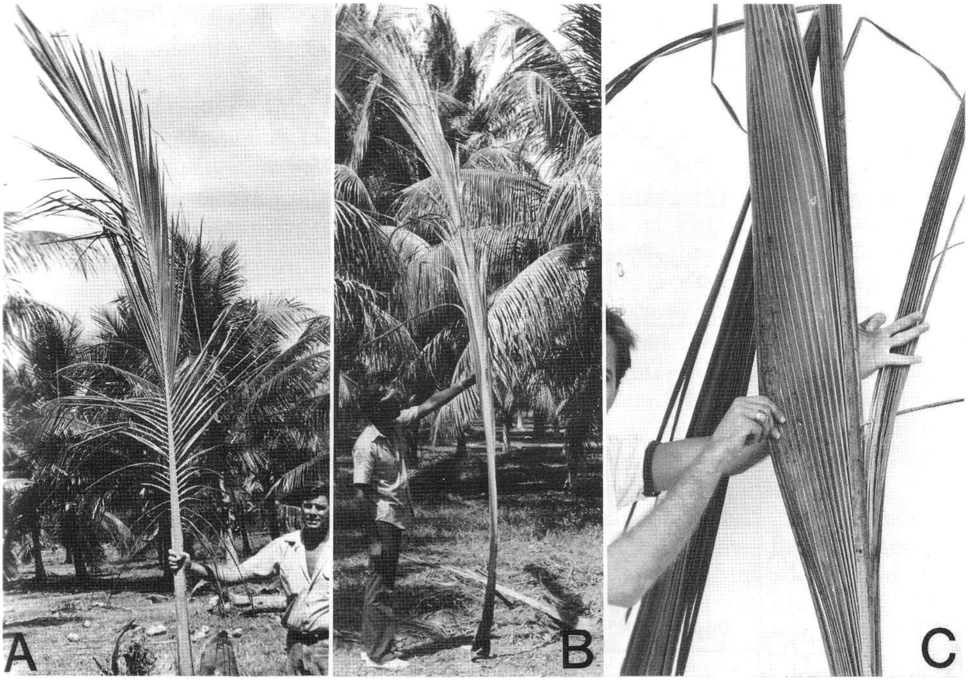

6. Leaves of high gibberellin-treated trees showing increasing amount of pinna fusion. A. Upper half of blade with pinna fusion. B. Most pinnae of blade fused to various degrees. C. Close view of fused pinnae in lower third of blade.

inflorescences before and after treatment (Fig. 7). Following the leaf positions from the base of the crown, there was an increase in leaf length due initially to sheath elongation and then both sheath and blade elongation. Undivided blade regions appeared after the longest leaves and continued for 9–10 leaves. These leaves showed the same trend in the position of the undivided regions as in the first experiment (Figs. 5,6): first the base, then the middle, and lastly the tip of blade. The last-formed leaves are equal in length to or shorter than leaves produced before the start of treatment.

Inflorescences axillary to the first elongated leaves (and also after the longest leaves in Fig. 7A) aborted. All those inflorescences expanding later were normal in structure. Dissected, unexpanded inflorescence buds had normal structure. Inflorescences opening shortly after the start of treatment produced abnormal, elongated fruits (as in Fig. 2) which did not mature. Four trees which were still growing 30 months after the start of treatment had normal leaves above the fused leaves and 10–12 normal inflorescences expanded above the last of the fused leaves.

Internodes and leaf insertions were elongated in positions of elongated leaves (Fig. 7C) as in the first experiment.

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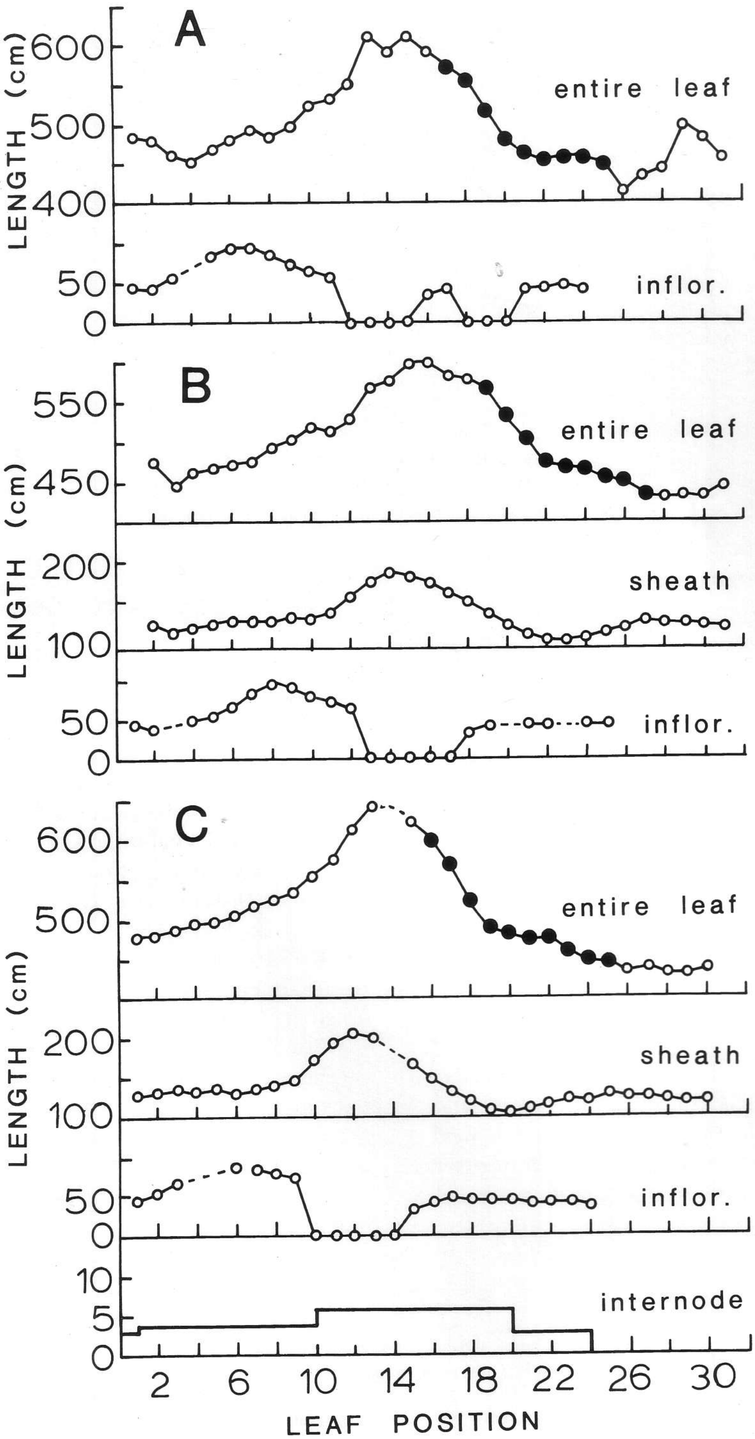
5. Leaves of high gibberellin-treated trees showing increasing amount of pinna fusion. A. Only lower-most pinnae fused and region very elongated. B. Only lower pinnae fused and little elongation. C. More lower pinnae fused. D. Pinnae fused in lower fourth of blade. E. Lower half of blade fused with some free basal pinnae. F. Lower two-thirds and tip of blade fused.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LEAF POSITION

Cytokinin Treatment.—There was no visible effect of either high or low BA on leaf length, blade shape, and inflorescence length or structure from the beginning of treatment until 42 months later. All were similar to those of the untreated controls. Fruits developed normally, and no obvious inflorescence abortion occurred.

Discussion

The mixture of gibberellins 4 and 7 promoted elongation growth of the trunk, leaves, inflorescence axis, and fruit. In all of these organs only those at the end of their growth were affected. Thus, newly exposed ovaries produced elongated but seedless fruits; inflorescences that were already expanding or about to push out of their enclosing bracts developed elongated peduncles; leaves near the spear stage and those most recently fully elongated became stretched; and internodes associated with the elongated leaves were themselves elongated. Many elongated leaves were up to 12–13 nodes below the spear at the start of treatment (Fig. 4A). This indicates that GA caused fully expanded leaves yet presumably not fully matured leaves, which were located below the tagged leaf (the third or fourth leaf below the spear) to elongate abnormally. Only the sheath was elongated in the oldest leaves. In younger leaves most elongation occurred in the blade, as evidenced in the shift of curves for sheath and entire lengths in Figure 7.

The undivided blade regions in sequential leaves generally follows a pattern starting at the base of the blade of early leaves and ending at the tip of the blade in later leaves. This is opposite to the general pattern of tissue elongation and maturation, which starts at the tip of the blade and moves down to the sheath as the leaf expands (Fig. 1 and Fisher 1978). Thus, GA blocks pinna separation only in those parts of the blade which are still enlarging at the time of treatment. All parts of the blade, including undivided regions, still have plications or foldings. Those leaves just initiating plication (sp-20 at the start of treatment) or increasing the numbers of plications showed no blockage of pinna separation when they finally emerged from the bud 20 plastochrons or about 30 months later. Thus, GA appears to act only on later stages of leaf development after all plications have been formed (Dengler and Dengler 1984, Dengler et al. 1982, Kaplan et al. 1982). Similar undivided blades (called "pinnae fusion") caused by GA was noted in other species of palms with pinnate and palmate leaves (Fisher 1980).

The earliest stage of leaf development, e.g. initiation of plications (Fig. 1C), and of inflorescence development, e.g. rachilla initiation (Fig. 1A) or bud initiation (Fig. 1D), were all unaffected by GA or BA in our experiments. Leaves and inflorescences which were at these early stages at the time of treatment finally grew out some 19–20 plastochrons or 28–30 months later and were quite normal. Both high and low GA treatments had an obvious effect on later developmental events. It is unclear if the ineffectiveness at earlier stages was due to an inability of these stages to alter development or because the level of GA in the young leaf and inflorescence primordia was too low.

Inflorescence abortion occurred at the four to five nodes associated with the longest sheaths and at nodes distal to the long-

←
7. Length (on arithmetic scale) of entire leaf, sheath only, and inflorescence peduncle for successive leaf positions on high gibberellin-treated trees of second experiment. In tree C the average lengths of internodes are also presented. Open dots = normal leaves; solid dots = blades with pinna fusion. Broken connecting lines indicate intervening missing or incomplete data. Leaf position starts with the oldest and ends with the youngest expanded leaf. Measurements taken 17 months after start of treatment.

est inflorescences. These positions were the seventh to tenth nodes below the original spear leaf. This is the region of stem elongation that has been documented in other palms (Fisher 1978).

A basic difficulty of interpreting our observations is the long plastochron interval, the time between expansion, and presumably initiation, of successive leaves. In treated trees the average plastochron interval was about 1.5 months during more than two years for treatment 1 and about 1.1 months for treatment 2. Control trees have an average interval of about one month, longer in the winter and a little shorter in the summer. Therefore, periodic treatments over a three-week (experiment 2) or six-month (experiment 1) period encompased either part of one or about four plastochrons, respectively. For interpreting developmental effects, the short burst of experiment 2 is more useful. For inducing major changes in development, i.e., the original goal of modifying inflorescences, the long term treatment 1 is preferable. However, we have no information on how long GA remains at effective concentrations in the tree after the last injection.

Two methods for applying growth substances to small palms have been used: periodic foliar sprays and feeding trough cut leaf tips. Neither GA nor BA had an effect on plant height, number of suckers, or "flower number" (presumably number of inflorescences was meant) in seedlings of *Chamaedorea* after a year of monthly spray treatments (Broschat and Donselman 1986). Spraying leaves of small coconut seedlings with GA_3 or the cytokinin kinetin had no effect of leaf length when measured a year after treatment, although these growth substances affected the dry weight of roots, stem, and leaves at some concentrations (Remison 1984). Leaf tip feeding with different gibberellins on several palm species (*Caryota, Chamaedorea, Chrysalidocarpus, Elaeis, Phoenix,* and *Rhapis*) showed that GA_3 and GA_4 + GA_7 were equally effective, while GA_{13} had little effect on promoting elongation of leaves and fusion of pinnae. Only *Rhapis* was old enough to flower, and GA inhibited flowering, although the basis for this response (bud abortion or lack of bud initiation) was not determined (Fisher 1980). Leaf feeding of seedling coconut with GA_3 resulted in similar pinna fusion (Schwabe 1976).

The application of GA_3 to flowers of *Phoenix* caused seedless fruits to develop (reviewed by Mohammed 1985), similar to the earliest effect of $GA_{4/7}$ in coconut—the production of elongated, seedless fruits on those inflorescences having newly exposed pistillate flowers at the start of treatment.

Partially undivided blades were reported and illustrated in coconut trees attached by leaf-eating beetles (*Plesispa* sp.) by Davis et al. (1985: 104). These abnormal leaves look similar to those in GA-treated trees (Figs. 5,6). Thus, raised gibberellin levels might be present in the infected trees, although Davis et al. (1986) suggested injury-induced drying of tissues caused leaflet margins to remain attached to each other. Undivided blades have also been seen by T. A. Davis (personal communication) in adult trees after rhinoceros beetle damage and in seedlings after drought.

Small abnormal leaves with only partly divided leaves occur in rare coconut trees in South India (Patel 1938). Such leaves are produced continuously over many years after the seedling stage (T. A. Davis, personal communication). They may be genetically based and related to disturbed endogenous levels of gibberellin. Undivided and distorted leaves also are symptomatic of boron deficiency again suggesting giberellin involvement.

Since high and low BA concentrations had no visible effect, we do not know if the cytokinin was even present in the regions of growth at elevated or effective concentrations. Broschat and Donselman (1986) found no effect of foliar sprays of BA on *Chamaedorea* seedlings.

We conclude that the trunk injection

method can be used to introduce effective doses of GA into coconut palms. Repeated injections can maintain GA levels that modify shoot growth over long periods. Although no significant changes occurred in inflorescences following our six-month treatment with high GA, a longer treatment period might still be successful in modifying the youngest buds.

Acknowledgments

We thank Jennifer H. Richards for commenting on our manuscript and T. A. Davis for sharing his wide experience with coconuts. José Panero and Garry MacDonald assisted with injections. Abbott Laboratories donated growth substance solutions. Research was supported in part by the National Science Foundation under Grant No. PCB-8300986.

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New Director of IPS Dies Unexpectedly

Iris Bannochie of Adromeda Gardens, Barbados, a new director of IPS, and good friend of many members, died suddenly, early in September. April *Principes* will include more about Mrs. Bannochie.

Principes, 33(1), 1989, p. 18

Palmy Extracts

from literature published from 1864 to 1939
compiled by Bill Gunther

"In a beautiful cathedral—, that of Las Palmas in the Canary Islands, the foundations of which were laid in the time of Ferdinand and Isabella of Spain, the exquisite pillars, characteristic of the city, are representations of palm trees."

from THE PALM TREE, by S. Moody, published in 1864.

"That noble palm, Maximiliana regia (eds. = M. Maripa),—one of the most conspicuous elements of the primitive forests of the Amazon, is still more frequent in the Casiquiari Region *andregia* (eds. = M. Maripa) is commonly seen perched on the granite peaks.—It probably existed there at a period when the surrounding low country was one great lake—out of which stood these island peaks."

from PALMAE AMAZONICAE, Richard Spruce, 1871.

"Some officious botanist removed the saw palmetto from the genus Sabal and made it a monotypic member of a new genus Serenoa—. There was no occasion for such a change. It only renders the study of botany more difficult and serves no practical use."

from SAW PALMETTO, by Edwin M. Hale, published in 1898.

"—Palms, the loftiest and noblest of all vegetable forms, that to which the prize of beauty has been assigned by the concurrent voice of nations in all ages; for the earliest civilization of mankind belonged to the countries bordering on the region of palms and to parts of Asia where they abound."

from EQUINOCTIAL REGIONS OF AMERICA, Alexander Humboldt, 1894.

"My attention was attracted one morning by a jar on the dining-saloon table marked "Miel de Palma," palm honey. It proved a delicious addition to griddle cakes and one of the most delicate syrups I had ever tasted. It was made from the sap of a large native palm, Jubaea spectabilis, groves of which were found along the dry coasts of Peru and Chile. In order to procure the sap, the trees must be cut down."

from THE WORLD WAS MY GARDEN, by David Fairchild, 1939.

"Tasting the quality of anything so sweet as dates may sound like a pleasant job. However, although eating a dozen may be a pleasure, tasting two dozen is less enjoyable, and eating three dozen at once will ruin any stomach as surely as a rough sea voyage."

from THE WORLD WAS MY GARDEN, by David Fairchild, 1939.

Principes, 33(1), 1989, pp. 19–20

Bugs of Lincus spp. Vectors of Marchitez and Hartrot (Oil Palm and Coconut Diseases) on Astrocaryum spp., Amazonian Native Palms

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The bugs of genus *Lincus* (Hemiptera: Pentatomidae: Discocephalinae) are considered vectors of *Phytomonas* palm diseases: 'marchitez sorpresiva' of the African oil palm, *Elaeis guineensis* Jacq. (Desmier de Chenon et al. 1983, Desmier de Chenon 1984, Perthuis et al. 1985), and hartrot of the coconut tree, *Cocos nucifera* L. (Desmier de Chenon et al. 1983, Louise et al. 1986). The occurrence of *Lincus* in primary forest was suggested (Louise et al. 1986); however, nothing on the natural habitat of the bugs is known.

Lincus spp. have been found on Amazonian native palms: 1) in Peru on *Astrocaryum macrocalyx* Burret (*Kahn & Mejia* 2057, USM) in the lower Ucayali River basin, on *A.* sp. aff. *A. macrocalyx* Burret (*Kahn & Llosa* 2094, USM, NY) in Madre de Dios, and on *A.* sp. aff. *A. murumuru* Mart. (*Kahn* 2031, NY) in the upper Huallaga valley; 2) in French Guyana near Cayenne on *A. murumuru* Mart. (*de Granville* 7222, CAY).

Specimens of *Lincus* were collected and sent to Dr. Rolston who considered them to be undescribed species.

The presence of both imagos and larvae on the palm trees suggests that the bugs carry out their whole biological cycle there. The frequency and density of bugs were both very high. They were found on 21 (36.8%) of the 57 *Astrocaryum* trees dissected. One to sixty bugs were counted per palm, although the use of an axe to cut down the palms and of a machete to dissect them may have allowed the escape of an unknown number of insects.

The four species of *Astrocaryum* form dense populations in periodically flooded forests. *A. macrocalyx* and *A.* sp. aff. *A. macrocalyx* are single-stemmed palms with a trunk up to 5 m in height. *A. murumuru* and *A.* sp. aff. *A. murumuru* are multistemmed palms with clusters of 2–6 axes (generally one adult and several juveniles) which develop trunks up to 3–4 m in height. All four species have large leaves, 6–7 m in length. The sheaths of dead leaves persist on the trunk forming a strongly armed muff which shelters ants, termites, larvae of curculionid and scarabeid beetles, spiders, scorpions, and snakes.

Lincus spp. were found inside the sheaths of the intermediate and lowest green leaves of the crown, among the spines on the back of the petiole. The bug is brown-black as are the spines, which makes the insect difficult to detect, except by its odor.

No bugs were found on *A. macrocalyx* near Manaus, Brazil; however, only one palm was cut down and examined. Bugs were sought without success on other species of the genus *Astrocaryum* (*A. chambira* Burret in Peru; *A. aculeatum*

Meyer, *A. horridum* Barb. Rodr., *A. munbaca* Mart., *A. sociale* Barb. Rodr. in Brazil; *A. paramaca* Mart., and *A. sciophilum* (Miq.) Pulle in French Guyana). Likewise, no bugs were found on palms of other genera examined in Peru (*Elaeis oleifera* (H.B.K.) Cortés, *Jessenia bataua* (Mart.) Burret, *Iriartella stenocarpa* Burret, *Mauritia flexuosa* L.f., *Pholidostachys synanthera* (Burret) H. E. Moore, *Phytelephas microcarpa* Ruiz et Pavon, and *Orbignya polysticha* Burret).

Bugs of the genus *Lincus* seem to be associated with some very closely related species in the section *Ayri* Drude of the genus *Astrocaryum*, all of which are found in seasonally flooded habitats. The relationship of *Lincus* with *Astrocaryum* is now being studied throughout the Amazon basin, and the possible role of *Astrocaryum* spp. as sources of *Phytomonas* is being analyzed.

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Prizes Offered for Palm Photographs

The editors announce a new contest: Submit your best Kodachrome slide or color photograph of a palm or palms with a short write-up to accompany it.

First Prize: membership in IPS for three years
Second Prize: membership in IPS for two years
Third and Fourth Prizes: a one year membership for each

The deadline for contributions is 1 July 1989. Judges will be the editors of *Principes* and two other persons.

Principes, 33(1), 1989, pp. 21–26

The Apung Palm: Traditional Techniques of Sugar Tapping and Alcohol Extraction in Sarawak

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In Sarawak the nipa palm, *Nypa fruticans* Wurmb, is commonly known as *apung*. It occurs as a narrow fringe along the banks of many minor rivers but may form dense stands, usually with some admixture of mangroves, covering extensive areas of mud flats in some of the larger estuaries. The palm is an important forest product because its various parts are utilized traditionally by the local people particularly Malays. Nipa exploitation in this East Malaysian state is mainly for sugar and alcohol extraction. The areas fringing the tidal river banks of the Batang Samarahan (stretching from Sambir to Tambirat), Batang Sadong (in the Pendam-Sebangan area), Batang Saribas and its tributaries (around Pusa and Spaoh) and Sungai Kerian (at Kabong) represent the major sugar producing districts. The sugar or *gula apung* is sold to consumers in various parts of the state and also to three distilleries (two in Kuching and one in Sibu) which make use of both refined and nipah sugars for production of alcohol and local wines. Longhouse communities use the nipa sugar for making an alcoholic drink referred to as *chap lingkau* or *arak*.

The nipa palm does not bear flowers all the year round, the flowering season being between June and September. Due to varying climatic conditions which fluctuate from one year to the next, the palms may flower as early as May or prolong into the month of October. There are two tapping seasons. The first season is the tapping of the *mayang*, the colloquial term for inflorescences about 1½ months old before the fruits are formed, and the other is the tapping of old inflorescences bearing fruits of 4 to 5 months old. The term for these infructescences is *termantu*. The tapping season for *mayang* lasts about 3 to 4 months commencing in July. The tapping season for the *termantu* usually commences around October or November and may end just before the next flowering season. Prior to tapping a massaging treatment or *goncang* that involves regular bending and twisting of the stalk is required. For the *mayang*, the tappers usually shake and lightly beat the flower stalk once a day (usually in the morning) for about four consecutive days before it is tapped the next day. In the case of the *termantu*, it is shaken and lightly beaten once a day about three to five consecutive days and then left for a week. This is repeated for two more times before the infructescence can be tapped, the whole procedure requiring about a month. The massaging is said to increase the flow of sap since it prevents the cells from hardening and atrophying as the stalk matures. One inflorescence stalk can flow (produce sap) for about two to three months depending on the length of the stalk; naturally the length of the *mayang* is shorter than that of the *termantu*. Yield of sap is sensitive to atmospheric humidity. Yields are high when transpiration takes place to a lesser degree on dull and cloudy days or in the night when relative humidity values are higher and temperature drops.

1. Nipa swamps in Sarawak, East Malaysia. The palm grows extensively along tidal river banks often as narrow fringe vegetation.

Tapping means that the inflorescence/infructescence stalk is cut and the sap that exudes is collected. Normally the stalk is scraped clean of fallen debris before a cut is made about 10 cm behind the head. A bamboo joint is then placed with the cut end of the stalk inserted through a hole at its side to collect the sap as it flows. The joint is further installed in a vertical position by means of a stick support. During sap collection usually in the morning, the tapper pares a very thin slice off the cut end and repeats this once more in the evening to keep the wound fresh and to facilitate exudation. On average the number of inflorescences/infructescences tapped varies from 145 to 272 per day. In Tambirat where most of this information was collected, one person working the whole morning can collect up to 180 bamboo joints as well as replace them with fresh/clean joints followed by retapping. Actual collection starts at 7:00 A.M. and ends at 10:00 A.M. As the sap arrives (each time about 20 to 30 bamboo joints packed into a rattan basket known as *ambin*) at the processing center, the sap is poured into a huge open pan or cauldron called the *kawah* which is placed over an earthern furnace or *keran*. A full *kawah* can hold 120–130 liters of sap. The bamboo joints emptied of sap are normally placed upside down on a shelf (or *para*) built above one side of the fire place to drain off remaining liquid and to dry by the heat from the fire. The furnace is fuelled by mangrove firewood. As more sap is poured into the pan a circular structure made of bark or sometimes hardboard is placed on top of the *kawah* to prevent the foam from overflowing as the sap boils. The circlet of bark is known in Malay as a *subang* or *kelingkang*. At times the white foam that rises during boiling to the top of the liquid in the *kawah* is skimmed off into jars where the solution that results ripens to vinegar

2. Close-up of the developing inflorescence known as the *mayang* to the local Malays. 3. The *termantu* or infructescence with maturing fruit head. 4. The inflorescence cut and inserted into a bamboo joint through a hole at its side. Sap that exudes from the cut end collects into the receptacle. 5. This lot of bamboo joints, in a rattan basket known as *ambin*, is taken along on each sap collection trip to replace those installed on tapped palms the day before. About five to six trips are made in one morning.

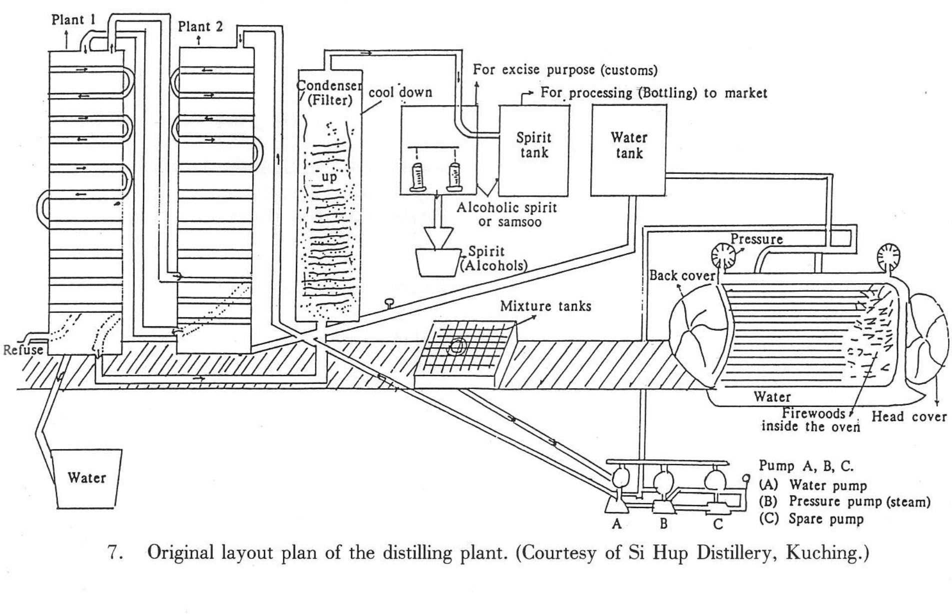
after a few weeks. During the heating process which lasts from 7:00 A.M. to 12:00 noon or sometimes as late as 2:00 P.M., constant stirring is required to facilitate evaporation and transformation into a dark yellowish or brown paste. The *kawah* with the paste is then removed from the fire and placed on the ground where it is further stirred for another half to a full hour with a special coconut scoop or *senduk*. A full pan of sap makes about 18–20 kg or ¾ of a biscuit tin (18.2 liters capacity) of sugar. Good quality sugar made in this way is hard, dry, light brown to almost yellowish in color and sweet to the taste. On the other hand, sugar of poor quality is soft, watery and sometimes has a sourer or bitter taste. The sugar is called *gula apung*.

Alcohol is prepared by local people living in longhouses from a mixture of nipa sugar and fermenting rice wine known as *tuak* which is a much-liked alcoholic beverage. About 3.6 kg—the equivalent of the local weight measure of one *gantang* of rice—is cooked and then cooled before mixing with 0.6 kg (or one *kati*) of yeast. The mixture is fermented in earthenware jars for about two weeks. At the end of this initial fermentation period, *tuak*—the whitish liquor obtained by squeezing the fermenting mixture through fine mesh and having it filtered—is produced. The fermenting rice mixture is now stirred into an aqueous solution of nipa sugar prepared in the proportion of 24.2 kg (40 katis) of sugar in 109.2 liters (or 6 biscuit tins) of water and left to ferment for another six days. The resulting fermented liquor is transferred to a 200.2 liter (44 gallon) capacity drum for distillation. The drum is filled up to one-third of its capacity and heated over a low wood fire for 3–4 hours. Vapors rising from the liquor condense on the underside of an inverted cone placed over the drum. The cone is filled with water and thus acts as a condenser. The distillate, dripping from the vertex of the inverted cone, is collected in a concave receiver which drains via a bamboo pipe into a bottle. Usually a second distillation is carried out on the cooled stillage from the first distillation by adding more yeast (about 36 g) and nipa sugar (about 3 kg) and allowing the fermentation process to continue for four more days. The alcoholic drink produced is known as *lingkau*. Yield is approximately 13% volume by volume from 27 kg of nipa sugar or 22 bottles (of 0.65 liter each) of *lingkau*.

In local distilleries, such as the one in Kuching which provided information, the preparation of alcohol from nipa sugar does not include the initial fermentation stage with cooked rice carried out by the natives. In a one-batch operation, about 675 kg of nipa sugar are dissolved in about 4,546 liters (1,000 gallons) of water in a concrete tank measuring 2.1 m × 2.2 m and 1.2 m deep internally. About 4.5 kg of active dried yeasts made into an aqueous solution are then added to the mixture in the tank. While the mixture ferments at room temperature for the next 4–5 days, the tank is covered with wooden planks. No strict temperature control is observed although on a hot day the planks are removed to stabilize the fermenting mixture. The distiller recognizes two crude tests of complete fermentation: a subsidence of foam or a fall in temperature of the mixture. The liquor now contains alcohol and water with acetic acid as an impurity. In the factory a series of these tanks with fermenting mixture is connected by a pumping system to a reservoir from which the still is fed. The fermented liquor is filtered as it flows into the reservoir. The stills are actually two closed columns fitted with perforated plates at intervals and steam is fed from the bottom. The steam is supplied by a tubular boiler burning mangrove firewood. The fermented liquor is pumped to the top of the columns where it trickles down through the plates. The dry steam passing upwards volatilizes most of the alcohol and some of the water, which then passes up the column through the perfo-

6. The labels of some of the special wines produced by Si Hup Distillery in Kuching.

rations. As it moves upwards, the water vapor condenses with some of the alcohol vapor and drops down again to be met by more steam and revolatizes. For more complete separation, the mixture of vapor and wash may go through the final column twice until the wash reaching the bottom of the column is free from alcohol. The



7. Original layout plan of the distilling plant. (Courtesy of Si Hup Distillery, Kuching.)

spent wash then passes out at the bottom of the column while the vapor (alcohol) reaching the top is almost free from water. The latter is led through a condensor unit and the distillate piped to outlets for collection. The alcohol goes into a mixing tank where herbs or other ingredients are added in the preparation of special wines. The final product is bottled. The steam distillation takes about 4–5 hours and the rate of distillation is between 135–230 liters per hour. Yield is lower compared with that obtained by local people's stills, i.e. 11% or about 50.0 liters from 675 kg of sugar. The alcohol, however, is of better quality being normally 130°–140° proof (the *proof scale* is about double the percentage of purity e.g. 100° proof alcohol is 57.19% alcohol according to U.K. standards).

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BOOKSTORE

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Principes, 33(1), 1989, pp. 27–32

On the Reproductive Biology of the Dwarf Palm, Chamaerops humilis in Southern Spain

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ABSTRACT

Chamaerops humilis is a dwarf palm which inhabits evergreen forests and xerophytic scrub communities around the Mediterranean region. It is reported that the species is dioecious and presumably wind-pollinated in southern Spain. Nevertheless, female flowers sometimes secrete nectar, and both male and female inflorescences attract weevils which feed on pollen and young fruits. It is hypothesized that, being anemophilous at present, *C. humilis* bears traits related to an earlier insect-pollinated condition.

A recent review of pollination studies in the Palmae (Henderson 1986) demonstrates that the information currently available on the reproductive characteristics of *Chamaerops humilis* L., the only palm native in S. W. Europe, is even scarcer than that on many tropical species. Quite disappointingly, not a single recent paper on *C. humilis* reproduction is cited in Henderson's review. The purpose of this paper is to contribute to the knowledge of the biology of a palm which, in spite of its abundance in the Mediterranean area, has never been the subject of interest for investigators.

Study Area and Methods

Data reported here are the result of observations carried out in southern Spain on wild populations of *C. humilis* during the years 1983 through 1987. Most observations were made at the Doñana Biological Reserve—a sandy coastal area (20 m a.s.l.) with a Mediterranean climate near the Atlantic Ocean in southern Spain. For further details on the vegetation and climate of Doñana the reader should refer to Herrera (1986, 1987).

The population was visited at weekly intervals during the years 1983 and 1984. Flowering phenology, sex ratios, and flower visitors, together with morphological features of inflorescences and flowers were recorded in a total of 11 clumps (putatively different individuals). Details of anthesis and phenology were gathered from a sample of 45 inflorescences. Additional observations were carried out in populations distributed across southern Spain. Maximum distance between two populations was 400 km.

Habitat and Habit

Chamaerops humilis (Palmito) in southern Spain commonly grows in the understory of *Quercus rotundifolia* (Evergreen Oak) forests, which represent the potentially climatic vegetation in the area. Due to its vigorous sprouting, however, *C. humilis* is very tolerant of disturbance. It may survive after heavy deforestation, fires, and pasturing, and it appears in nearly every stage of degradated vegetation. Because of that, it is a very common plant in forests and shrublands from sea level to mountain ranges up to 1,000 m. *C. humilis* dominates the highly xerophytic scrub inhabiting coastal arid zones of southeastern Spain with less than 300 mm of rain per year on average (Cape of Gata), but it also grows on the wettest, Atlantic slope of the region where precipitation may average more than 2,000 mm per year. The Dwarf Palm has no obvious preferences regarding type of soil or substratum, since it equally occupies sandy areas, rocky

1. Habit of *Chamaerops humilis* L.

basaltic, granitic or limestone hillsides, and rich, deep soils on marginal areas.

C. humilis has an underground rhizome which produces shoots with palmate, sclerophyllous leaves. Eventually, old shoots develop an unbranched trunk up to 2 m high, covered by a fibrous "bark" and terminated by a crown of leaves. Such a growth habit is quite uncommon and more often plants remain shrubby, leaves starting their development under the level of soil surface and, as they grow, the whole plant becoming a semispherical structure of palmate leaves up to 1 m high. Usually the rhizome forms new shoots around the oldest one so that the individual becomes a clump of vegetatively generated shoots (Fig. 1).

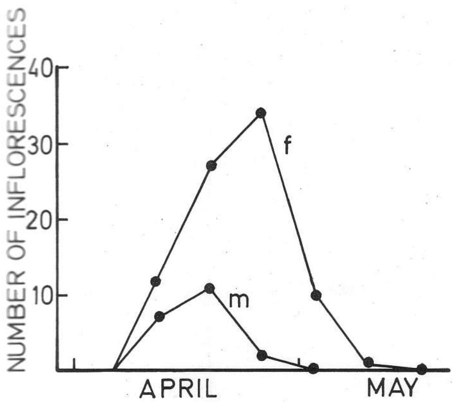
Breeding System

The plant has sometimes been described as polygamodioecious, that is, it is supposed to bear unisexual and, sometimes, bisexual flowers (Amaral Franco 1980). Nevertheless, every southern Spanish wild population checked by me during 1983–1987 behaved as completely dioecious. Not a single hermaphroditic flower was found. In the more thoroughly studied population of Doñana, sex of inflorescences produced by 11 clumps, which account for the whole population in a relatively large area, was assessed during 1983–1984 (Table 1). Inflorescences of only one sex were produced inside each clump and, moreover, clumps producing male inflorescences during 1983 did likewise during 1984. In a parallel way, those clumps with female inflorescences during 1983 behaved as females also during 1984. Consequently, sex expression was unchanged from one year to the next in the population. Sex ratio of female to male clumps was 2.3 in both 1983 and 1984 (Table 1). The ratio of female to male inflorescences was 2.9 in 1983 and 4.4 in 1984. Female biased sex ratios seem to be the rule, which may account for low levels of fruit set observed (see below).

Table 1. Number and sex (f, female, m, male) of inflorescences produced by Chamaerops humilis *clumps during two consecutive years.*

	1983		1984	
Clump	No. of Inflorescences	Sex	No. of Inflorescences	Sex
1	3	f	7	f
2	3	m	3	m
3	0	—	14	f
4	6	f	6	f
5	1	f	0	—
6	7	f	7	f
7	28	f	32	f
8	9	m	7	m
9	7	f	18	f
10	28	f	70	f
11	15	m	15	m
Overall	80	f	154	f
	27	m	35	m

Chamaerops humilis blooms once a year, during the period of maximum flow-

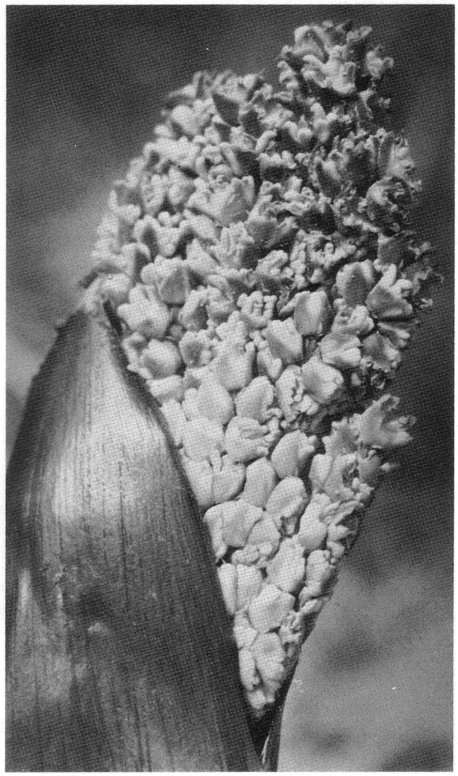


2. Flowering phenology of *C. humilis*. f, female; m, male inflorescences.

ering activity of the Mediterranean shrub communities at low elevations (early spring; Herrera 1986). Figure 2 shows the blooming period of male and female plants separately in 1983. There was a delay of seven days between male and female flowering peaks, with males reaching peak bloom earlier. Also, the female-biased structure of the population is easily appreciated.

Inflorescences and Flowers

Male flowers are 4–5 mm in diameter, with three sepals united in a low cupule with three pointed tips, and three ovate petals joined slightly at the base. Filaments of the anthers are expanded and united basally. No sign of a pistillode is found in staminate flowers. They are borne in branched inflorescences up to 20 cm long which commonly appear at ground level (Fig. 3). The number of flowers per inflorescence shows substantial variability (x = 154 ± 24, n = 10, range 40–300). The whole male inflorescence is yellow, produces a faint odor, and liberates large amounts of dry pollen which is carried away from the anthers by the wind. Although flower anthesis is quite synchronous the pollen-shedding phase of any inflorescence extends for about seven days.



3. Male inflorescence of *C. humilis*.

Herrera (1987) reports on each male flower shedding 214,000 grains of pollen on average. There is no nectar secretion, but pollen-seeking insects are often found on male inflorescences (see below).

Female flowers (Fig. 4) are 3–4 mm in diameter and have three free carpels and six staminodes. The number of flowers per inflorescence ranges from 38 to 90 (x = 57 ± 5, n = 12). Newly opened flowers and inflorescences are yellow but, as pollination takes place, they rapidly become green. Since flowers open sequentially from the top to the bottom of the inflorescence, it is very common to see inflorescences where the top half is green, with flowers no longer receptive, while the lower half is yellow and the flowers on it still receptive. The duration of a female inflorescence ranges from seven to fifteen days. Some

4. Female inflorescences of *C. humilis.* Left, inflorescence with yellow receptive flowers. Right, view of an inflorescence with developing ovaries, ten days after anthesis.

female flowers were found to secrete nectar which, measured on a weight-weight basis with a hand refractometer, yielded 27% sucrose equivalents. Accurate quantification of the amount of nectar secreted was precluded by the fact that it did not accumulate anywhere but simply glided onto the base of rachis. Nectar secretion was by no means widespread in the population, as it was observed in just few clumps. A variety of insects were attracted to the nectar which included ants (*Lasius niger* L., *Tapinoma erraticum* Latr., *Plagiolepis schmitzii* Forel and *Camponotus lateralis* Oliv.) and, especially beetles. A single unidentified species of Curculionidae 4 mm long, *Derelomus chamaeropis* (Fab.), accounted for the vast majority of insects. The same weevil has been found in every *Chamaerops humilis* population checked for insect visitors all through southern Spain, from the drier to the moister sites. The weevils crawl over the flowers and often slip inside the prophyll. They consistently appear at both male and female plants (up to twenty insects per inflorescence). When on male flowers they eat and get dusted with pollen.

In a female flower of *C. humilis* each of the three free carpels may develop into a drupaceous fruit. Thus, the true fruit should be considered a "polydrupe" which may comprise 1–3 drupes. Nevertheless, the term fruit will hereafter be applied to the drupe, which in fact behaves as an independent dispersal unit. Fruits are dull-yellow to brown when ripe and contain a single, stony seed (mass 780 mg on average) covered by a fibrous mesocarp which smells strongly of rancid butter. Table 2 displays fruit set in seven female clumps, with differences between initiated and ripe fruits being due to predation by (1) *Derelomus* weevils during the early stage of development (up to 10 mm in diameter) and (2) rodents when fruits had reached their definitive size (up to 25 mm). Developing ovaries eaten by weevils were hollow, showed a large hole on their surface and, after turning black usually fell to the ground. In four clumps some fruit were initiated while in only two there were fruits which escaped predation. 1.32% of the carpels initiated a fruit, but only 0.14% reached maturity. Thus, losses of fruit due to predispersal predation lowered the original fecundity by a factor of ten.

Discussion

Observations have shown that the species can be considered truly dioecious. Occasional existence of populations with a different breeding system cannot be ruled out but, undoubtedly, polygamodioecy (Amaral Franco 1980) is far from being common. It is interesting to note that a cultivated specimen grown from seed and not suffering water stress in any moment of the year has been observed to bear inflorescences which are sometimes entirely male and other times bear male together with bisexual flowers (Herrera, pers. obs.). It is likely that the assertion that this species is polygamodioecious is based on observations of cultivated plants. The above mentioned plant departed much from the reproductive behavior in the wild since, in addition to the spring flowering period, it exhibited another blooming episode during the summer.

Chamaerops humilis male inflorescences shed vast amounts of powdery pollen which is readily transported by the wind. On the other hand, female flowers sometimes secrete nectar, and both types of inflorescence are visited by curculionid beetles. The question arises, thus, whether the species is insect- or wind-pollinated. It would be difficult to give an unequivocal answer, however, as it appears that the plant shares traits of both anemophily and entomophily. The weevils acted as predators of developing fruits, so I have the feeling that their role as pollinators, if any, should be negligible. *Derelomus chamaeropis* is closely associated with the flowers of *C. humilis* in the Mediterranean region (Lesne 1926, Lepesme 1947 *in* Henderson 1986) but they probably should not be considered pollinators, but unspecialized parasites of flowers and fruits.

Table 2. Flower and fruit production in female clumps of C. humilis *during 1983.*

Clump	Number of Flowers	Number of Fruits Initiated–Ripe
1	171	0–0
4	342	6–0
5	57	0–0
6	399	0–0
7	1,596	36–18
9	399	124–0
10	1,596	15–2
Overall	4,560	181–20

In his review on palm systematics and ecology, Tomlinson (1979) stated that dioecy is often associated with wind pollination. More investigation is needed before we can affirm categorically that *C. humilis* is anemophilous, but it seems likely that wind-pollination is in fact operating in southern Spanish populations. Nectar secretion by some female plants may represent little more than an ancient trait comparable to the existence of staminodes void of pollen in the female flowers. These traits may have been significant long ago to the reproductive biology of the plant but no longer functional in extant populations. *C. humilis* belongs to a set of Mediterranean shrub species whose families show strong tropical affinities (e.g., Anacardiaceae, Santalaceae, Oleaceae). It is but an example of the often dioecious shrub taxa which compose the "tropical element" of Mediterranean vegetation (Quezel 1985). This set of taxa, including *C. humilis*, existed well before the establishment of the Mediterranean climate (Raven 1973, Axelrod 1975), so it is likely that during the Tertiary they lived under a tropical climate. Only recently would *C. humilis* have undergone adaptations to more seasonal ecological conditions which favored the existence of drier and more open habitats such as sclerophyllous forests. The shift to dioecy and wind-pollination may have occurred recently enough to make the pollination mode appear ambiguous.

Acknowledgments

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Principes, 33(1), 1989, pp. 33–39

Prehistoric Development and Dispersal of the Desert Fan Palm

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The desert fan palm (*Washingtonia filifera* Wendl.) lives in a variety of arid and semi-arid natural environments throughout southern California and Baja California, and in two locations in western Arizona (Fig. 1). While it appears tolerant of these xeric climates, the tree survives only in the presence of a reliable source of groundwater (Read 1974). As a result of this phreatophytic quality, the species is found most typically in oases along hillside seeps and in canyon washes, particularly on the western and northern slopes of the Coachella and Imperial valleys. Randall Henderson, who spent much of his life searching for groves of *W. filifera*, estimated in 1961 that a population of 11,000 of these trees grows wild in the southern California desert. Since then many new palm oases have been discovered, in both California (Jonsson 1985) and Arizona (Brown et al. 1976), as well as in Baja (Cornett 1987*b*). Despite these recent discoveries, Cornett (1984) estimates that the current wild population in the American Southwest covers less than 1,000 acres.

In the human environments of California, the fan palm's stocky trunk and distinct crown adorn many Central Valley farmsteads, and any visitor to the cities and suburbs of southern California knows well the aesthetic appeal of a street lined with these curious trees. It is fitting that *W. filifera* appears in so many California environments, for it is the only palm native to the state. Yet, as an ornamental novelty the species has travelled far beyond its native land, and is today one of the most widely grown members of the family Palmae in the world (McClintock 1978). The great travel saga of this popular tree, however, began long ago, in the shroud of prehistory.

Early Prehistoric Development

Where the earliest palms originated remains the subject of debate due to the paucity of Mesozoic pollen and fossil data. From what little paleobotanical information is available to as far back as the upper Cretaceous, three divergent hypotheses have been developed. Moore (1973), combining his knowledge of the fossil record (much of the paleobotanical work on palms was completed after his publication) and modern plant distributions suggested that the family Palmae originated during the Cretaceous in West Gondwanaland (modern South America), and subsequently migrated into East Gondwanaland and Laurasia. Contrary to Moore, Walker and Walker (1986, from Uhl and Dransfield 1987), by proposing a Laurasian origin for the monocotyledons, pointed to the Northern Hemisphere as a potential center of development and dispersal for the palms, a possibility Moore (1973) had earlier considered and rejected. More recently, Uhl and Dransfield (1987) taking into account palm morphology, as well as the paleobotanical record and log of current distributions, have suggested "the first palms may have originated at a time when the separation of Gondwanaland and Laurasia was incomplete and dispersal between the two supercontinents was still possible," allowing the family to become widespread on both landmasses.

1. The desert fan palm in its natural habitat; clarification of the palm's prehistoric development and dispersal will help determine our policies toward its conservation. Photo credit: Debbie Elliott-Fisk.

Regardless of where the palms first originated, it is clear that by the Paleocene they had begun to radiate from their origin, and to differentiate into identifiable groups. The coryphoid group, and in particular the Livistoninae subtribe to which *W. filifera* belongs, proliferated early and rapidly in response to a warming trend during the early Paleocene (Axelrod 1950). This warming trend continued into the Eocene, by which time the genus *Washingtonia* had fully established itself in the floral community of southern California. This floral province, called Mohavia, encompassed what are today the Mojave and Sonoran deserts; at that time much of the current range of the desert fan palm—the Imperial and Coachella valleys—lay submerged beneath the sea.

Over the ensuing course of the Oligocene and Miocene, this Tertiary warming trend developed into a trend toward aridity and cooler temperatures. This trend, climaxing in the middle Pliocene, was accentuated inland by the earlier uplift of the San Gabriel, San Bernardino, San Jacinto, and Santa Rosa mountain ranges (MacDougal 1914). The climatic changes accompanying these topographic modifications are considered responsible for the differentiation of the Sonoran and Mojave desert flora (Axelrod 1950). Lower winter temperatures and decreased annual rainfall signaled the disappearance of *W. filifera* from the Mojave plateau. Along the coast, prolonged humid conditions associated with increased orographic precipitation created an unfavorable habitat for the species, resulting in both crown rot (Jaeger 1933) and a rapid decrease in seed germination (Moraes 1980). The distribution of the palm henceforth dwindled, leaving isolated stands surviving where groundwater seepage occurred along geologic faults on the leeward slopes of the Colorado Desert (Moran 1979, Vogl and McHargue 1966). As the water supply further decreased, so did the palm's habitat; unlike many other plant species which flourished during the Tertiary aridity by developing specialized xerophytic traits, *W. filifera* remained dependent upon groundwater sources for its survival. Consideration of the areal extent to which its population diminished raises important and unanswered questions about the origin and development of the palm's current distribution.

Late Prehistoric Development

The traditional and most widely accepted view holds that *W. filifera* exists as a relic of a once widespread southern California population. The onset of a milder and moister climatic regime associated with the Pleistocene glaciation is credited with preserving the species, and along the shores of Lake Cahuilla, a fluctuating brine lake fed by the diverted Colorado River, the palm is said to have thrived (Parish 1907, MacDougal 1914, Jaeger 1933, Henderson 1965). There remains today a discontinuous belt of palms just above the ancient shoreline at the base of the Indio hills (Smith 1958). The lake level throughout the Pleistocene was notably unstable, however, and it has yet to be explained how a phreatophytic tree that cannot flower until it is at least 15 years old (Brown et al. 1976), and that reproduces once per century (Vogl and McHargue 1966) could maintain itself in such a dynamic environment.

Even more challenging to the relic hypothesis is a 1986 publication by McClenaghan and Beauchamp on the species' genetic variability. Through a series of electrophoretic studies on 446 palms from 16 Colorado Desert sites, the authors discovered unexpectedly low genetic differentiation between oases, with only 2.3% of the total genetic variability attributable to between-population diversity; the remainder was due to within-population differences, which themselves were considered low. This finding runs counter to the tenet that small, isolated populations will genetically diverge.

As an explanation for this genetic similarity, one could offer van Valen's niche width-variation hypothesis, which states that an adaptive relationship exists between ecological amplitude and genetic variability. This would imply that the low diversity levels found among *W. filifera* populations are a function of the species' low ecological versatility. Likewise, one could anticipate uniform selection pressures evoking low genetic variability. Both of these possibilities, however, ignore important empirical characteristics of the desert fan palm and its distribution.

Washingtonia filifera, although a heliophyte, has a remarkable ability to endure frost and low temperatures; horticultural reports from Britain (Cooper 1983), Germany (Smith 1964), Ohio (Myers 1985), Alabama (Colvin 1983), and California (Cornett 1987*a*) have all reported *W. filifera* specimens surviving sub-freezing temperatures. The species also displays a high tolerance for alkaline soils (Jaeger 1933), as well as a notable resistance to fire damage, the result of a protective insulating sap which flows through its porous trunk (Henderson 1965). Most important, the fan palm survives in two distinct desert habitats—seeps and washes. A study by Vogl and McHargue (1966) of the vegetational composition of fan palm oases in the Colorado Desert helped reveal the tree's ecological adaptability: of the 78 species recorded by the authors, *W. filifera* proved to be the only one distributed among all 24 oases sampled. The low genetic differentiation among palm populations does not appear to be attributable to a narrow ecological amplitude.

McClenaghan and Beauchamp (1986) suggest the California populations of *W. filifera* are not relics at all, but rather represent the products of seed dispersal from a source population having low genetic variability. They reason that "climatic changes may have completely eliminated fan palms from the Colorado Desert and restricted the species to small refugia populations in Baja California." The dispersal of seeds from one of the refugia would have resulted in genetically similar colonizing populations.

Several migrating birds, including the western and mountain bluebirds (*Sialia mexicana* and *S. currucoides*), the cedar waxwing (*Bombycilla cedrorum*), and the house finch (*Carpodacus mexicanus*), could have acted as primary dispersal agents, but the possibility seems unlikely. Bullock (1980) has documented that birds have difficulty swallowing the seeds, and frequently regurgitate them. Furthermore, upon arriving at the oases, they tend to become sedentary in the shelter provided by the palms, thus limiting the potential dispersal range to only a few meters.

The coyote (*Canis latrans*) is considered to be the most likely disperser of *W. filifera* seeds. Henderson (1947) first proposed the coyote as a dispersal agent after noticing large amounts of undigested seeds in their scat on oases floors. Coyotes are known to consume large quantities of palm seeds, and to travel long distances (Bullock 1980). A report by Cornett (1985) that the ingestion of the seed by coyotes increases its germination success adds further support to the opinion that they have contributed to its dissemination. If it is assumed, however, that coyotes randomly consume the seeds, and that there existed more than one refugium population, it remains to be resolved how these animals could establish a widespread population of such striking genetic homogeneity. Undeniably, the coyote has contributed to the observed genetic homogeneity of desert fan palm populations by facilitating gene flow, but our consideration of McClenaghan and Beauchamp's findings would be incomplete if we did not examine the potential influence of man—the anthropogenic factor.

Anthropogenic Development

The distributional range of the Cahuilla Indians closely coincides with that of *W. filifera*. Larger groves of the palms were favorite habitation sites of the Cahuilla (Bean 1972), who are credited with having extended the tree's limits by carrying its edible seeds from one oasis to another (Chase 1919, Henderson 1947, McClintock 1978). Seed dissemination by random collection, however, cannot explain the low genetic variability observed among *W. filifera* populations. While archaeological evidence for prehistoric cultivation of *W. filifera* has not been uncovered (Wilke 1978), the Cahuilla are confirmed to have had contact with the Yuman Indians, known agriculturalists of the Colorado River Delta (Bean and Saubel 1972). The importance of the palm in the life of the Cahuilla invites consideration of the possibility that they long cultivated the tree.

Cultivated plants can be recognized by the following: 1) existence in an unnatural environment, 2) multiple use and integration into the social fabric of the tending society, 3) a body of myths and legends surrounding their origin and use, and 4) low genetic diversity throughout the population as a result of human selection. The majority of palms in the Colorado Desert survive along hillside seeps far above the valley bottom (Cornett 1984). While some consider this the natural habitat of the palm (Vogl and McHargue 1966), Henderson (1961, 1965), noting stands in canyons up to 1,000 meters, suggests these palms are descendants of the population that once grew along the fringe of Lake Cahuilla. Interestingly, the ancient lake shore is where Bean and Saubel (1972) speculate the Yuman and Cahuilla tribes came into contact. Moran (1979) observes that "some plants used by the Indians are found near Indian campsites far from other known stands." He concludes that these were purposefully planted by the Cahuilla in prehistoric times.

If the utilitarian value of a plant is any indication of its desirability as a cultivar, then the Cahuilla had substantial reason for planting the palm. In addition to providing a sheltered habitat, the trees yielded a wide variety of useful products. The dried fronds were used as construction materials for houses, called "kish," and for granaries (Parish 1907). Sandals, baskets, utensils, and tools were fabricated from them as well (Moran 1977). As aesthetic additions, the leaf fibers were used for apparel (Bean 1972), and the seeds were considered excellent filling material for gourd rattles (Bean and Saubel 1972). The leaves were also used to make "nukily," images of the dead that were burned in Cahuilla memorial rites (Chase 1919), and served as symbols of victory (Stone 1959).

As a food source, the palm's spongy pith, when boiled, provided relief during times of famine (Bean and Saubel 1972). On a more regular basis, the fruit was consumed in several forms: both a beverage and a jam were made at times, but more commonly the small, sweet delicacies were eaten fresh, or were dried and ground into flour (Brumgardt and Bowles 1981). Cornett (1987*c*) has suggested that the fruit of *W. filifera*, by virtue of its high carbohydrate content, ". . . had the potential of being an important dietary mainstay."

The Cahuilla also utilized palm materials for making fire. The pithy wood of small floral branches was rotated against a larger piece of dry wood resting on a bed of leaves, creating heat by friction. The origin of this fire-making process is recounted in the creation myth of Ninmaiwaut (see Bean and Saubel 1972), indicating the important role of fire in Cahuilla society; indeed, they are known to have burned the palm thatch regularly, but their purpose remains debated.

Henderson (1961) was of the opinion that the Indians burned the persistent dead shag to drive away evil spirits, while earlier Hubbard (1962) had speculated that the palms were burned as a smoke offering to the dead. From a functional point of view, Parish (1907) first suggested the Indians set fire to the thatch to increase the tree's yield by destroying insect pests harmful to the fruit (particularly the bostrychid beetle and the red spider mite), and recently Cornett and Stewart (1986) have documented an empirical increase in spadix production among burned trees. Brown et al. (1976) suggest, however, that yellowjackets were the pest the Indians desired to drive away. Vogl and McHargue (1966) add that "burning entire oases made them more accessible and facilitated hunting." Moreover, burning helped maintain the groves by increasing seed germination of the palm through the elimination of ground litter and undergrowth that would compete with the palm for water.

The trading of palm products among Indian groups (Bean and Saubel 1972), and the private ownership of groves and individual trees (Brumgardt and Bowles 1981) stand as further evidence of the extent to which *W. filifera* was integrated into Cahuilla society. Finally, Cahuilla oral legends, stemming form the prehistoric, leave little doubt that the palms were planted in aboriginal times. Patencio (1943) tells the story of the culture hero Sungrey and the creation of the first palm as follows:

> One of the head men of the people of Sungrey felt his time was about gone. His years among his people were many, and he must be prepared to go. This man wanted to be a benefit to his people, so he said, "I am going to be a palm tree. There are no palm trees in the world. My name shall always be Moul (palm tree). From the top of the earth to the end of the earth my name shall be Moul."
>
> So he stood up very straight and very strong and very powerful, and soon the bark of the tree began

to grow around him. And so he passed from the sight of his people.

Now the people were settled about the country in many places, but they all came to the Indian well to eat the fruit of the palm tree. The meat of the fruit was not so large, but it was sweet like honey and was enjoyed by everybody—animals and birds too. The people carried the seed to their homes and palm trees grew from this seed in many places. The palm trees in every place came from this first palm tree, but, like the people who change in customs and language, the palms often were somewhat different, but all, every one of them, came from this first palm tree, the man who wanted to be a benefit to his people.

Significant in this account is not only the carrying of seeds to home sites from whence all the palms grew, but the recognition of variation among the trees, a prerequisite for purposeful human selection. The low genetic diversity among California populations of *W. filifera* discovered by McClenaghan and Beauchamp may well reflect the results of such a selection process acting on the palms during their late prehistoric development.

Conclusion

In the distant past, the survival of the desert fan palm relied upon the random gifts of nature, its distribution guided by unrelenting climatic and tectonic forces. Today, however, its continued existence depends upon the calculated decisions of humans. We have planted the tree on every inhabited continent, while simultaneously threatening its native habitat with the space and water demands of urban and agricultural development.

The status of the palm—whether it is an ancient relic, a product of recolonization, or a feral escape—will help determine our policies toward its conservation. Questions regarding its status, however, are not easily answered. To help resolve the question of recolonization, McClenaghan and Beauchamp recommend electrophoretic studies of *W. filifera* populations in Baja California as a means of searching for and identifying potential source refugia with genetic affinities to the Colorado Desert oases. Using the same data, I believe we could shed new light on whether or not Indian selection and cultivation of the plant contributed to its relative genetic homogeneity: If similarly situated *W. filifera* oases in Baja display low genetic diversity, we can conclude that natural factors, be they environmental or botanical, have produced this condition. If the genetic differentiation in this region is high, however, we can regard the anthropogenic factor as dominant in California. In either case, the prehistoric development of the desert fan palm invites further investigation by the botanist, the geographer, the anthropologist, and the layman.

Acknowledgments

I thank Dr. Debbie Elliott-Fisk for her professional encouragement and recommendations, and Bettina Ann Krohn for her assistance in proofreading this manuscript.

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CLASSIFIED

Principes, 33(1), 1989, pp. 40–44

Discovering Palms in Europe

ROLF KYBURZ

K-Palms Nursery and Seeds, 39 Poinciana Drive, Browns Plains, Qld. 4118, Australia

People coming to my nursery frequently want to know what made me give up a professional career 13 years ago to start exclusively growing palms. In the beginning I wondered myself, but eventually I realized that ever since I was a little boy growing up in Europe, palms were something special to me. Even at an early age I always had the urge to travel to see the world, to know what was beyond the mountains on the horizon. Palms were the symbol of the exotic, the faraway places of different people and plenty of sunshine. I'm sure palms must convey the same images to most people who get hooked on them. This is nowhere so obvious as when you visit the colder areas of the world. I'd like to describe a few such places in Europe but I know there are also localities elsewhere in cold climates with a variety of palms.

Palermo

Having finalized my business in Sicily, I was taken on my last day to the Palermo Botanical Garden, a somewhat neglected but charming park with a large collection of subtropical plants. There were the usual species of the following genera one finds in temperate subtropical areas: *Sabal, Trachycarpus, Washingtonia, Syagrus, Phoenix,* etc. What I especially remember are most magnificent specimens of a *Trithrinax campestris* with a trunk perhaps 7 m tall and a large proliferation of *Chamaerops humilis,* the Mediterranean fan palm. It is really outstanding to see the incredible variety within this one species. There were nonsuckering types with short fat trunks, thinly stemmed, densely suckering ones with quite small crowns, and all sorts of combinations between these extremes. Some had small leaves, others bigger fans, and the coloring of the leaves ranged from grass green to grey blue. All of this variety is called *Chamaerops humilis.*

Porto Ercole

Some time ago I saw a reference in *Principes* to a garden in Porto Ercole (corresponding roughly in latitude to Northern Tasmania, Wellington, New Zealand, Southern Hokaido, or Boston) in Italy which was supposed to contain many palms planted in the middle of the last century. Because of the passage of time, neglect, and war, the names of the surviving species were apparently very much in doubt. Once I knew I was going to be in Italy, I decided to go and see if I could identify the palms. In Rome I teamed up with Carol Graff of Tropical Landscaping in Miami. It was a pleasant train journey on a beautiful summer day, which took us north along the West Coast to Porto Ercole and the peninsula of Monte Argentario, an area well known for its beauty and benign climate, and also steeped in history and full of interesting people, which it has produced over the centuries. Our host, the owner of "La Casa Blanca," was expecting us and received us at the gate of his fabled estate. He is Don Cino dei Principi Corsini Marchese di Laiatico, who, however, prefers to be addressed simply as Cino. We had a fascinating day with Cino, who despite a broken leg, hobbled all over the vast estate on the slopes of Monte Argentario which overlooks a very beautiful small harbor. There were stories of nobility, of national heroes, composers and inventors, artists and patriots, saintly people and thieves, but above all, of idealistic people with visions and ideas. All shared one thing; they were connected in some way with this place and were part of its history.

The garden was founded by Cino's ancestor, Baron General Vincenzo Ricasoli, an officer in the Piedmontese Cavalry under the Savoy King, when Italy consisted of many small kingdoms and was not united as we know it now. The King of Savoy had agreed to help Britain and France against the Russians. So in 1850 the Baron was sent with his Sardinian Cavalry to battle in the Crimean War. A Russian cannon ball put an end to his war efforts by smashing one of his legs. He then sailed back to Porto Ercole with 37 Russian war prisoners whom he had captured before the accident. They were kept in an ancient fortress above the harbor, from which they were taken every day to work in his park. The once steep slope was thus converted into flat terraces ideally suited for planting. The Baron, who was a self taught botanist, then set forth to travel the tropical and subtropical world and during the rest of his life he brought back thousands of plants for his garden. It is estimated that in his final days the park had one of the finest collections of subtropical plants in Europe. It particularly excelled in a very large variety of *Eucalyptus*, but of course there were palms and cycads. In 1888 Baron Ricasoli published a book with a list of all the plants in his garden. The list is long and often states the same species under several different names. Also many species have been through a variety of botanical name changes over the last 100 years depending on the latest insight or whimsy of the botanists of the day. Here then, is a modern version of the list of palms we think were in the Baron's garden in 1888.

Allagoptera campestris
Archontophoenix alexandrae
Brahea armata
B. edulis
Butia yatay
Ceroxylon alpinum
Chamaedorea elatior
C. elegans
Chamaerops humilis
Coccothrinax argentea
Cryosophila nana
Hedyscepe canterburyana
Howea belmoreana
H. forsteriana
Jubaea chilensis
Linospadix monostachya
Livistona australis
L. chinensis
Lytocaryum weddellianum
Nannorrhops ritchiana
Phoenix acaulis
P. canariensis
P. dactylifera
P. × intermedia, (P. dactylifera × P. canariensis)
P. paludosa
P. pusilla
P. reclinata
P. rupicola
P. sylvestris
Polyandrococos caudescens
Ptychosperma elegans
Rhapis excelsa
Rhopalostylis baueri
R. sapida
Sabal blackburnia
S. mauritiiformis
S. mexicana
S. minor
S. palmetto
S. princeps
Syagrus flexuosa
S. macrocarpa
S. romanzoffiana
Thrinax parviflora
Trachycarpus fortunei
Washingtonia filifera
W. robusta

Included in the original 1888 listing are the following palm names which have defied my resources to work out their modern names:

Cocos gaertneri (=Syagrus macrocarpa)
Phoenix aequinoctialis
P. peradenia
P. peruviana
P. sahariensis
Sabal longifolia

S. longipedunculata
S. speciosa
S. tectorum

After the death of the Baron, the garden gradually fell into neglect for all sorts of reasons, including lack of water which killed a lot of palms. During World War II, the estate with the stately villa, became the regional headquarters for the German troops. One of the first official acts was to remove the beautifully made porcelain name tags that all palms and most other plants wore for botanical identification. Towards the end of German occupation the whole estate was bombed by the allies, which of course caused enormous damage. Many palms were lost and many still bear the wounds—as seen by trunks with big chunks blasted out and others with two crowns indicating damage to the growing tip. So what is left are the tough survivors, palms 100 years old and older, those that can take lack of water and care, and the occasional frost or cold winter which can be extreme in Europe once every 25 years. Here then is a list of what we believe to be growing there now:

Brahea armata
B. edulis
Chamaerops humilis
Jubaea chilensis
Livistona australis
L. chinensis
Nannorrhops ritchiana
Phoenix canariensis
P. dactylifera
P. sylvestris
Sabal mauritiiformis
S. minor
Syagrus romanzoffiana
Trachycarpus fortunei
Washingtonia filifera
W. robusta

Chamaerops humilis has established itself to such an extent that it is self seeding and has taken over whole areas, almost smothering anything else growing. The *Nannorrhops ritchiana* is the most beautiful specimen I have ever seen, with several bent trunks up to 1.5 m long, one trunk branching at about 1.2 m. All in all we found it not easy to identify some of the palms due to their great age, height, damage, distortion, and climate induced growing habits. The above list is reasonably accurate but could include some more species of *Phoenix* and *Sabal*.

In conclusion it must be said that in 1888 when all the plants growing in this estate were listed, they must have represented a most ambitious and remarkable collection of palms and other plants. The variety of palms was probably unequalled anywhere in Europe with the possible exception of the Royal Botanic Gardens at Kew.

We also noted that the majority of survivors were the rough trunked palms, having good insulation against the cold. Gone were all those with crown-shafts, obviously not able to protect themselves against sudden temperature drops.

Locarno

Locarno (latitude equivalent to Montreal and the most southern part of New Zealand) is located on the shores of Lake Maggiore in the southern, Italian-speaking part of Switzerland. The lake lies across the border of Italy and Switzerland, an area which is usually referred to as the Lake District. Here the weather is extremely benign due to the protection of the alps, steep mountains rising out of the lakes in the north, reflected warmth from the large expanse of water, and winds from the warmer south. Anyone who has ever been to this very picturesque area, would be astonished by the proliferation of palms, particularly *Trachycarpus fortunei* of which I doubt one will find finer specimens anywhere in the world. Whole streets in Locarno are lined with the tallest palms in immaculate condition. There is also a 120-year-old *Jubaea chilensis* as part of a traffic island and, along the lake shore, we found the most perfect specimen of *Brahea armata*, reputedly also about 120 years old. Near Locarno is Isola di Brissago, an island about 1 km offshore in Lake Maggiore and now a botanical garden with many subtropical plants including palms. *Trachycarpus*, *Butia*, *Syagrus*, *Jubaea*, *Chamaerops*, *Sabal*, *Phoenix*, and *Brahea* are found distributed all over the island; *Trachycarpus fortunei* grows most prolifically, in parts forming almost impenetrable jungles smothering anything else. The island, with its buildings, parks, plants, beautiful walks, and surroundings, is one of the most romantic places I have ever encountered. I am very fortunate to have seen this speck of paradise many times during my lifetime. At a very early age it was my introduction to palms.

Brissago

The township of Brissago (197 m above sea level) is located on Lake Maggiore and has a road, snaking along the lake's edge, with houses stuck on an extremely steep mountainside. To reach these houses one needs not only considerable driving skill but also a local guide. Carl Schell lives in one almost inaccessible place about 80 m above the lake. He led our party to a parking place some 15 m above his house from where we descended into his house via a " telephone-cabin-sized " cable tram. At his house we met Dr. Walder and Dr. Meier, other Swiss members of the International Palm Society. Sitting there with these palm emthusiasts, looking over the palm tops into the distance with steep mountains rising out of the water, one could imagine very easily being in Tahiti or some other enchanted island in the lush Pacific. When I list the palms growing in Carl Schell's garden, I must remind the reader that we are talking about a place in Switzerland, a country which in most people's minds is associated with mountains, snow and eternal ice! The following palms are fully exposed, without winter protection.

Arenga engleri
Brahea armata
B. edulis
B. elegans
Butia capitata and two varieties
Ceroxylon interruptum
C. quindiuense
Chamaedorea microspadix
C. radicalis
Chamaerops humilis
Jubaea chilensis
Livistona chinensis
Phoenix canariensis
P. dactylifera
P. theophrasti
Rhapis excelsa
R. humilis
Sabal mexicana
S. minor
S. palmetto
Trachycarpus fortunei
T. martianus
T. wagnerianus
Trithrinax acanthocoma
Washingtonia filifera
W. robusta

The following palms receive a degree of overhead protection in winter.

Archontophoenix cunninghamiana
Chamaedorea elegans
C. seifritzii
Howea forsteriana
Lytocaryum weddellianum
Phoenix roebelenii
Rhopalostylis baueri
R. cheesemannii

The winter of 1985/86 was severe with very low temperatures all over Europe. Dr. Meier had had a specimen of *Trachycarpus fortunei* growing for 25 years in his garden near Zurich, some 200 km further north; minus 30° C put a stop to that. The temperature in Carl Schell's garden reached a low of −8° C. A great many palms which had been growing for more than 120 years died that winter also on the French Riviera. The following palms did not survive that night:

Acoelorrhaphe wrightii
Caryota mitis
Ceroxylon utile
Livistona australis
Rhopalostylis sapida

It goes without saying that these gentlemen keep on trying to grow an ever increasing collection of exotic palms.

We also visited the estate of Dr. Walder in Valle Verzasca, a wild and craggy mountain valley leading north towards the Alps. The success story of his palm garden is perhaps not so much in its great variety but rather the steep back of the house which has turned into a self propagating, totally acclimatized jungle of *Trachycarpus fortunei,* with plants of all sizes from seedlings to fully grown 15 m palms.

Conclusion

Palms in Europe are obviously not a new discovery. People have long grown and loved many more palms than the two native species, *Chamaerops humilis* and *Phoenix theophrasti.* I have seen palms in Roman mosaics and in a Byzantine church. However, in modern times they have been grown for their beauty and tropical image for at least 150 years in reasonable quantities all over the more temperate parts of Europe.

Principes, 33(1), 1989, p. 44

NATURAL HISTORY NOTE

Flowering in Corypha

An interesting phenomenon occurred in 1988 in the Miami area. To date, seven *Corypha* palms are known to have flowered. Although the individual flowers are not open at the time of this writing, the huge inflorescences are quite impressive.

The first to be noticed were two *Corypha umbraculifera,* the Talipot Palm, at the USDA Sub-tropic Research Station. The seeds of these imposing palms were collected at Atkins Garden, Cuba in 1952. The seedlings were planted at the Station during the following year.

In December 1987, a staff member at Fairchild Tropical Garden saw a newly developing flower spike of *Corypha taliera.* This smaller relative of the Talipot, *C. umbraculifera* is also a native of India. The seed of this palm was collected in 1956 in Rio Botanic Garden.

Soon afterward, we learned of additional *Corypha umbraculifera* displaying young inflorescences. Two of these plants are at the University of Florida's Tropical Research and Education Campus. According to Dr. Carl Campbell, these were received as seedlings in 1930. The palms were planted in 1933. Another was discovered to be sending up a new inflorescence at the USDA Station. Its origin is not known. A seventh *Corypha umbraculifera* is in a private residence in Coral Gables near Fairchild Tropical Garden. The origin of this palm is also unclear.

Botanists and palm enthusiasts agree that a certain level of maturity must be reached by a *Corypha* before it has the potential to flower. The time required by an individual is determined by its environmental conditions. Once maturity is attained, climatic conditions must trigger the flowering process. While these factors may not be under the control of man, it would be of great interest to know the cause of this spectacular event.

For more information about *Corypha umbraculifera,* please refer to Principes 19(3), 1975, pp. 83–99 and Principes 31(2), 1987, pp. 68–77.

CHARLES E. HUBBUCH

THE INTERNATIONAL PALM SOCIETY, INC.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS

December, 1987

Income		
Membership	$ 41,100	
Interest	11,347	
Subscribers	3,116	
Seed Bank	32,507	
Publications	1,106	
Genera Palmarum	145,600	
Postage	3,611	
Bookstore	10,950	
Donations	5,200	
Miscellaneous	297	
Total Income		$254,834
Disbursements		
Printing of Journal	$ 42,778	
Genera Palmerum	3,126	
Seed Bank	25,925	
Bookstore	7,190	
Accounting	1,394	
Botany Research	7,500	
Miscellaneous	1,169	
Total Expenses		$ 89,082
Excess Receipts over Disbursements		$165,752

BALANCE SHEET

December 31, 1987

Assets		
Petty Cash	$ 298	
Cash in Banks		
Douglas County Bank	170,160	
Imperial Savings	25,878	
American Commercial Bank	14,929	
California Savings and Loan	7,958	
Dean Whitter Trust	5,355	
World Savings & Loan (Endowment Fund)	29,901	
Book Inventory	8,181	
Revolving Publications Fund	59,613	
Equipment	6,924	
Total Assets		$329,197
Fund Balance		
Net Worth—Beginning of Year	$163,445	
Excess Receipts over Disbursements	165,752	
Balance		$329,197

Principes, 33(1), 1989, p. 46

LETTERS

Dear Natalie,

I gather that at the Biennial, there was considerable discussion on the content of *Principes*. Herewith a few thoughts. Unfortunately, I was not able to be at the Biennial—my budget does not run to Sheratons.

I belong to a number of plant societies in Australia, New Zealand, and America and there is always a problem about the balance of technical and hobby articles. There always seems to be a shortage of articles available for printing and the editors are constantly asking for contributions from members.

There are some who think that *Principes* has been too heavily weighted on the technical side. As a non-botanist but, hopefully, a serious hobby collector, there is seldom an article which I do not enjoy, though some of the articles are rather above my head. But the journal must satisfy such a very wide range of readers that really serious articles have a definite place. Technical descriptions of new palms are essential.

I would like to see a little more on the hobby side—but who is to produce it? Our two editors are extremely busy people—both technical people, thus we are lucky enough to know that the information in the journal is accurate and authoritative. I do hope that members do not expect the editors to write the hobby articles—so they must come from the hobby members.

I have contributed a number of articles to various plant society journals and newsletters and I probably could have produced more of them. For some reason there seems to be a reluctance by hobby members to write articles—some say they are not knowledgeable enough; some say they cannot write well, there are all sorts of excuses. The more correct answer would be, I believe, that most hobby members are lazy and expect everything to be done for them.

For what it is worth, it is my opinion that there will be more hobby articles when the hobby members realize that they are responsible for the lack of such articles. Surely, with a membership running into some thousands, there are ten or twenty members who could write a page or two on some aspect of the hobby growing or collecting of palms?

The competition recently produced some excellent nontechnical articles. Perhaps the members need the incentive or carrot such as this to get them writing—though they should not. I have had a tremendous amount of interest, information, and friendship from being a member of the Society—I have tried to put a little back in. I am sure the two are related. Those who put nothing into the society other than their subscription, really cannot expect to get much out of it.

You have asked that I write on the palms in the embryo Botanical Gardens at the University of the South Pacific and I have already started on this—it should be with you before too long.

R. H. PHILLIPS
G.P.O. Box 1151
Suva, Fiji

Principes, 33(1), 1989, pp. 47–48

NEWS OF THE SOCIETY

The IPS Loses a President

Ed McGehee, an avid gardener who was recently elected president of The International Palm Society for a second consecutive term, died Sunday, October 16, after collapsing in his garden in Fort Lauderdale. He was 66.

Mr. McGehee had just returned from The Society's Biennial meeting in Australia, where he was ailing, his wife, Peggy, said. He had previously been diagnosed as having a heart problem. Mr. McGehee became interested in The Society almost 20 years ago when he was living in Chicago. Back then he was raising roses, gladiolus, and other flowers.

"He was a research man," his wife said. "He liked to read as much about plants as work with them and had a huge library of all types of garden books."

Mr. McGehee was born in Pittsburgh. He met his wife in the seventh grade. They married on Christmas Day in 1946. Two years later Mr. McGehee received a degree in engineering management from Carnegie-Mellon University, although he later attended graduate school and taught English. He served as director of the cooperating colleges program at the University of Chicago, which linked many of the university's programs with more than 20 other colleges.

In 1970 the couple moved to Fort Lauderdale and three years later Mr. McGehee decided to pursue a law career. He attended the University of Florida, commuting on weekends to hold the family together.

Until his death, Mr. McGehee practiced real-estate law in Lighthouse Point, never neglecting his garden. "He took a special interest in it," his wife said. "It was real relaxation for him." On the couple's two-thirds-acre plot on the Intracoastal Waterway is planted a cornucopia of palms.

In addition to his wife, Mr. McGehee is survived by his daughters, Luvia Sniffen of Readfield, Maine, and Anne McGehee of Fort Lauderdale; sons, Peter of Durham, Conn., and James of Absarokee, Mont.; and three grandsons.

Revised from an article by
MARA DONAHUE, The Miami Herald
Tuesday, October 18, 1988

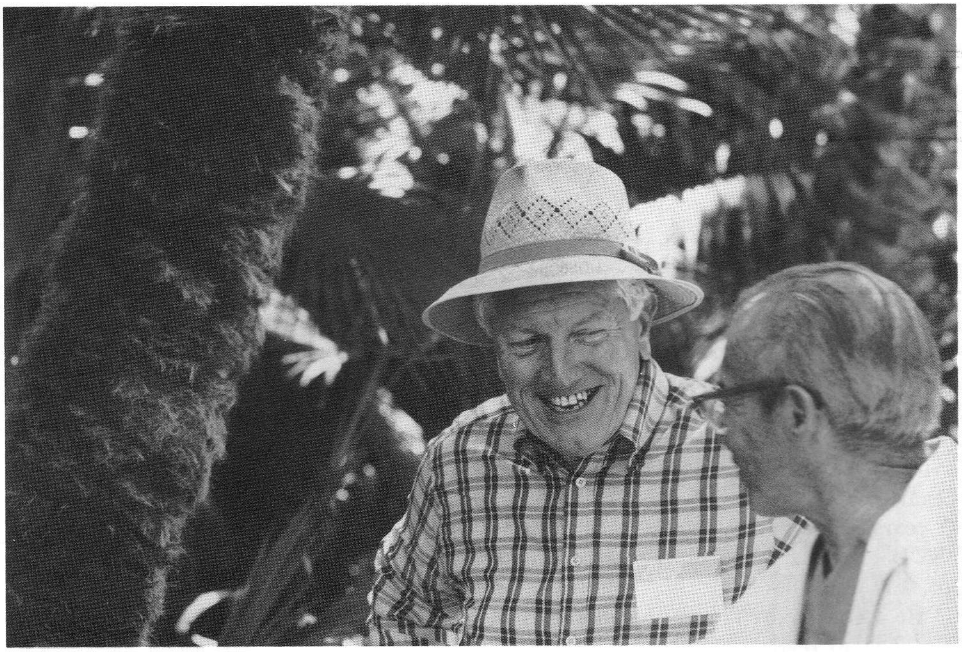
Ed McGehee

I shall never forget the first time I saw Ed and Peggy McGehee. Ed, with a rather large head, topped by a safari type straw hat (see Fig. 1), on a broad-shouldered stocky body, slightly stooped, was hurrying toward us. Sara Colvetto and I were attending a meeting of the South Florida Division of The International Palm Society held that day at the Jennings' Estate in Coconut Grove, Fla. It was his first Palm Society Meeting. He never missed another unless he was out of the state . . . and many of those trips were to attend a meeting of another Palm Society Chapter.

Soon, he was elected to our board, became the president, and then its treasurer. He served as chairman or co-chairman of the two yearly sales sponsored by the South Florida Chapter. This task in itself was tremendous. All the while he had a leaky heart valve and should have been taking it leisurely. One year his back bothered him so much that he couldn't go to bed, rather he slept for a few hours in his chair. He never complained. This I learned from Peggy.

He was one of the few members who volunteered for the Metro Zoo palm project in Miami. He was one of eleven who volunteered to plant palms at Heritage Park in Ft. Lauderdale.

I think he rather envied those of us who have been in IPS from its beginning. He constantly asked questions concerning our early days, where we'd had our meetings and our trips, about early members or their



1. Edward M. McGehee, with a smile familiar to many of us, talks to Maxwell Stuart at the San Diego Zoo, during the 1986 Biennial Meeting of IPS. Photo by C. Graff.

contributions. He did not talk about himself and his many accomplishments.

He was a collector of palms and palm seeds. He left 55 packages of germinating palm seeds—more seeds arrived from the seed bank the day after his death; over 150 palms in containers and 140 species in the ground on his ⅔ acre plot where he and Peggy lived on the Waterway in Ft. Lauderdale. He collected heliconias, bamboos, aroids, cycads, and miscellaneous plants. He joined their respective societies so that he could read their literature. He loved books and among his many books were all the new books about palms. (He owned two volumes of "Genera Palmarum," a leather bound and the regular edition.) His thirst for learning was insatiable. He amassed gardening tools of every description . . . not just one of each but several. His last big requisition was a folding garden cart which he planned on using at F.T.G. Member's day and future palm sales. It would take up less room in his van and thus leave more space for plant buys.

Ed did not employ a gardener to plant or care for his treasures. He, with Peggy's help, did it all. He did condescend to have a man mow the lawn and trim the hedges . . . the man must have forgotten the hedges and Ed, just two weeks back from the arduous trip to "down under" where he'd been troubled by shortness of breath, was clipping the hedges on his last afternoon.

Death was instantaneous. He was but 66. He'd had a full life.

GERTUDE COLE

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Water Treatments for Palms

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I have grown palms in containers for the past twenty years and have had plenty of happy and unhappy experiences in my efforts not only to germinate seeds, but also to grow them past the difficult seedling stage.

A number of years ago, when I first became aware of various water treatment techniques, I made inquiries as to the cost factor. I concluded that for a hobby, the costs were too prohibitive. Like many hobby growers, I saved rain water and used it for special plants. It was a great deal of work, and took up a lot of space. Certainly I couldn't use bottled water or rain water for the large number of plants I am growing. This past spring, I visited the Sherman Foundation, a small botanical garden in Corona del Mar, California and was thoroughly impressed with the good health and vigorous appearance of the plants. After some inquiries, I concluded that the most outstanding difference between us was the fact that they utilized R. O. (Reverse Osmosis) and D. I. (Deionized) water. Once again, I contacted various water companies and found that I would not be able to get a suitable unit for my needs for less than $50.00 or $60.00 a month. Well, that might not seem like much, but that added to my other plant expenses such as water, gas, electricity, fertilizer, soil emendments, etc. all mount up. Need I say more? If I were in business, I could claim a tax deduction, but I am not. A little investigating showed that phosphoric acid, readily available and quite inexpensive, would lower the pH factor. I then purchased a simple pH test kit at a local aquarium supply store and immediately tested the pH of my tap water, my stored rain water, water treated with Green-o-matic, and vinegar water. The different water tested had at least one thing in common: a 6.2 to a 6.4 pH. The tap water, however, read about 7.5 to 8.0 pH.

I then purchased a Siphon-X which draws up a concentrated solution of Peters water (soluble fertilizer with NPR of 10-10-10) in the ratio of 16 to 1. I planned to fertilize my plants every time I watered with a pH of about 6.2. I experimented by adding small amounts of phosphoric acid to a pail and tested the outgoing water with litmus paper purchased from the aquarium supply store. After a short while, I was able to duplicate the reading of my rain water and bottled distilled water. At last I had found a method to water easily and efficiently my potted plants. The only thing left to do was to fit my faucet and hoses with a quick coupling device, so as to facilitate a rapid change from tap water to treated water, to either hose down the patio or water the plants in the ground. The only disadvantage to using the Siphon-X is that there is a drop in the water pressure but I soon became used to it.

The only thing left to do was to bide my time and see if all the trouble I had gone through would make any difference in the health and appearance of my plants. My opinion is that it does make a big difference, especially when it comes to seedlings. Species that I have always had trouble with are doing better. Growth and color are noticeably improved. This includes other plants, not just the palms.

I realize that there are many areas that do not have a specific pH water problem, but in the southwest U.S.A. it is one of our biggest. All I can say is that I don't even want to think of all the seedlings and palms I have lost over the years because I couldn't give the young plants the rain water they obviously needed. I also enjoy not having to think about fertilizing the plants at a given time. I simply do it every time; except that I hold back on it during the months of January and February.

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Palm Growing in Central Florida

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Palms are generally easy to grow in central Florida. Only a few specific guidelines must be considered in their propagation and cultivation. As you may have observed, there are several palms which are hardy here. First of all, don't overlook the natives, as they are excellent for several reasons.

Propagation of palms is generally from seed; however, the clustering types may sometimes be amenable to division. In order to be more assured of germination, the collected seeds must first be cleaned of pulp (fruity tissue) and then dry for a few days if the seed is wet from the pulp. Palm seeds generally are not viable for long periods so it is advisable to plant them within a week or two of collecting. Seeds are readily available if you are willing to look around. They can be found in parks, along streets, in private yards, in the woods, and you can purchase them. Mature seeds are usually available from July until November here in central Florida. If you spot seeds on a palm which interests you and it is on private property, just ask the owner; most people are very generous. Purchasing of palm seeds is another matter, as most seed supply houses specialize in quantity. Of course, as a member of The International Palm Society, you have access to the whole world by way of The Seed Bank.

Once the seed is ready to plant, a well drained soil mix should be obtained. Composition of the mix isn't extremely important as long as it has the following characteristics: must be porous and well drained, should contain at least 60 percent organic material, and be free of pests. Place the soil in a container with good drainage, gently firm the soil (do not pack) so that it is within one inch of the top of the container, scatter the seeds on top and cover with soil to a depth of about one half the seed diameter. Wet the soil thoroughly and allow to drain. Germination of palm seed requires from a few weeks to several months, depending upon the species. The seeds must be kept moist but not soggy until they germinate. When the temperature is kept at 80 to 85° F degrees, they germinate much faster. That does not mean that they will germinate in a few days, but that they will germinate in a few months instead of several. One way to maintain a uniform moisture level is to place the container of soil and seed in a plastic bag and seal it. Keep it in a warm shady place.

After germination of the seed, you may separate the seedlings and transplant them as desired in individual containers. Most landscape type palms should be transplanted singly, whereas, those used for interior purposes are generally planted as multiples to a obtain bushy appearance.

Newly transplanted seedlings should be kept in a shady area until they have become acclimated (at least a month), then moved into direct sun.

Palms are heavy feeders; however, the exact fertilizer analysis is not critical. Some palms, such as the *Phoenix* species, require a substantial amount of manganese and magnesium. Any good garden supply store will carry a special fertilizer with a substantial amount of these elements. Feed your palms several times each year during the growing season, and you will be rewarded with lovely foliage and good growth.

Most palms are easily transplanted. When the specimen is being moved from a container, the roots should be separated so that they are no longer in a tight ball in the shape of a pot. Don't be afraid of breaking a few, there are plenty if the plant is healthy. When repotting or transplanting a palm the general rule of maintaining the same plant depth in the soil applies. If the soil level has left small feeder roots bare, then, a little extra soil on top may be helpful but in most cases the plant should not have any soil added on top of the existing root ball. Transplanting from one inground location to another should be preceded by a root pruning process. This is accomplished by inserting a shovel vertically about 12 inches into the soil and about 12 inches from the trunk, all around the plant. Wait about 2 weeks, then move the palm to its new home. Here in central Florida, it is always advisable to add peat generously under and around the plant.

As your palm grows the lower leaves may be discarded by the plant. To encourage optimum growth and improve the appearance of the plant, the lower leaves should be trimmed off as they turn yellow.

Indoor palms usually don't require much attention, however, a periodic soap and water cleaning of the foliage and regular fertilization will maintain their health. The most common problem experienced with indoor palms is spider mites which the soap and water treatment will control. Indoor palms will withstand relatively low light conditions for short periods but don't expect them to survive for months under these conditions. Consider rotation of indoor plants into good light (near a window or onto a porch) at weekly intervals to maintain their health.

Back Cover

Corypha umbraculifera, in full flower in a village orchard, Kergalle, Sri Lanka. Photo J. Dransfield. See p. 44.