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Cover Picture

Zuikonishiki, a dwarf *Rhapis excelsa*. See pp. 99–104.

PRINCIPES

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The "Americanization" of Dwarf Rhapis Excelsa: How I Got Involved In An International Secret

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Rhapis excelsa is one of the oldest ornamental palms in the world. Native to the temperate regions of China, dwarf varieties have been popular container plants in Japan for over three centuries. Forms of *Rhapis excelsa* were introduced into America during the 1850's. Our Victorian ancestors often used these plants as indoor parlor palms and courtyard accents. Many old Victorian homes in the South still display beautiful clumps of *Rhapis*, over 100 years old. In 1939, Fairchild Tropical Gardens in Miami planted twelve single canes of *Rhapis excelsa* six feet apart. Today these palms stand in a 10′–12′ tall "hedge" which is more than eight feet wide and eighty feet long. These palms of Fairchild and the Victorian homes are large "standard" *Rhapis excelsa*; the dwarf varieties of *Rhapis excelsa* were not collected by Americans until the 1960's—a surprise since we are usually quick to discover, import, and cultivate highly prized plants of other countries. Perhaps dwarf *Rhapis excelsa* could be called "the secret of the Orient"!

I discovered this secret, by chance, in 1976. At that time, few Americans distinguished one species or type of *Rhapis* palm from another. Fortunately, I chose dwarf *Rhapis excelsa* for commercial production and later found it the most adaptable type of *Rhapis* for interior use. However, back then, it was just another *Rhapis* palm.

Rhapis Gardens began with the purpose of finding and producing plants which were not "typical tropicals." A well-known South Texas nurseryman, J. B. Wright, suggested that we consider growing *Rhapis* palms. Mr. Wright had admired these palms for many years, but had never found a reliable supplier. As we began to search for a source of plants and information, we found that *Rhapis* palms were available on a limited basis and production information was non-existent. My husband, a graduate of Cornell University, suggested that I contact the Bailey Hortorium. I received a reply from Dr. Harold E. Moore, Jr., an outstanding palm authority and editor of PRINCIPES. Dr. Moore reported that little was known about the culture of these Far Eastern palms, but recommended several PRINCIPES articles which had information about the few known species of *Rhapis*. He offered encouragement and requested that I someday share my experiences and knowledge with The Palm Society.

In the past six years, I have reached many conclusions on the growth and culture of the dwarf forms of *Rhapis excelsa*; however, I have "Americanized" the growing methods of these palms. The traditional Japanese culture of *Rhapis excelsa* is very involved and complex, and not easily adaptable to the American lifestyle. The methods used by Rhapis Gardens are successful and simple—but required many years of experimenting. As promised to Dr. Moore, I will gladly share my current knowledge with the members of The Palm Society.

1. *Rhapis excelsa*, Daruma in 7″ pot.

2. *Rhapis excelsa*, Tenzan in 7″ pot.

Our first challenge was to locate a source for *Rhapis* palms. Only a few nurseries in California and Florida had palms available in quantity. Sample *Rhapis* were totally different in size, leaf shape, and overall appearance—some were seedlings, while others were new divisions. A Californian broker supplied several *Rhapis excelsa* from Japan which were uniform, named varieties. According to the broker, California nurseries routinely imported bare-root *Rhapis*, potted, and sold them. He warned that only small palms could be purchased since the U.S.D.A. would not admit foreign plants over three years old or 18″ tall.

Several factors needed to be analyzed before a decision could be made. The forms of *Rhapis* from Japan were far superior to the domestic samples, but Texas seemed a long distance from the Orient for frequent orders. In addition, imported palms often carried hibernating scale and suffered from "jet lag"! I projected that Japanese prices, plus air freight, plus costs of acclimatizing the palms would result in extremely high prices at the market level. However, plants of dwarf *Rhapis excelsa* produce several offshoots per year, which can be grown and sold. The solution to costs and problems of continuous imports was simply to purchase growing stock and propagate *Rhapis excelsa* in Texas. American descendants of Japanese *Rhapis* could then be domestically produced at low cost and grown to large sizes. The 1977 dollar was strong, Japanese prices were reasonable, and air freight was tolerable. (Times have since changed! Japanese prices have doubled and air freight has tripled; as for the dollar . . . .).

Four varieties were originally selected for propagating stock: Tenzan, Koban, Daruma, and Kodaruma. Two thousand palms were imported during the first year. The importing was easy; the hard part was just beginning. The Japanese were happy to sell the palms, but provided only vague hints concerning culture. Instructions included using three sizes of granite for soil, 50% shade, and Japanese Bush Warbler droppings as fertilizer. Our nursery is 1,500 miles from the Rocky Mountains (the closest granite source); 50% shade in

3. *Rhapis excelsa*, Koban in 8″ pot and Zuikon-ishiki in 5″ pot.

4. *Rhapis excelsa*, Kodaruma in 7″ pot.

Japan equalled ??% shade in South Texas; and alas, we didn't import any birds. We considered our native seagull as a possible source for droppings, but our employees just wanted to collect seashells! Thus began the years of trial and error.

Experimenting is an integral part of many commercial operations. Most ordinary plants have numerous guidelines which are established and proven (and often available from a local extension service). Further testing is usually a means of "fine-tuning" predetermined growing methods. In our case, we faced an almost impossible situation with few guidelines and five variables present—type of soil, type of fertilizer, rate of fertilizer application, amount of shade, and possible insects. Another drawback was the slow growth rate of *Rhapis*—first test results were over a year away.

We initially set up twelve experiments using bone meal, cottonseed meal, fish emulsion, and several different commercial fertilizers and soil mixes. Plants were shaded to 55% and sprayed with general insecticides. During the first year, imported scale inundated the palms, most fertilizers burned (application rates were too high and we could not control the levels of organic fertilizers), the sun toasted the leaves, and our "1,000 ppm of salt" city water silently encrusted our soils. Surprisingly, few palms died—proof of the endurance of *Rhapis excelsa* (although I refuse to describe the appearance of the survivors).

The following year, we shaded to 73%, installed a water deionizer, used several soil mixes, limited our choices of fertilizer to the commercial chemical types, submitted soil samples monthly for lab analysis, and used a systemic for pest control. That year ended with better results—shade was adequate, scale was almost eliminated, a peat-based mix proved successful, and the best fertilizer was 20–20–20 at low rates. Today, our experiments continue and provide new methods for growing *Rhapis* palms.

Propagation of our dwarf *Rhapis*

5. *Rhapis excelsa*, Gyokuho, 7″ pot.

excelsa is by division. Clones provide a true plant variety and a constant supply of stock. Each mature palm produces an average of two offshoots per year. "Pups" remain attached to the parent plant until a root system develops that will fill a 4″ or 4½″ pot. An offshoot this size usually takes two years to reach a salable 5″ pot size, and six to seven years to qualify as a 10″ pot size. Some of our imported stock, purchased at three years of age, are now 10 year old specimens, over 42″ tall with 12–15 canes.

We totally acclimatize dwarf *Rhapis excelsa* to low light conditions. Our greenhouses are now shaded to 90% in the summer and 80% in winter. Palms to be sold are held under 95% shade for three to six months. As a result, our palms can easily adapt to low light conditions of 200 f.c. (98% shade) and still maintain growth.

The variegated forms of *Rhapis excelsa* require different culture than the green varieties. The Zuikonishiki is a white and green striped palm which prefers very low light and reduced fertilizer rates. Another variegated, the Chiyodazuru, has chartreuse leaves with delicate white stripes. The variegation disappeared within several months after importing this variety. Correspondence with the Japanese resulted in the advice "more cool, less

6. *Rhapis excelsa*, Zuikonishiki, 5, 10, and 7 years old.

Table 1. Comparisons of 10 year old varieties in U.S. commercial production—10″ pot size, grown under an average 1,000 foot candles; height measured from soil line to top of leaves; average leaf split indicates leaf on pup versus leaf on tallest cane; light recommended is a minimum–maximum range for each variety.

Name	Average Lv. Split	Growth Habit	Average Height	Fert. Rate	Light F.C.	# of Canes	Comments
Daruma	4–11	tall	36″	1/2	150–4,000	12	leaf resembles the standard *R. excelsa*
Tenzan	2–5	tall	36″	1/2	150–4,000	8	long, oval, drooping leaves
Koban	2–6	medium	32″	1/2	150–4,000	10	large oval leaves
Kodaruma	3–6	short	24″	1/2	150–4,000	20	small twisted leaves
Gyokuho	2–3	short	24″	1/2	150–4,000	10	small oval leaves
Daikokuten	4–11	tall	36″	1/2	150–4,000	12	large thick leaves
Zuikonishiki	3–6	short	20″	1/4	100–800	10	green stripes on white leaves
Chiyodazuru*	3–6	short	22″	1/2	100–800	12	light stripes on green leaves
Kotobuki	2–5	tall	34″	1/2	100–2,000	8	white stripes on green, leaves resemble Tenzan

* Chiyodazuru—bright light will result in loss of variegation. Grow in low light with the higher recommended fertilizer level to maintain the striped appearance.

shine." Three years later, after many experiments, we discovered that the Chiyodazuru produces beautiful stripes if grown under very low light and fed high rates of fertilizer.

Our last shipment of *Rhapis excelsa* was received in 1979. The order consisted of 200 Kobans and 50 Kodaruma. We found many palms which seem to be "different." The Koban has large, oval leaves and upright growth; the Kodaruma has more segments per leaf and a very short compact growth. The odd ones seemed to be a combination of both varieties—small oval leaves on short canes. The mystery palm was nick-named "Bush baby" until we verified the type to be Gyokuho. This variety is a pleasant surprise and seems to be a favorite.

We propagate five green and three variegated varieties of dwarf *Rhapis excelsa*. Some people often think that the dwarf forms of *Rhapis excelsa* will eventually all look alike, regardless of variety. However, many of our original palms are 10–15 years old and remain true to variety. Of our total stock, very few are "unknowns" and we hope these may be new "sports." Only time and more experiments will tell!

A last word is needed on the genus *Rhapis*. America is finally becoming aware of "*Rhapis* palms," but confusion about the different species is still prevalent. Two main species are *Rhapis excelsa* and *Rhapis humilis*. Several other *Rhapis* are native to the Far East, but have not yet been classified or named and are presently listed under the general category of *Rhapis* sp. An unclassified Thailand *Rhapis* is becoming common because it is easily grown from seed. This palm is often incorrectly listed as *R. humilis*. The Thailand palms have thin canes, frail leaves, and segments per leaf which vary. *Rhapis* "*Thailand*" should not be mis-

taken for *Rhapis excelsa* or *Rhapis humilis*. It is to be hoped that greater interest in the genus *Rhapis* palms will result in more knowledge of the species.

I am presently involved in researching any and all known types of *Rhapis* in America. So far, *Rhapis humilis* is only prevalent in California. This species is scarce and expensive, and will seldom tolerate the hot summers of the Gulf Coast or indoor culture. *Rhapis* "*Thailand*" is easily grown in Florida, but has limited success in interior culture and in Texas landscapes (our drastic 40 degree temperature fluctuations seem to be detrimental). *Rhapis excelsa* is the only species which is reportedly adaptable to all interiors and temperate regions of the United States.

Varieties of Dwarf *Rhapis excelsa*

The Japanese have collected, cultivated, and classified over 100 varieties of dwarf *Rhapis excelsa*. In America, the more popular and available types are green Daruma, Koban, Tenzan, Gyokuho, and Kodaruma, and variegated Zuikonishiki, Chiyodazuru, and Kotobuki. Each variety has an individual leaf shape and growth habit. Some are short and compact; others are tall and slender. Table 1 compares the varieties.

Commercial production provides perfect conditions for maximum growth rates of 3″–6″ per year (depending on variety). Interior light levels usually result in slower growth rates of 1″–3″ per year.

Acknowledgments

I am grateful to the late J. B. Wright for the original idea of *Rhapis*, to the late Dr. Harold Moore for encouragement, to the Japanese who discovered dwarf *Rhapis excelsa* 300 years ago, and to my many employees who have assisted me in "Americanizing" the culture of these delightful palms.

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Tissue Culture of Date Palms—A New Method to Propagate an Ancient Crop—and A Short Discussion of the California Date Industry

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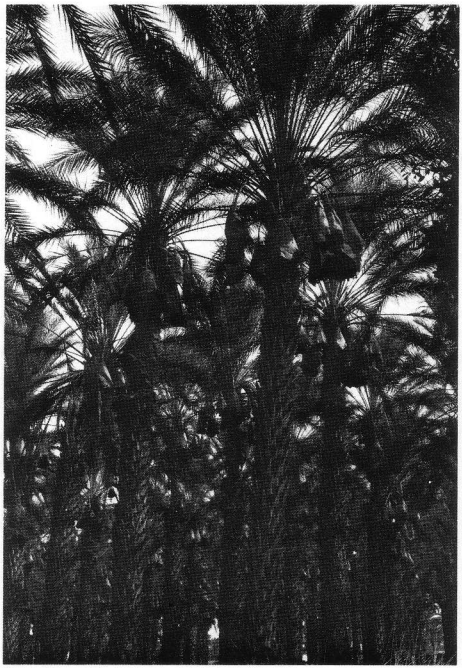
The date palm, *Phoenix dactylifera* L., is one of the economically most important species of the Arecaceae (Palmae). Date palms provide a staple food crop for several North African and Middle East countries (Fig. 1). Records reveal that the date palm has the distinction of being one of the oldest cultivated tree crops beginning at least as early as 4,000 B.C. (Zohary and Spiegel-Roy 1975).

Extent of the U.S. Date Industry

The date industry in California is restricted to the hot arid, inland desert regions of Riverside and Imperial counties. About 99% of the dates produced in the United States are grown in the Coachella valley of Riverside county. The total date acreage of Riverside county has remained relatively constant since the 1950's and today consists of 3,868 acres (Anon. 1978, Mitchell 1973). Also, some insignificant date acreage is located in adjacent Imperial and San Bernardino counties and the Phoenix and Yuma regions in Arizona. Dates are a specialty crop in California and in 1978 yielded 24,317 tons of fruit worth $19,130,000 from 3,542 bearing acres (Anon. 1978).

Cultural Innovations in the U.S. Date Industry Since the 1960's

The California date industry began around the turn of the 20th century through the introduction and multiplication of proven date palm clones which were obtained from North Africa and the Middle East. Excellent reviews of date palm industry's establishment and history are available (Nixon 1971). Prior to 1964, the date industry was highly labor-intensive, such as that of other date producing countries in the world. An integration of mechanical and hand operations has occurred in the U.S. industry based on economic necessity (Wright 1975). The termination of the Mexican National Program in 1964, and with it cheap agricultural labor, has resulted in the introduction of successful new mechanical methods to pollinate, dust, and harvest dates. These techniques were developed by USDA and University of California agricultural engineers (Perkins and Brown 1964). Mechanical harvesting has been successful because the cultivar "Deglet Noor" comprising 85% of the date trees in the Coachella Valley is amenable to this method. Deglet Noor is a naturally semi-dried date and can be allowed to ripen on

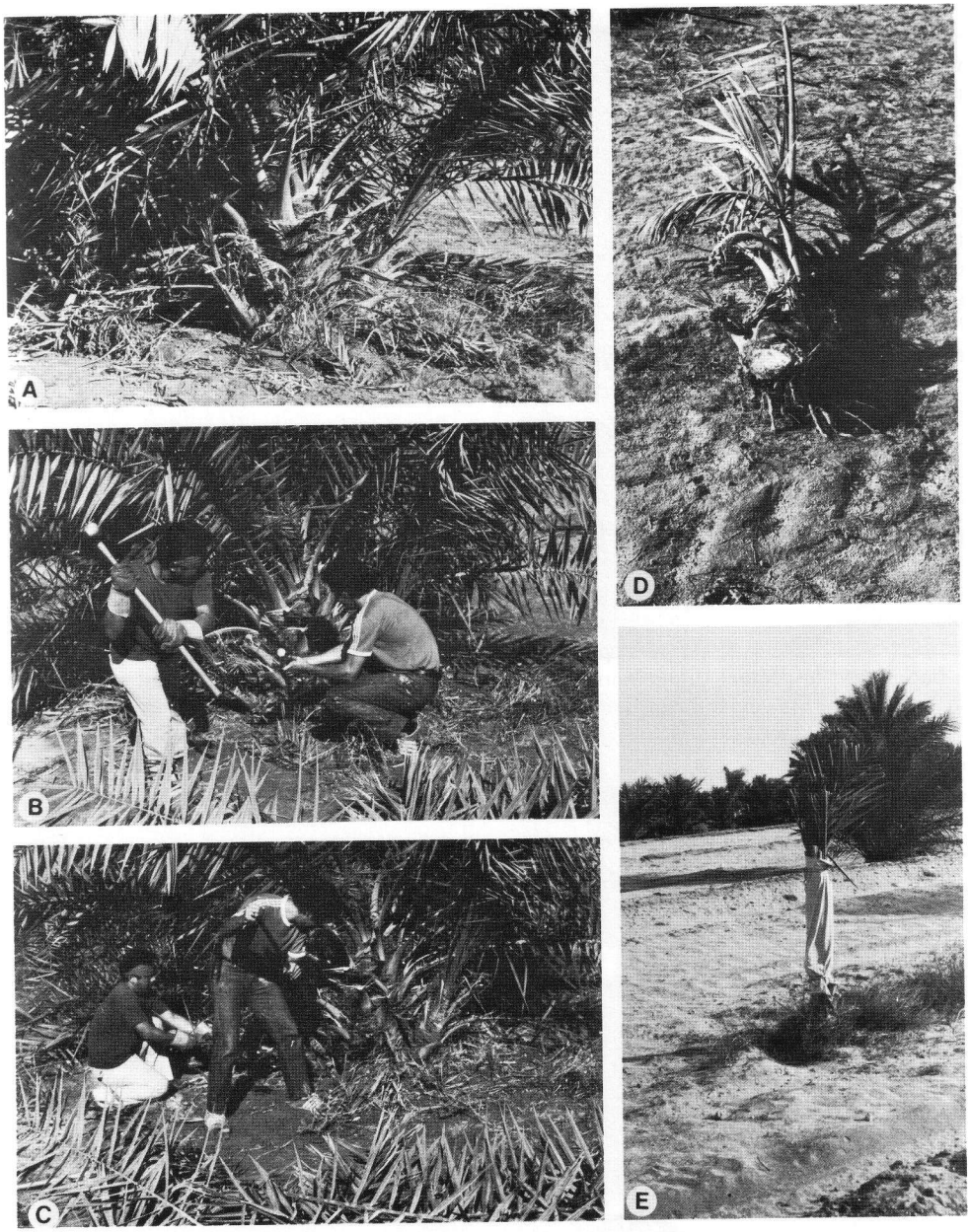


1. Date palm (variety "Deglet Noor") commercial garden located in Indio, California, with ripe fruit bunches. Approximately 300 pounds of fruit can be harvested from each of these 30 year-old trees.

the bunch. The whole bunch may be removed, eliminating individual hand picking. Picked whole fruit bunches may be harvested and processed in a uniform manner (Huxsoll and Reznik 1969). Naturally soft dates such as the Medjools and Barhees are not amenable to mechanical harvesting and must be hand picked and processed. Successful mechanical pollination of trees using a ground applicator has been achieved (Perkins and Burkner 1973). These applicators can also be employed in dusting operations. However, some growers prefer both hand pollination and harvesting. Mechanical pollination, probably accounts for only 20–25% of the crop fruit set. Other attempts to devise methods to mechanize further cultural practices such as pruning, bagging and fruit bunch tie-down have not been adopted because they are economically not feasible. The date industry has drastically reduced the labor force necessary to perform its cultural practices to only 20–25% of its former level since the introduction of these techniques (Wright 1975). Any substantial increase in soft date acreage is not probable because of increased labor demands that would result in their maintenance. New improved cultivars must compare favorably with Deglet Noor in order to be planted and no foreseeable replacement is apparent (Carpenter 1979).

Methods of Date Palm Propagation

The key to the success and viability of the California date palm industry has been the large uniform quality fruit production, usually 12,000 to 14,000 pounds of fruit are produced per acre. A single Deglet Noor tree may yield 200 to 300 pounds of fruit a year. Such uniform yields have only been possible because of the foresight of the original date growers to procure and propagate desirable clonal varieties by offshoots (Nixon 1971). Offshoots are lateral buds located at the base of the trunk above the point of leaf attachment. These buds grow out producing a tree which is an exact copy of the parent. Only a limited number of offshoots are produced by vegetative buds during the juvenile life cycle of the palm, the first five to seven years of growth. Thereafter, bud development is usually devoted to the generation of fruit bunches (Fig. 1). Occasionally, high offshoots will develop in the fruit producing region of the tree. Production of high offshoots is infrequent and unpredictable and the reason for their origin is not known. Less than a dozen offshoots are usually produced during the life of a palm, and the number may vary considerably among different varieties. Commercially acceptable date palms cannot be propagated from seed. Half the progeny will be male and half will be female. The



2. Field techniques to propagate the date palm vegetatively. Newly initiated leaves are growing out from crown. (a) Example of 7 year-old date palm bearing offshoots. (b) Positioning chisel to sever offshoot from parent tree. (c) Detachment of roots and fiber to obtain offshoot. (d) Freshly cut offshoot with preformed adventitious roots. (e) Offshoot wrapped with burlap bag planted in field after 1 year.

seedling female palms usually produce fruit which is commercially inferior in quality to the clonal parent.

Offshoots should have roots initiated prior to the time of their detachment from the parent tree to ensure survival when planted. Roots are produced naturally from the base of the offshoots when they are in contact with soil. Offshoots slightly above ground level can be induced to form roots by mounding soil around their bases; in the case of higher offshoots air layering will suffice. Prior to the time of detachment from the parent trees offshoots are severely pruned (Fig. 2a). The offshoot is removed from the tree in a procedure involving two men (Fig. 2b, 2c). One man positions a large chisel between the offshoot and the parent tree while the second man drives the chisel with a sledge hammer to sever the vascular connection. The crown portion of the shoot is wrapped with a burlap bag to protect the growing plant against excessive cold and heat during the early years of growth. The transplanted offshoot will produce its own foliage, offshoots and fruit bunches in three to five years (Fig. 2d, 2e). Generally, 40 palm offshoots are planted in one acre and are spaced about 20 feet from each other.

World Demand for Offshoots

Adult fruit bearing trees are denuded of offshoots to facilitate easier cultural handling and increased fruit yields per tree (Mitchell 1973). Thereafter, adult date palms seldom, if ever, produce more offshoots. Available offshoots are either employed in new local plantings or are sold to foreign buyers for planting overseas. For example, Israel has developed a vigorous date industry patterned after that of the U.S., employing imported offshoots. Offshoots from the Coachella valley are a world-wide source of commercially desirable disease-free trees. The prices of an offshoot may vary from $25 to $50 each, depending on the size and type of cultivar.

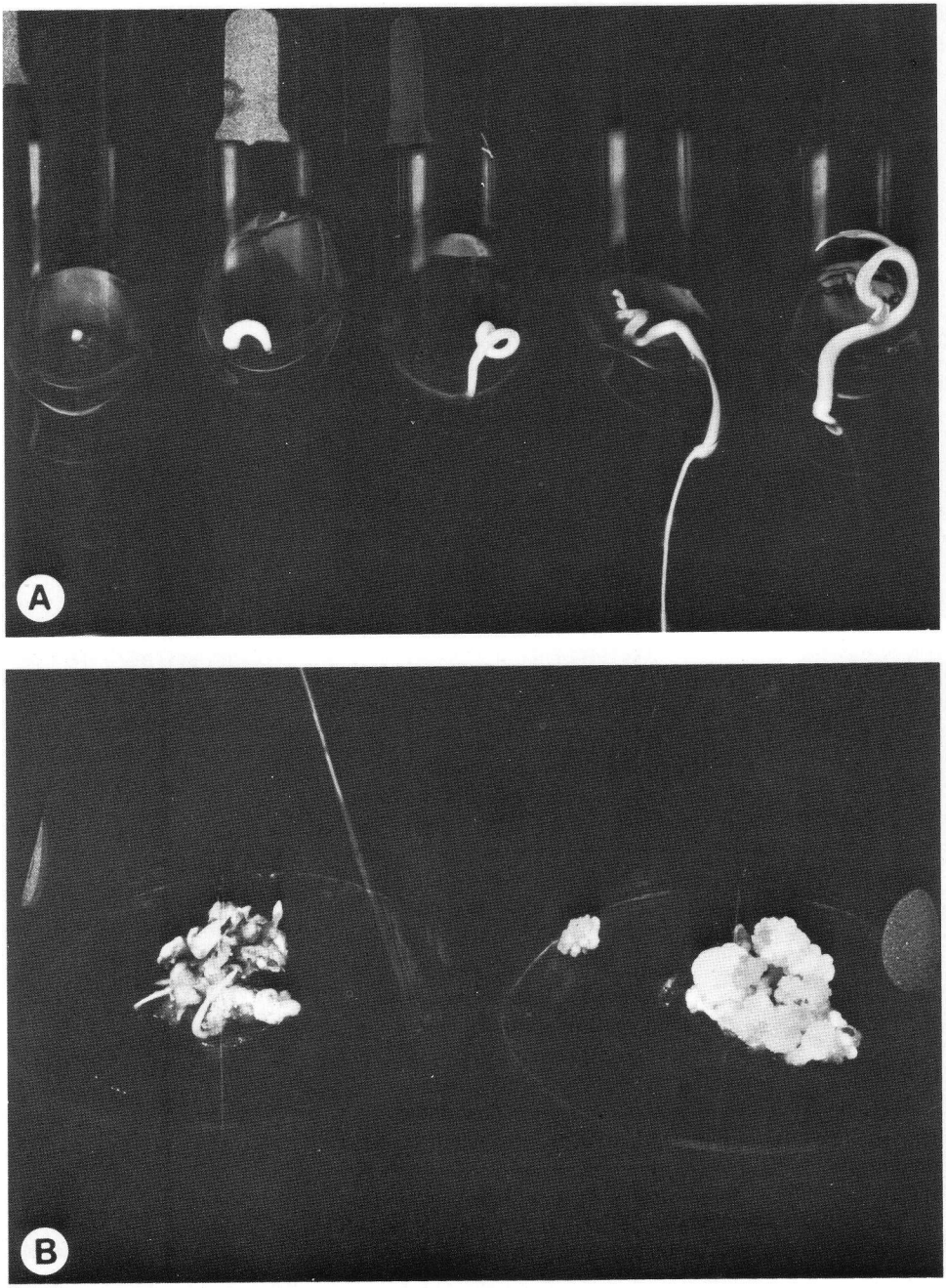
The existing method of vegetative propagation of date palms is reliable but slow. Should the California industry attempt to expand date plantings using proven clonal varieties, only 100–200 acres with 40 date palms per acre could be planted each year. Presently, about 4,000 to 6,000 offshoots are produced annually in the Coachella valley (Mitchell 1973). It would require decades to replace the existing date acreage in the Coachella valley with a superior variety.

In Morocco and Algeria, the bayoud disease (causal agent—*Fusarium oxsporum* Schlect. var. *albedinis*) has devastated the date industries destroying 10 million palms since the turn of the century (Carpenter 1973). It would require several decades perhaps centuries to repopulate devastated areas with resistant cultivars propagated clonally using conventional methods. Further, modernization of the Old World date industry similar to that of the U.S. could not readily be applied since many presently employed date varieties produce fruit which are not amenable to mechanical harvesting and processing. Deglet Noor and other commercially comparable cultivars are not available on a large scale.

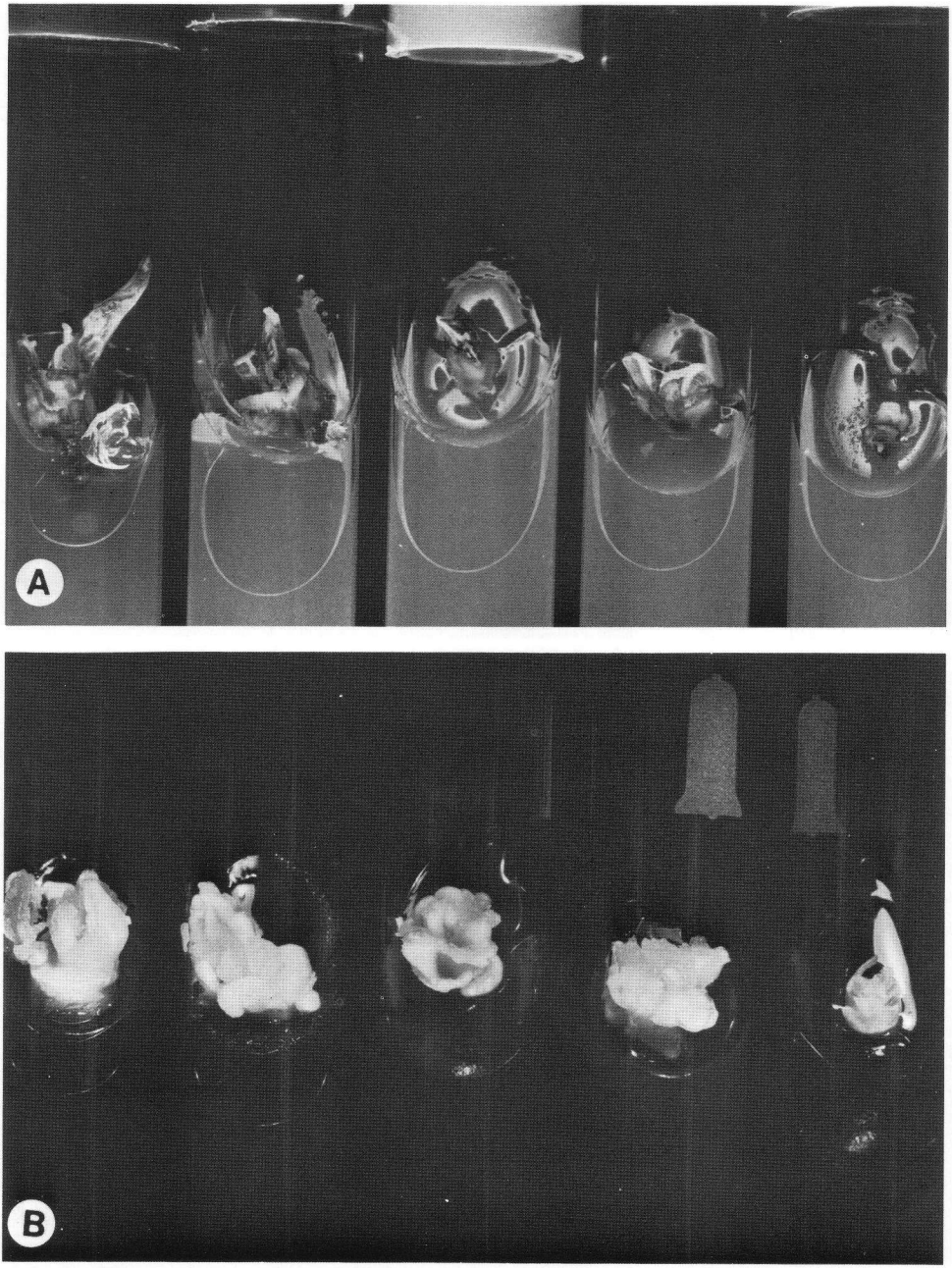
Tissue Culture as a New Means to Produce Clones

Tissue culture micropropagation is a term used to describe the cloning of plants under artificial sterile conditions. Tissue culture cloning is often economically more feasible and faster than using existing vegetative propagation methodology to increase rapidly large numbers of a desired clone. Since the early 1960's, several plant species have been commercially propagated using tissue culture techniques including orchids, ferns and an ever increasing multitude of herbaceous ornamentals (De Fossard 1976, Murashige 1976, Reinert and Bajaj 1977). However, propagation techniques for woody species are notably less developed.

Interest in the development of suitable



3. Morphogenetic potential of excised date palm embryos from Halawy fruit cultured *in vitro*. (a) Germination sequence, from left to right: freshly excised embryo, elongation of cotyledon after 2 weeks in culture, continued cotyledon elongation after 3 to 4 weeks in culture, germination of the primary root after 4–6 weeks in culture and emergence of the first foliar leaf, after 4–6 weeks in culture. (b) Totipotency of embryos cultured on nutrient medium containing 100 mg/l 2,4-dichlorophenoxyacetic acid. Left: callus producing organized structures after 4 months in culture. Right: nodular callus devoid of any organogenesis.



4. Effect of charcoal on date palm lateral bud explants. (a) Lateral buds cultured on nutrient medium devoid of charcoal. (b) Lateral buds cultured on nutrient medium containing 0.3% activated charcoal. Note that buds cultured on medium without charcoal are exhibiting growth inhibition compared to buds cultured on medium containing charcoal.

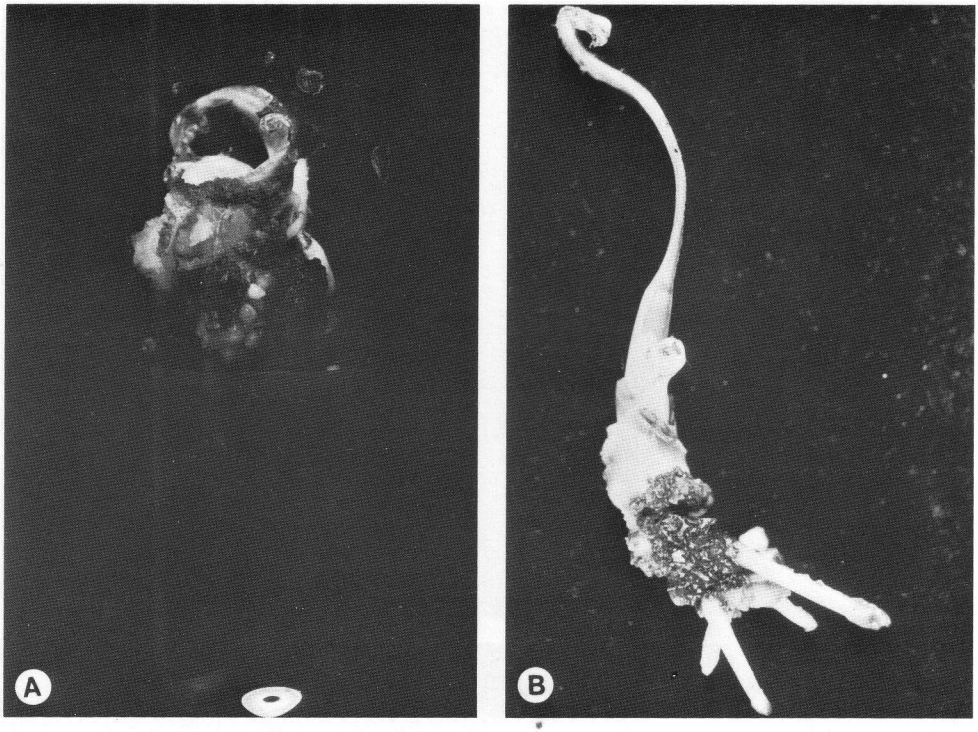
procedures to clone palms *in vitro* began in the 1960's and early 1970's (De Guzman and Del Rosario 1964, Rabéchault, Ahée and Guénin 1970, Schroeder 1970). Embryo culture, a type of tissue culture procedure in which the embryo is excised from the seed and grown separately, may have several potential applications in palm research and breeding studies. Rare palm hybrid embryos such as that of the "Makapuno" coconut cultivar which normally does not germinate in nature may be propagated *in vitro* (Balaga and De Guzman 1970, De Guzman and Del Rosario 1964, Ventura, Zuniga, Figueroa and Lazo 1966). Also, Hodel (1971) suggested that embryo culture could aid in the germination of other incompatible interspecific and intergeneric palm hybrids or slowly germinating palm seeds (Fig. 3a). Host-pathogen relationships such as that for "Lethal Yellowing" disease common in coconut may be studied through the inoculation of growing embryos in sterile culture (Fisher and Tsai 1979). Further, embryo explants may also serve as a tissue source to rapidly multiply palms *via* callus (Fig. 3b). Embryogenetic callus that has given rise to plantlets or miniature tissue cultured plants has been obtained from excised embryos of several palm species such as coconut (De Guzman, Del Rosario and Ubalde 1974), oil (Corley, Barrett and Jones 1976, Rabéchault, Ahée, and Guénin 1970) and date palm (Ammar and Benbadis 1977, Reynolds and Murashige 1979; Tisserat 1979) (Fig. 3b). Unfortunately, embryo culture is not useful for multiplication of desired clones due to the highly heterozygous nature of the embryo.

Clonal propagation using tissue culture must involve the culture of somatic tissues or organs from the vegetative and/or reproductive structures of the clone. Two striking factors regulate the growth of palm tissue and organ explants *in vitro*: 1) the omnipresent occurrence of explant and medium browning, and 2) the inherent explant totipotentiality, or its ability to regenerate an entire plant from cultured cells.

Browning is a wound response resulting when the explant is cut or damaged. Browning substances released by such injuries may be inhibitory or lethal to the development of the cultured tissue. Several early investigators noted this phenomenon and attributed their negative results to its occurrence (Reuveni and Lilien-Kipnis 1974, Schroeder 1970). The browning phenomenon was overcome by addition of adsorbants to the nutrient medium (Fisher and Tsai 1979, Poulain, Rhiss and Beauchesne 1979, Reynolds and Murashige 1979, Tisserat 1979). Applications of activated charcoal (0.1 to 1%) has been found to reduce browning for palm embryos (Fisher and Tsai 1979, Tisserat 1979) and other vegetative tissue sources (Reuveni and Lilien-Kipnis 1974, Tisserat 1979, Wang and Huang 1976) (Fig. 4). Likewise, addition of polyvinylpyrrolidone (200 mg/l) to the nutrient medium has been found to retard successfully browning in date palm shoot tip cultures (Poulain, Rhiss and Beauchesne 1979).

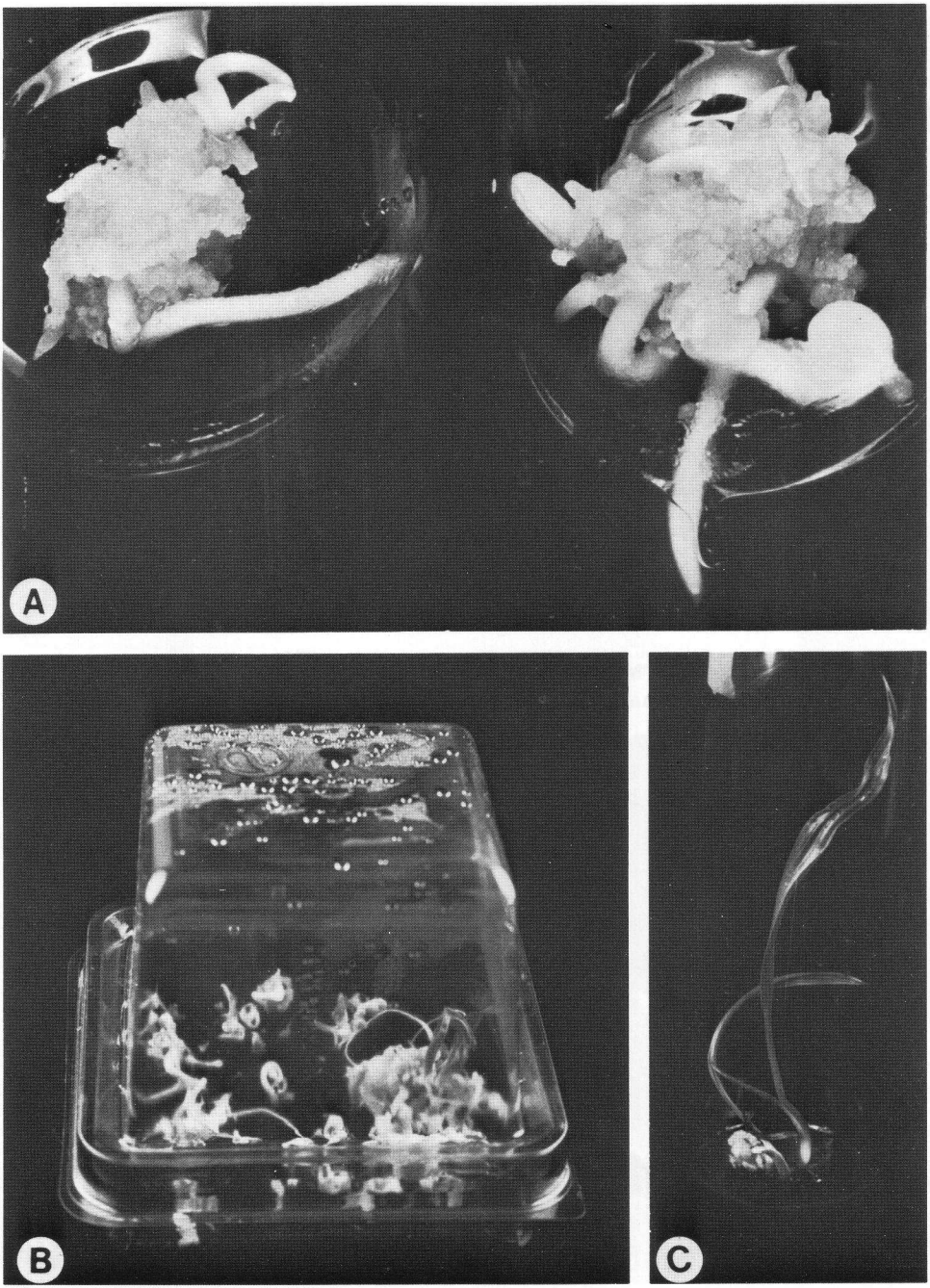
Plantlets have been derived from the rooting of cultured shoot tips in oil palm (Staritsky 1970) and date palm (Poulain, Rhiss and Beauchesne 1979, Reuveni and Lilien-Kipnis 1974, Tisserat 1979) (Fig. 5). Rooted shoot tips will only provide one plant per explant; while an almost unlimited number of plantlets are available from embryogenetic callus.

The best type of somatic explant source to produce a callus capable of giving rise to plantlets is from meristematic regions of the plant. Mature leaves, fruits, inflorescences, stems, roots and other specialized plant organs and tissues will have the least chance to grow *in vitro* because they are composed mostly of cells which are highly differentiated and usually incapable



5. Examples of rooted date palm shoot tips. (a) Early initiation of adventitious root primorida at the base of the tip after 4 months in culture. (b) Shoot tip with several elongated adventitious roots after 6 months in culture.

of undergoing further cell divisions. In contrast, prolific embryogenetic callus has been obtained from date palm shoot tips (Tisserat 1979), lateral buds (Tisserat 1979, Tisserat and DeMason 1980) and immature inflorescences (Reynolds and Murashige 1979) (Fig. 6). In date palm, explants were cultured on nutrient medium containing Murashige and Skoog salts, 3% sucrose, 100 mg/l *i*-inositol, 0.4 mg/l thiamine·HCl, 3 mg/l N^6-(Δ^2-isopentyl) adenine, 100 mg/l 2,4-dichlorophenoxyacetic acid, 0.3% neutralized activiated charcoal and 0.8% Phytagar. After several transfers at 8 week intervals the explants enlarge and eventually produce a white nodular callus. This callus may be subdivided and proliferated almost indefinitely. The author has had several callus clones of date palm in culture for up to 3 years and no diminished embryogenetic capacity has been observed. Histological sections of this callus reveal that it consists of microscopic proembryonic bodies and meristematic centers (Tisserat and DeMason 1980). Transfer of callus to a nutrient medium devoid of hormones allows visible asexual embryos and plantlets to develop (Fig. 6). Palm plantlets produced from callus arise from a somatic embryo that germinates through a sequence of events called asexual embryogenesis. The process of asexual embryogenesis is analogous to the germination of the normal zygotic embryo within the seed (Corley, Barrett and Jones 1976; Tisserat and DeMason 1980). These plantlets may be transferred to soil where they assume a growth pattern comparable to that of a seedling (Figs. 6, 7, 8). Assuming that no



6. Examples of embryogenetic date palm callus derived from lateral buds. (a) Callus cultures producing several asexual embryos cultured on nutrient medium without hormones. (b) Plantlets, asexual embryos and callus produced from "Medjool" cultivar callus plated on agar medium within a PlantCon. (c) Isolated plantlet derived from callus.

7. Examples of date palm plantlets derived from callus in high humidity transition containers. These plantlets have been in soil for $\frac{4}{6}$ months.

8. Examples of free-living tissue cultured date palms varying in age from 1 to 2 years. These plantlets may now be transferred into the field.

9. Cryopreservation of date palm clones through micropropagation.

genetic change has occurred during the differentiation process, these plants will produce uniform clonal trees that are copies of the parent tree. A single individual date palm tree or offshoot may theoretically be developed into a million or more genetically uniform individuals. A note of caution should be mentioned regarding this clonal process; aberrant plantlets derived from plant tissue cultures are not uncommon (Reinert and Bajaj, 1973).

Cloning through plant tissue culture may be coupled with cryogenic storage in order to accumulate and preserve a clonal palm repository (Tisserat, Ulrich and Finkle 1981). The National Date Palm Germplasm Repository was established in 1977 at the U.S. Date and Citrus Station, Indio, California. Numerous living trees of Old World and New World varieties are retained in this collection which could serve as a source of future date palm breeding material. Maintenance of such living germplasm collections is expensive and involves large spatial requirements. Cryobiology may be implemented as an alternative method to store crop germplasm (Fig. 9). Date palm calli may be frozen to the temperature of liquid nitrogen (−196° C) and kept indefinitely without genetic change. Thawed calli readily produce plantlets (Tisserat, Ulrich and Finkle, 1981). Such a procedure could serve to preserve endangered fruit tree clones with a minimum amount of expense, maintenance and space.

Two methods exist to produce plantlets using tissue culture techniques: 1) asexual embryogenesis in which somatic embryos germinate, and 2) organogenesis, the sequential production of roots from shoots

or shoots from roots. Date palm plantlets may be derived using either process.

Future research should now be directed at developing a quality-control test to determine the clonal purity of tissue cultured plantlets. Vegetative and fruiting characteristics of clonal plantlets should be evaluated and compared with the parent. Electrophoretic tests involving protein, isoenzyme and nucleic acid banding patterns could be developed as a preliminary test to eliminate any potentially aberrant tissue cultured palms from being cultivated further.

Refinement of the plantlet production process is necessary in order to make this technique commercially feasible. Understanding and control of the mechanism to mass produce axillary shoots from cultured tips and buds, in date palms at least, would alleviate such concern regarding the clonal nature of these plantlets. Many palms do not exhibit any natural method of vegetative propagation such as production of offshoots (e.g., African oil palm, betel palm, and coconut palm). Plantlets derived from callus would appear to be the only viable method to clone these palms.

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Palms of the Cerrado Vegetation Formation of São Paulo State, Brazil*

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The word "cerrado" in Portuguese means "dense" or "closed." Originally it was used as an adjective in the term "campo cerrado" to distinguish a campo (field or grassland) in which trees and shrubs are present so as to form a rather open woodland, open scrub or savanna, from a "campo limpo" (clean field) which is a pure or almost pure grassland (Eiten 1972).

Palms which generally occur within the cerrado vegetation formation of the Brazilian Highlands are cited by Martius (1824, 1951), Warming (1892), Rizzini (1963) and Eiten (1972). For the cerrado within the State of São Paulo in particular, the binomials *Attalea exigua*, *A. geraensis*, *A. humilis*, *A. loefgrenii*; *Butia eriospatha*, *B. leiospatha*; *Cocos eriospatha*, *C. petrea*, *Diplothemium campestre* and *Syagrus flexuosa* are cited in various publications (see Wettstein 1904, Ferri 1944, 1955, 1969, Rachid 1947, Rawitscher 1948, Ferri and Coutinho 1958, Mattos 1966 and Angely 1970). Toledo (1952) described a new species of *Acanthococos* based on material collected in the município of Pirassununga. Glassman (1967) described two new species of *Syagrus*: *S. loefgrenii* from Rio Claro and *S. rachidii* from Pirassununga. These two species subsequently were reduced to *S. loefgrenii* by Glassman (1971).

In 1972 the authors collected ample material of palms from diverse areas of the cerrado in São Paulo State (Fig. 1). In addition, materials were examined from collections in the herbaria of the Institute of Botany of São Paulo and the Department of Botany, Institute of Biosciences, University of São Paulo. The authors studied all these materials and concluded that only six species of palms are found within the State.

Key to the Palms of the Cerrado of São Paulo

1.* Plants acaulescent, armed with straight black spines; 2–4 leaves emerging from the soil with long, straight pinnae to 60 cm long and 1 cm wide; from a distance easily confused with grasses of the cerrado. ... *Acanthococos emensis*

1. Plants acaulescent or caulescent, unarmed, when acaulescent never confused with grasses; leaves varying in number.

2. Pinnae in clusters of 2–5 along the leaf rachis.

3. Plants with long, slender, flexible stems, 1.0–2.5 m tall, up to 10 cm in diameter, occurring in clumps; inflorescences with more than 8 branches. ..... *Syagrus flexuosa*

3. Plants with subterranean stems. (In *Syagrus loefgrenii* the stems are always clumped and may emerge to 60 cm above ground).

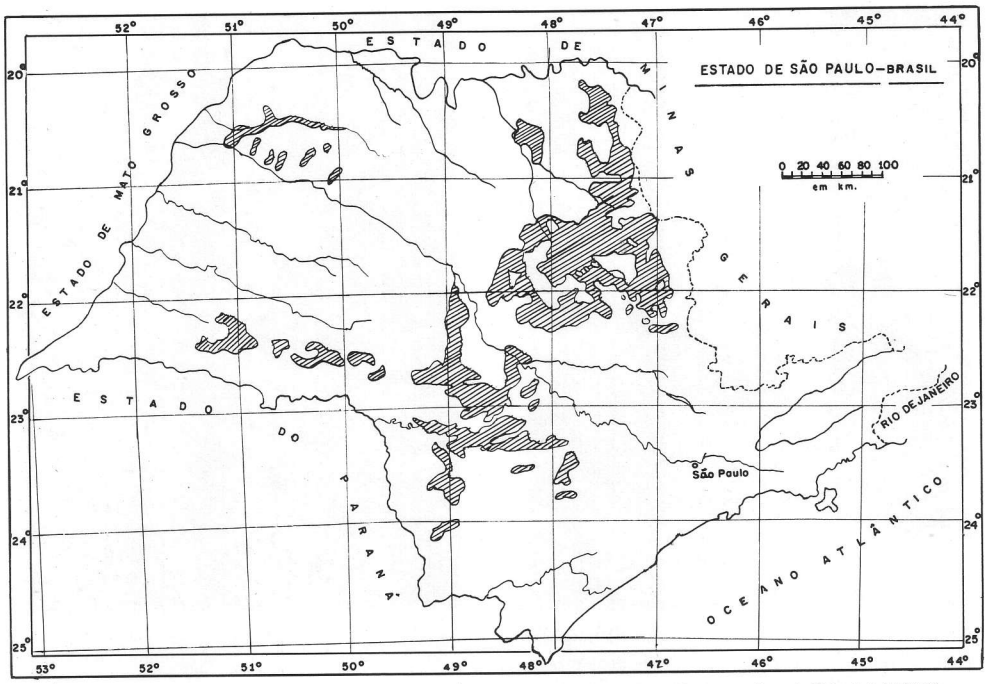
4. Inflorescence with 5–8 branches. .... *Syagrus loefgrenii*

4. Inflorescence spicate. ..... *Allagoptera campestris*

2. Pinnae distributed uniformly along the leaf rachis.

5. Rarely acaulescent; leaves gracefully recurved, pinnae glaucous, bright green below; bracts smooth; staminate and pistillate flowers on same inflorescence. .... *Butia paraguayensis*

* Translated from the Portuguese by Dennis Johnson.



1. Map of São Paulo state showing areas of cerrado vegetation. After Borgonovi and Chiarini (1965).

5. Always acaulescent; leaves also recurved but pinnae dull, pale green below; bracts deeply grooved; staminate and pistillate flowers on different inflorescences; pistillate inflorescences with sterile staminate flowers on the upper branches. ..... *Attalea geraensis*

Acanthococos Barbosa Rodrigues, Palmae Hasslerianae Novae 1. 1900.

This genus was considered by Moore (1973) as a synonym of *Acrocomia*; however, the authors were unable to find any other reference to a new combination of the species. Therefore, until new studies are carried out, the authors are maintaining *Acanthococos* as a distinct genus.

1. **Acanthococos emensis** Toledo, Arquivos de Botânica do Estado de São Paulo (Nova Série) 3(1): 4, t. 1–2. 1952.

Plants acaulescent with 2–4 leaves emerging from the soil; easily confused with grasses of the cerrado vegetation. Rachis armed with straight, black spines. Inflorescence enclosed in 2 bracts, the lower membranous to leathery, smooth; the upper fusiform, acuminate, leathery to woody, covered with soft hairs associated with very stiff bristles and long spines, these last moderately to densely covering its upper part. Staminate flowers with 3 sepals slightly connate at the base, slightly imbricate; petals 3, not valvate; stamens 6, enclosed; rudiment of ovary present. Pistillate flowers with 3 sepals and 3 petals, free and imbricate; staminodes present, forming a cup-like ring with 6 teeth; ovary ovoid, velvety, with 3 stigmas exserted. Fruit more or less spherical, covered with caducous bristles. Seed 1, very rarely 2. (Fig. 2).

Specimens examined: Pirassununga, Emas, unprotected cerrado, *Medeiros-Costa and Panizza 0149, 0150, 0151, 0152*, 14/08/1972 (IPA); Same loca-

2. *Acanthococos emensis*. Photograph showing the depth of the subterranean stem of this acaulescent species. Minicípio of Pirassununga, São Paulo.

3. Inflorescence of *Syagrus flexuosa*. Campos cerrados of Bao Vista and Pirassununga, São Paulo.

tion, *Medeiros-Costa and Panizza 0165, 0166*, 30/10/1972 (IPA).

Syagrus Martius, Palmarum Familia 18. 1824.

1. **Syagrus flexuosa** (Martius) Beccari, L'Agricoltura Coloniale 10: 466. 1916.

Cocos flexuosa Martius, Historia Naturalis Palmarum 2: 120, t. 64, 86. 1826.

Cocos flexuosa Martius var. *cataphracta* Martius, Historia Naturalis Palmarum 2: 120. 1826.

Cocos campestris Martius, Historia Naturalis Palmarum 2: 121, t. 87. 1826.

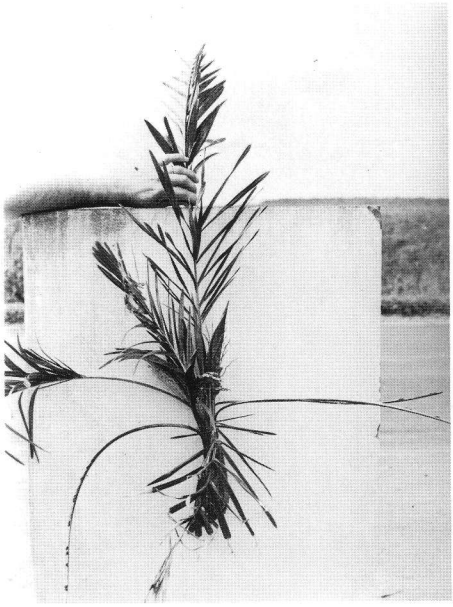
Syagrus campestris (Martius) Wendland, Index Palmarum, Cyclanthearum, Pandanearum, Cycadearum quae in hortis Europaeis coluntur, synonymis gravioribus interpositis 17, 38. 1854.

Cocos urbaniana Dammer, Engler Botanischer Jahrb. 31: 22. 1902.

Syagrus urbaniana (Dammer) Beccari, L'Agricoltura Coloniale. 10: 468. 1916.

Plants always occurring in clumps, stems slender, flexible, from 1.0–2.5 m tall. Leaves with sheathing base becoming fibrous at edges; petiole smooth; pinnae distributed in clusters of 2–5 along the rachis. Staminate flowers smaller than pistillate, distributed on the same inflorescence. Fruits ellipsoidal with fibrous, mucilaginous mesocarp, edible. (Fig. 3).

Specimens examined. Pirassununga, Emas, cerrado protected from fire, *Medeiros-Costa and Panizza 0145*, 07/04/1972 (IPA); Pacas, Rio Feio, cerrado, *Edwall 144*, October 1905 (SP); Tietê, cerrado palm up to 2 m tall, *F. C. Hoehne and A. Gehrt s/n*, 01/12/1936 (SP); Anhembi, Fazenda Barreiro Rico, in cerrado within the forest, *M. Kuhlmann 4541*, 02/05/1959 (SP); Emas, cerrado, *M. Ferri s/n*, 29/08,1943 (SP); Mogi-Mirim, cerrado, *M. Kuhlmann and P. Gonçalves s/n*, 16/10/1942 (SP).



4. *Syagrus loefgrenii*. Cerrado, municípo of Itirapina, São Paulo.

2. **Syagrus loefgrenii** Glassman, Fieldiana, Botany 31: 240, f. 4. 1967 (correction of "lofgrenii")

Syagrus rachidii Glassman, Fieldiana, Botany 31: 245. 1967.

Plants acaulescent (stem rhizomatous) or rarely with a stem 60 cm above ground, always clumped. Leaves with petioles with smooth fibrous edges, pinnae distributed in clusters of 2–4 along the rachis. Inflorescences with flowers of both sexes, staminate equal to or slightly smaller than pistillate flowers. Fruit ellipsoidal with fibrous, mucilaginous mesocarp, edible. (Fig. 4).

Specimens examined. Itirapina, cerrado, *Medeiros-Costa and Panizza 0153, 0154, 0155, 0156, 0157, 0161*, 18/09/1972 (IPA); Pirassununga, Emas, unprotected cerrado, *Medeiros-Costa and Panizza 0183, 0184, 0185, 0186, 0187, 0188, 0189*, 01/12/1972 (IPA); Sertão de Itirapina, 12 km NW of the city. Burned over savanna, acaulescent, *Glassman and Gomes 8012*, 02/07/1965 (SP); Pirassununga, campos cerrados of Boa Vista, *Rachis s/n*, 05/09/1947 (SP—holotype of *S. rachidii*); Campo Alegre, palm of the campo and sandy cerrado, *J. F. Toledo and Gehrt s/n*, 25/09/1940 (SP—paratype of *S. rachidii*); Rio Claro, *A Loefgren 573*, 05/05/1888 (SP—holotype of *S. loefgrenii*).

Allagoptera C. G. Nees, Flora 4: 296. 1821.

Diplothemium Martius, Palmarum Familia 20, 1824.

1. **Allagoptera campestris** (Martius) O. Kuntze, Revisio Generum Plantarum 2: 726. 1891.

Diplothemium campestre Martius, Historia Naturalis Palmarum 2: 109, t. 76, figs. 1–4, t. 78. 1826.

Diplothemium campestre Martius var. *genuinum* Drude in Martius, Flora Brasiliensis 3(2): 432. 1881.

Diplothemium campestre Martius var. *glaziovii* Dammer, Engler Botanischer Jahrb. 31: 23. 1902.

Plants acaulescent. Leaves with pinnae distributed in clusters of 2–3 (4) along the rachis. Inflorescences spicate, bearing staminate and pistillate flowers in triads from the base of the rachis to a little above the middle, above that only staminate flowers.

Specimens examined. Pirassununga, Emas, campos cerrados, *N. Rachis s/n*, 21/09/1945 (SPF); Idaiatuba (cerrado ?), *H. P. Krug s/n*, 08/11/1942 (SP).

Note: The unbranched inflorescence distinguishes this species from all others found in the cerrado of São Paulo.

Butia (Beccari) Beccari, L'Agricoltura Coloniale 10: 489. 1916.

Two species cited in the literature are *Butia eriospatha* (Martius ex Drude) Beccari and *B. leiospatha* (Barbosa Rodrigues) Beccari (Wettstein 1904, Ferri 1944, 1955, Ferri and Coutinho 1958, Rachid 1947, Rawitscher 1948).

Butia eriospatha has its area of distribution in the states of Rio Grande do Sul and Santa Catarina (Glassman 1979) and *B. leiospatha* "belongs in the uncertain category because of the absence of authentic specimens, and the descriptions and illustrations are insufficient to delineate it as a clear cut species" (Glassman, 1979).

Specimen *0178* (IPA) was identified by Glassman as *Butia paraguayensis* (Barbosa Rodrigues) L. H. Bailey. All of the specimens collected by the authors were comparable to that species.

1. **Butia paraguayensis** (Barbosa Rodrigues) L. H. Bailey, Gentes Herbarum 4: 47. 1936.

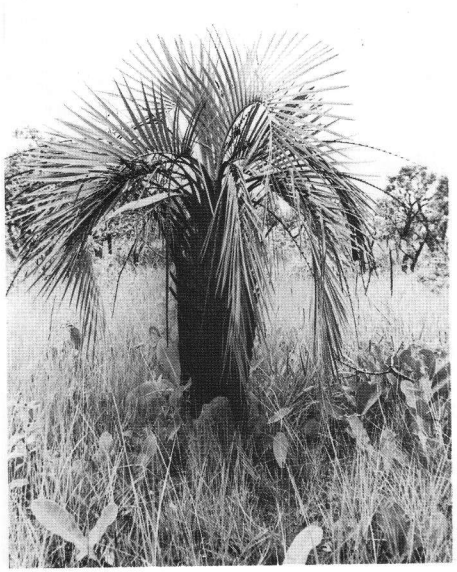
Cocos paraguayensis Barbosa Rodrigues, Palmae Novae Paraguayenses 9, t. 2. 1899.

Syagrus paraguayensis (Barbosa Rodrigues) Glassman, Fieldiana, Botany 32: 151, figs. 13–17. 1970.

Butia yatay (Martius) Beccari var. *paraguayensis* (Barbosa Rodrigues) Beccari, L'Agricoltura Coloniale 10: 503. 1916.

Plants rarely acaulescent or with stems to 1.5 m. Leaves gracefully recurved, pinnae equidistant, opposite or at times subopposite, glaucous, bright green below. Inflorescences enclosed in 2 bracts, the lower covered with rusty hairs, the upper smooth or lightly striate without hairs. Staminate flowers with 3 sepals, acuminate, concave, connate at the base; petals 3, oblong; ovary rudimentary, tripartite. Pistillate flowers 1-3 or rarely more on each branch; sepals 3, convolute-imbricate, petals 3, convolute; staminodes present forming a membranous, tridentate ring. Fruit oblong to ellipsoidal, generally with 2 seeds. (Fig. 5).

Specimens examined. Pirassununga, Emas, cerrado, *Medeiros-Costa and Panizza 0167*, *0168*, 30/10/1972 (IPA); same location, *Medeiros-Costa and Panizza 0178*, *0179*, *0180*, *0181*, *0182*, 01/12/1972 (IPA); Mogi-Guaçu, forest reserve (Fazenda Campininha), cerrado, *M. Kuhlman 3924*, 20/09/1956 (SP); Mogi Guaçu, forest reserve (Fazenda Campininha), near Pádua Sales, cerrado *O. Handro 451*, 11/11/1955 (SP); Mogi-Guaçu, Fazenda Campininha, cerrado, *J. Mattos 12.477*, September 1965 (SP).



5. *Butia paraguayensis* in the cerrado of Emas, município of Pirassununga, São Paulo.

Attalea Humboldt, Bonpland and Kunth, Nova Genera et Species Plantarum 1: 309. 1816.

Four species of *Attalea* are cited in the literature for the cerrados of São Paulo: *A. loefgrenii* (Wettstein 1904); *A. geraensis* (Wettstein 1904, Glassman 1977); *A. exigua* (Rawitscher and Rachid 1946, Rachid 1947, Ferri 1955, Handro and Figueiredo 1971); and *A. humilis* (Mattos 1966).

Based upon the specimens collected, observations in various field locations, and bibliographic studies, the authors concluded that only one species of this genus

6. *Attalea geraensis*. Município of Itirapina, São Paulo.

exists in the cerrado of São Paulo: *Attalea geraensis* Barbosa Rodrigues. This assertion is justified by the following three points:

1. *Attalea loefgrenii* Wettstein is not valid (Dahlgren 1936). Wettstein (1904) did not make a description in Latin of the species. The excellent photograph in Plate 54 shows, without any doubt, specimens of *Attalea geraensis*. In an attempt to resolve this question, the authors visited the areas of cerrado in the region of Sorocaba, the location cited by Wettstein for *A. loefgrenii*, and found there specimens similar to those of other areas that were identified as *A. geraensis*.

2. *Attalea exigua* Drude differs from *A. geraensis* in the structure of the pinnae, which first of all are aggregate and divergent (Drude 1881, Bondar 1964), and secondly are equidistant (Barbosa Rodrigues 1898, 1903, Bondar 1964, Glassman 1977). In all of the areas visited by the authors, including Pirassununga and Itapetininga, where *A. exigua* was cited by Rawitscher and Rachid (1946), Rachid (1947), Ferri (1955), and Handro and Figueiredo (1971), no specimens were found with leaves having clustered and divergent pinnae. All of the specimens observed and collected there are *A. geraensis*.

3. *Attalea humilis* Martius ex Sprengel, in addition to the larger size of its parts, is also distinguished from *A. geraensis* by the presence of dark scales on the dorsal side of the central nerve of the pinnae (Bondar 1964). Scales were not found on the specimens collected at Fazenda Campininha, where Mattos (1966) referred to the occurrence of *A. humilis*. Care was also taken to look

closely for the presence of scales on the specimens collected in other areas, also with negative results.

1. **Attalea geraensis** Barbosa Rodrigues, Plantas Novas Cultivadas no Jardim Botânico do Rio de Janeiro 6: 22, t. 7. 1898.

Plants acaulescent with 3–6 leaves emerging from the soil, rachis recurved, pinnae opposite, at times subopposite, not in clusters. Staminate and pistillate inflorescences on the same plant, enclosed in 2 woody bracts. Staminate flowers with 3–4 petals, lanceolate, acuminate; stamens 6–9, erect, enclosed. Pistillate flowers much larger than staminate; staminodal ring present, covering ⅓ of ovary; stigmas exserted. Fruits ovoid with 1–4 seeds. (Fig. 6).

Specimens examined. Itapetininga, Fazenda Sta. Luiza do Campo Largo, SSE of Itapetininga, *S. M. Campos 186*, 15/03/1960 (SP); Sertão de Itirapina, 12 km NW of the city, burned over savanna, acaulescent, *S. F. Glassman and J. C. Gomes Jr. 8014*, 02/07/1965 (SP); Mogi-Mirim, *A Gehrt 31859*, 06/06/1932 (SP); Pirassununga, Emas, unprotected cerrado, *Medeiros-Costa and Panizza 0146*, *0147*, *0148*, 07/04/1972 (IPA); Itirapina, cerrado, *Medeiros-Costa and Panizza 0160*, 18/09/1972 (IPA).

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NEWS OF THE SOCIETY

Special Press Release

Inquiries have been received from four different locations regarding the organization of new chapters of the Palm Society, Inc. We are pleased and will do all we can to encourage these objectives. It will be interesting to watch their development. The "new chapters" and their coordinators are:

Arizona, USA: John Casey, 2505 Foote Drive, Phoenix, AZ 85008, USA. 20 current Palm Society Members.

Gulf Coast, USA: Dr. Tom Mignerey, 3947 Hwy 297 A, Cantonment, FL 32533, USA. 9 current Palm Society members and growing!

New Zealand: Arno King, 143 Kowhai Road, Mairangi Bay, Auckland 10, New Zealand. 12 members, a Newsletter, and enthusiastic.

North Queensland, Australia: J. Kelly, PO Box 1268, Townsville 4810, North Queensland, Australia. 8 current members in Townsville with many more in the surrounding area. A tropical climate and a proposed botanic garden especially dedicated to palms makes this a very exciting endeavor.

It is hoped that the foregoing will be a challenge for other Palm Society members to form chapters. Some possibilities are: United Kingdom with 25 current members; Continental Europe with 40 members; the Philippines with 10 members; South Africa with 23 members; Brownsville, Texas area with 18 members; Louisiana with 10 members; Maryland/Virginia/Washington DC with 20 members; New York and New Jersey with 32 members; North and South Carolina, Georgia and Tennessee with 36 members; and Ohio, Pennsylvania and Illinois with 30 members.

The formation of a chapter, the sharing of information made possible through meetings and quarterly newsletters and meeting fellow members who share your common interest creates some special magic! Please contact Lynn McKamey or Jim Mintken (Promotional Committee) if you desire guidelines or assistance in forming a chapter in your area.

News from Central Florida

The 1983 winter meeting of the Central Florida Palm Society, held on February 12 at the Imperial House restaurant in Winter Park, was a huge success, thanks to the combined efforts of Dave and Marion Besst and Ed and Nancy Hall.

Before the luncheon everyone had a tour of the lovely landscaping at the Besst and Hall homes. Refreshments and the video tape of Dave's television program on Palms for Central Florida were enjoyed along with the tour of the Besst's beautiful

(*Continued p. 130*)

Principes, 27(3), 1983, pp. 126–130

China Has More People and Places Than Palms

MELVIN W. SNEED
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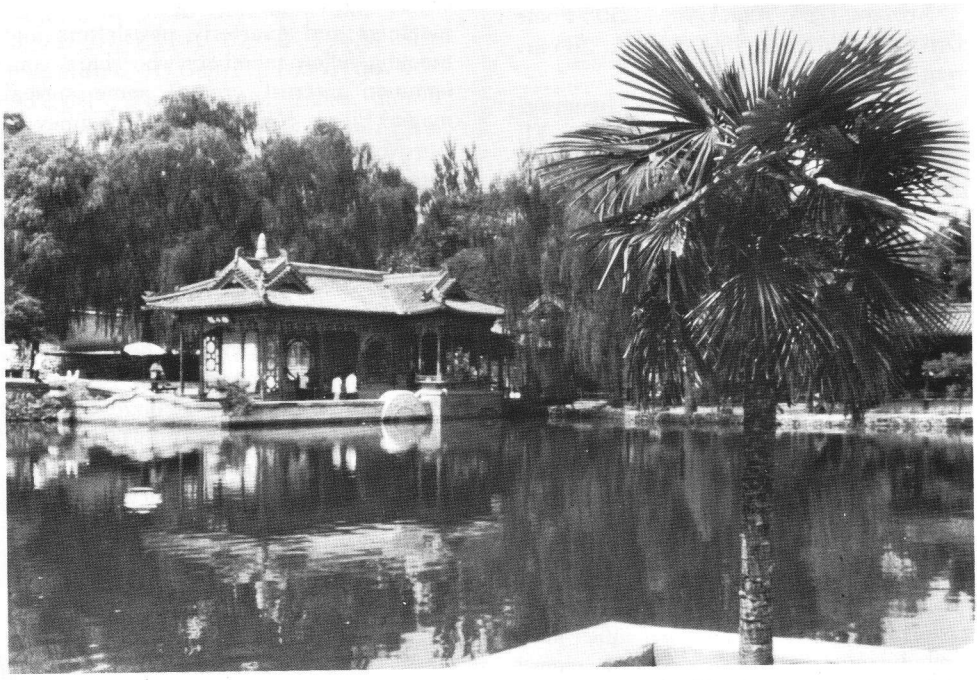
For a great many years, longer than the Palm Society has existed, it was not possible for ordinary tourists to obtain legitimate visas for travel into China. In fact travel there had been prohibited by the U.S. Department of State. There were many reasons for this hiatus but, in time, the reasons have paled into insignificance. More recently things have "opened up" so travelers with a yen to know more about the existence of palms and other plant life, as well as the way of life in this great nation (which has over one-fourth, one billion, of the world's population) have been welcomed.

Every palm enthusiast has experienced the beautiful *Livistona chinensis*, indigenous to "Central China." Where is "Central China"? We flew over it, rode trains and buses through it, yet never saw anything resembling an indigenous stand of this palm. Perhaps we got there a bit late.

The People's Republic of China embraces a huge area of South Central Asia. It is larger than the continental U.S.



1. *Trachycarpus* near Xian, Central China, Hua Qing.

2. *Trachycarpus* specimen, downtown Xian. The palm withstands extremely cold weather here.

If one superimposed a map of China, Peking in the northeast would straddle New York City, while Urumqi, capital of the far western region, would engulf Portland, Oregon. We traveled such an area in some 26 days during summer 1961.

At this writing, most would-be palm travelers cannot, and should not, on their own, attempt to explore China. Even if one can get an entry visa, he would get nowhere without a mastery of the Chinese language and its dialects. English is not generally used nor even understood in the major cities, much less in the outer reaches of China.

We went on a Lindblad Tour, with only a small group, originating in Hong Kong, hence into China via railroad to Canton. This southwestern metropolis almost straddles the Tropic of Cancer. Off the coast here, in the South China Sea, is Hainan Island, location of The Institute of Southern China for Tropical Plants. The southern area of China, particularly Hainan, has the palm populations which are most exciting. Due to our group tour itinerary and some of its exacting time schedules, we were unable to visit Hainan and had precious little time in Canton, which has a worthwhile botanic garden.

North of these areas, one traveling the breadth of China will frequently see palms around public places such as temples, pagodas, parks, hotels and even markets. Most of these are in pots which can be moved into sheltered areas to weather the severe cold which hits much of China during the winter. Often these are old specimens in huge, attractive earthen or wooden containers. *Trachycarpus* (indigenous to China) was frequently seen growing outdoors as far north as Xian, in central China. See specimen at nearby Hua Qing Hot Springs, (Fig. 1), where the trees were prominent in landscaping of the pavilions surrounding the springs, whose therapeutic waters are visited by natives and tourists alike. Local people brought small, round vials which were lowered into the tubular openings of the spas, held by cords, which they pulled up for a quaff of the liquid. The warm, mineral-like taste did not appeal to us, even though we were hot and thirsty.

A little farther on, same area in the city of Xian, we thought we saw a different species of palm growing in the open. It was lovely (Fig. 2) but proved to be another *Trachycarpus*.

Going on, we flew some 2,000 miles northwest to Urumqi, capital of the Xinjiang Uygur Autonomous Region, China's most western province. We looked down on undulating hills of loess and saw snow-capped mountains in the distance. But we saw no palms. In this area few, if any, could survive the winters except those grown in containers which can be shoved under protective cover. But see the fine

3. Potted palms and guardian lion.

potted palms vieing with guardian lion in Fig. 3, which may be typical of palm culture over much of northern China.

Palms notwithstanding, Urumqi is the center of an extremely fascinating region. Its population is comprised of some 15 different ethnic groups. Fanning out of there we went into the Southern Mountains, where Khazakh herders gave us a superb performance on horseback, and to the Heavenly Lake where in the cool, alpine-like setting we saw people gathering mushrooms and a strange, lotus-like dried flower which was called to our attention by a very helpful young lady who had been collecting them. We were told the flower was used medicinally. Another day we went to the edge of the Gobi Desert at Turpan, an oasis and the lowest place below sea level on earth except for the Dead Sea.

We visited other provincial capitals on our return trip across northern China as we went east to Peking. Here again the palms mostly were in pots. Most interesting, perhaps, were the plantings in the Imperial Gardens at the rear of the palaces in the Forbidden City. Palms were here in some numbers, especially *Raphis*, and some of them in this sheltered area may not have been in pots (Fig. 4).

Our Lindblad Tour group left us in Peking and went back to the States, so we bid adieu to our friends with whom we had shared experiences in our travels over some of the vast expanses of the People's Republic of China. All of us felt we had acquired new friends and an understanding of China's aspirations.

When we were asked by our very helpful guides of the China Travel Agency how we desired to spend an extra day in Peking awaiting the scheduled flight with Swiss Air, which would take us westward to

4. Palms in the Forbidden City, Peking.

5. Miss Zhang, our guide, Phyllis and Mr. Liu, at Institute of Botany and Botanic Garden, Peking.

Bombay and then to Europe, we said, spontaneously, "We have heard that Peking has a botanical garden, so we would like to see it." But our very professional and knowledgeable guides knew nothing about that as, apparently, no tourists ever had been taken to the place. They would look into the matter.

Early next morning, at breakfast, in marched our smiling guide to announce that "The car is waiting to take you to the botanic garden." Later she added, "We have located a person there who can speak English. Never before have we taken a visitor there, nor have I visited it."

The trip was perhaps an hour's drive from the Peking Airport area of our hotel. Mr. Liu, (see Fig. 5) of the Institute of Botany, Chinese Academy of Sciences, greeted and briefed us about the fine developing garden, established in 1956. New structures are being built to house

the research laboratories and other facilities for introduction and acclimatization of plants from all over China and, perhaps, the world. Half of the nearly 3,000 species of plants were in greenhouses. First and foremost (to us) of the ten rooms under glass was the "Tropical Palm Room." Here we saw specimens of *Caryota ochlandra*, *Phoenix dactylifera*, *P. roebelenii*, *Elaeis guineensis*, *Hyophorbe lagenicaulis*, *Livistona saribus*, *L. chinensis*, *Chamaedorea elegans*, *Cocos*, *Arecastrum romanzoffianum*, *Archontophoenix alexandrae*, and *Chrysalidocarpus*, among others.

The Peking Garden is only in its beginning stages. We feel confident that the Chinese government will support its future development. Certainly we appreciated their hospitality and courtesy in permitting us to visit it.

NEWS OF THE SOCIETY

(*Continued*)

gardens. In addition to the palms, both gardens have extensive bromeliad collections and assorted cycads. Rain dampened the occasion, but not the enthusiasm and the tours were greatly appreciated by all.

We were honored to have Mr. Richard Douglas, Palm Society President, and Mr. Paul Drummond, immediate past President, in attendance. Mr. Douglas gave a very interesting slide presentation on cold hardiness of palms in California and hybridization of *Chamaedorea*.

The nominating committee, headed by Mr. Gordon Smith, reported on candidates for The Central Florida Palm Society. Mr. Tom Pavluvcik, Mr. Joe Alf, and Mr. Hersh Womble were elected to President, First Vice President, and Second Vice President, respectively. Nancy and Ed Hall were elected to Secretary and Treasurer and Frank Radosta to Editor of The Newsletter.

Ed Hall donated a beautiful specimen of *Rhapidophyllum hystrix* for a door prize and a hybrid *Chamaedorea*, created by Richard Douglas and donated by U. A. Young, was auctioned, with the proceeds added to the Society Treasury. The door prize was won by Jerry Poklepovic and the *Chamaedorea* hybrid was purchased by Jane McArthur.

NANCY HALL

Palm Society Nominating Committee Notice

The Palm Society Nominating Committee consists of: Donn W. Carlsmith, Hawaii; Dennis V. Johnson, Texas; and Paul A. Drummond, Florida, Chairman.

In 1984 we will be electing a new president, vice-president, secretary, treasurer, and about eight directors.

Your ballots will be mailed to you in the spring of 1984 in ample time for their return and compilation before the 1984 Biennial Convention in Northern California in the summer of 1984.

Individuals who wish to make their own nominations for positions of officers or members of the Board of Directors of the Society may do so by obtaining the written permission of the nominee, and the written endorsement of another Society member, and mailing these with your own written endorsement of the nominee to the Chairman of the Nominating Committee. These must be received by the chairman by March 1, 1984 to be eligible for consideration.

PAUL A. DRUMMOND, CHAIRMAN
9540 Old Cutler Rd.
Miami, FL 33156

Principes, 27(3), 1983, pp. 131-137

The Coconut Palm, The Robber Crab and Charles Darwin: April Fool or a Curious Case of Instinct?*

HUGH C. HARRIES
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When Charles Darwin wrote his *Journal of Researches into the Natural History and Geology of the Countries visited during the voyage of H.M.S. Beagle round the World, under the Command of Capt. Fitz Roy, R.N.* it appeared that the date, Friday, 1st April, 1836, held no special presentiment for him. His entry for that day reads, "*April 1st.*—We arrived in view of the Keeling or Cocos Islands, situated in the Indian Ocean, and about six hundred miles distant from the coast of Sumatra. This is one of the lagoon-islands (or atolls) of coral formation, similar to those in the Low Archipelago which we passed near. When the ship was in the channel at the entrance, Mr. Liesk, an English resident, came off in his boat" (Darwin 1845, p. 452). At that time, Mr. Liesk might have been lonely because, according to the Darwin scholar, R. B. Freeman (personal communication 1981), the only other English speaking resident, Captain John Clunies Ross, had gone away to Singapore. So that, if Mr. Liesk knew it was April Fool's Day, then the unexpected arrival of a vessel flying the Union Jack was too good an opportunity to miss. If he was tempted to play a practical joke, then of all the people on board the Beagle, who would be a better April Fool target than the eager young naturalist whose very inquisitiveness might seem like gullibility?

It is unlikely that Mr. Liesk played a "practical" joke, in the physical sense, because Darwin says (p. 453) that he did not go ashore until the next morning, after anchoring. The joke had to be a verbal one and, if it was successfully perpetrated, then Darwin included it, unknowingly, in his Journal narrative for April 1st. He began his account of the islands with a history of the inhabitants, "in as few words as possible," made a comment on slavery which would have been a topical subject at the time of publication, and gave a resume of the islands' economy, ". . . the main vegetable production is the cocoa-nut. The whole prosperity of the place depends on this tree: the only exports being oil from the nut, and the nuts themselves, which are taken to Singapore and Mauritius, where they are chiefly used, when grated, in making curries. On the cocoa-nut, also, the pigs, which are loaded with fat, almost entirely subsist, as do the ducks and poultry. Even a huge land-crab is furnished by nature with the means to open and feed on this most useful production" (p. 453).

The Crab and the Coconut

The remarkable behavior of the coconut crab, or robber crab, *Birgus latro* L., was the subject of travellers' tales long before Darwin's day. It was mentioned by Rumphius (1741) and by Soleyman in the tenth century (Reyne 1939, quoted by Davis and Altevogt 1978). The crab is supposed to climb up the trunk of the coconut palm, into the crown of leaves, and cut off the fruit. It then climbs down

* For other pictures and more about Robber Crabs see *Principes* 27: 89-93.

again, to peel the fallen fruit, accumulating fibers from the thick husk as a bed in its burrow. Last, but by no means least, it cracks the hard nut and digs out, and eats, the oily endosperm.

Like any good raconteur, Mr. Liesk would not have insisted on the absolute authenticity of every part of his story, because he would know that to do so would strain his victim's credulity. So he disclaimed the crab's ability to climb and Darwin duly reported, "It would at first be thought quite impossible for a crab to open a strong cocoa-nut covered with the husk; but Mr. Liesk assures me that he has repeatedly seen this effected. The crab begins by tearing the husk, fibre by fibre, and always from that end under which the three eye-holes are situated; when this is completed, the crab commences hammering with its heavy claws on one of the eye-holes till an opening is made. Then turning round its body, by the aid of its posterior and narrow pair of pinchers, it extracts the white albuminous substance .... These crabs inhabit deep burrows, which they hollow out beneath the roots of trees; and where they accumulate surprising quantities of the picked fibres of the cocoa-nut husk, on which they rest as on a bed .... It has been stated by some authors that the Birgos crawls up the cocoa-nut trees for the purpose of stealing the nuts: I very much doubt the possibility of this; but with the *Pandanus* the task would be very much easier. I was told by Mr. Liesk that on these islands the Birgos lives only on the nuts which have fallen to the ground" (pp. 462–463).

Although there is no reason think that Darwin suspected a practical joke, he would naturally be sceptical until he had seen the crab for himself. The first opportunity to do so may have been on Sunday, 3rd April, when he reported (p. 458) that he and Captain Fitz Roy were entertained to dinner at the settlement. This occasion would have given Mr. Liesk a chance to embroider his original story. For instance, he may have known the reputed method for catching the crab. This is to climb up after it and, when it has entered the crown of the palm, tie a rope made of grass around the trunk just below the leaf canopy. When the crab descends, *tail first*, it feels the grass and, supposing itself to be on the ground, lets go and falls to its death on stones carefully placed below (Green 1961, quoted by Davis and Altevogt 1978). Mr. Liesk would also have served coconut crab as part of the meal and this would allow Darwin to mention that the crab "grows to a monstrous size" and "is very good to eat" (pp. 462–463). His other statements clearly depended on Mr. Liesk's information rather than on his own observations. On his return to England, Darwin added a footnote supporting his view that the crab might climb *Pandanus* (Zoological Society of London, 1832) and a paragraph about the places it had been found, "Captain Moresby informed me that this crab inhabits the Chagos and Seychelle groups, but not the neighbouring Maldiva Archipelago. It formerly abounded at Mauritius, but only a few small ones are now found there. In the Pacific, this species, or one with closely allied habits, is said to inhabit a single coral island, north of the Society group" (p. 463). Also according to Captain Moresby, one crab even escaped from a wired-down, tin biscuit-box, illustrating for Darwin, "the wonderful strength of the front pair of pincers" (p. 463).

It is on the basis of Darwin's *subsequent* reputation, that this version of the coconut crab's habits has colored many popular natural histories. Reference books, such as the *Encyclopedia Brittanica*, still mention it and it is discussed by scientists—from agriculturalists and botanists to geographers and zoologists. Circumstantial evidence that the crab can climb has, apparently, been validated by movie films which show it going head first in either direction, up or down (Davis and Altevogt 1978). No such proof has been

obtained to confirm that it can peel or crack a coconut, though it is generally agreed that it will eat coconut endosperm from an already broken nut. It is, in fact, polyphagous and will even eat dead coconut crabs (Rock 1916).

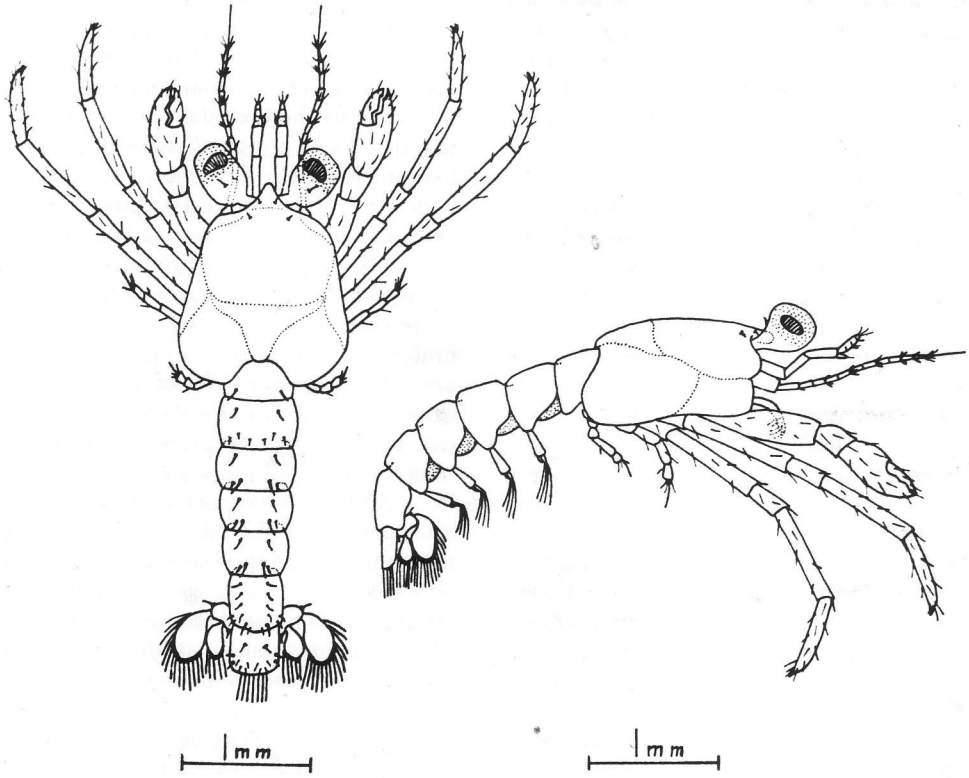
The association between the crab and the coconut has also been the basis for speculation about the original home of the coconut—a question which botanists have failed satisfactorily to resolve (Beccari 1917, Child 1974, Harries 1978). Thus, Beccari, arguing against an American origin for the coconut, because the coconut crab is not found on that continent, added his own variation to Darwin's theme. He suggested that the thick husk of the coconuts growing on Palmyra Island in mid-Pacific was an evolutionary adaptation—hypertrophy of the pericarp, stimulated by the efforts of the crab to reach the seed of the young fruit. Beccari's other arguments were more convincing.

Current opinion, which favors a Melanesian origin for the coconut, admits that while the evidential value of the association confirms conclusions drawn from botanical, historical or ethnological considerations it fails to pinpoint a precise location because the crab is found over such a wide extent of the tropics, in the Indian and Pacific Oceans from 40°E to 140°W (Child 1974). Those who do not entirely rule out an American option suggest that the relationship between the crab and the coconut is almost incidental (Purseglove 1972). This, in effect, is a polite way of saying that Darwin was wrong. But, if Darwin's account was not factual, *then for that very reason* a far more satisfactory explanation can be offered. Of course, any mundane ideas about the crab and the coconut will not have the romantic appeal of Darwin's fascinating version.

A New Hypothesis

The coconut crab is remarkable chiefly for being a land-living hermit crab that does not carry a shell to protect its abdomen. The final size of the crab, which may weigh up to 2½ kg and measure 15 cm across (or 45 cm including pincers), is not restricted by the availability or the size of the abandoned sea snail shells that other hermit crabs use. Freedom from such a shell would also give greater mobility when climbing, although Warner (1977) considers robber crabs to be "rank amateurs" when compared to *Grapsus*, the rocky shore crab, or *Aratus*, the mangrove tree crab. By any criteria, the only evolutionary situation in which the crab could forsake the protection of a shell is when it is not at risk from any predator and when circumstances afford a superior alternative. Such an environment is found on archepelagic coral atolls, where the coconut palm became the dominant plant form (Harries 1978), and the coconut crab became the dominant land animal (Reese 1965). Its only danger might come from sea birds and this could account for differences of opinion as to whether it is diurnal or nocturnal. Whereas Darwin, Rock, and Davis and Altevogt all say it is diurnal, Daniel and Prem Kumar (1947, quoted by Davis and Altevogt 1978) say it is mostly nocturnal in Great Nicobar Island (and Helfman (1977) considered it nocturnal in the Marshall Islands). By day fully grown adult crabs may be safe from aerial attack; smaller young crabs may not and would come out only at night.

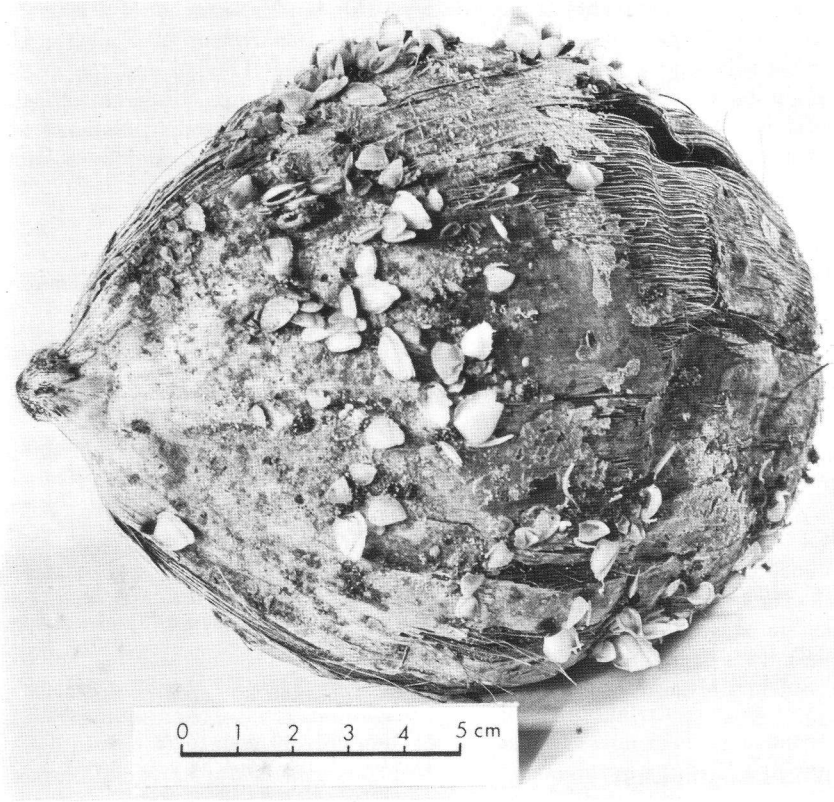
The ability of the coconut to reach other parts of the same atoll or other atolls, or to colonize newly emerged volcanic islands, or to occasionally establish on suitable continental mainland beaches, is the result of natural dissemination by floating (Harries 1978). That is the process which greatly contributed to the evolution of the thick husk noted by Beccari and observed in similar habitats in both the Pacific and Indian Oceans (Sauer 1967). The true association is, therefore, between the crab and the husk of the coconut, but not as Beccari surmised. Instead, it is proposed



1. Glaucothoe stage of *Birgus latro*; dorsal and lateral views. From Reese and Kinzie (1968).

that the postlarval glaucothoe stage of the crab (Fig. 1, note small size of this stage) chooses to live in cracks and crevices of the coconut husk while it is floating—as other hermit crabs have chosen, not shells, but holes in corals and sponges (Burton and Burton 1976). The moist, but aerated, environment in the softer fibers at the eye end of a floating coconut would also be shared by other marine organisms, some of which would be the coconut crab's prey. For example, Ward and Allen (1980) tested the viability of floating coconuts and recorded that, "While afloat the nuts were colonized by crabs, barnacles, and seaweed (See Fig. 2). The effects of these 'passengers' on germination is not known but the nut which germinated after immersion for 74 days was carrying barnacles and seaweed, and small crabs had taken up residence in the top of the nut where the husk was beginning to come away from the endocarp." The crab could, of course, cling to other flotsam, trunks and leaves, but these would tend to enter the water in small numbers and fairly infrequently after windstorms and tsunamis. By contrast, the monthly flowering of the coconut palm throughout the year ensures a constant dropping of fruits, many of which fall into the lagoon (Rock 1916) or into the open sea.

The coconut, as a surrogate home, would not only replace the mollusc shell, it would also provide the means whereby the crab can become widely dispersed. The



2. Barnacle encrusted coconut showing crevices in the husk that would shelter young crabs and protect them from dehydration. Photo by R. Gerard Ward.

pre-glaucothoe stage, lasting 20–30 days (Reese and Kinzie 1968), cannot hope to achieve the range of floating cocoonuts which can stay in the water at least 214 days (Ward and Allen 1980), and probably longer. When washed up on a beach the coconut might begin to germinate but the combined floating and germination period can exceed 220 days (Harries 1981) and until the husk becomes completely permeated by roots, the young crab would be protected from dehydration. If the coconut does not germinate, perhaps because the crab itself has damaged the growing point, then the rotting endosperm, oozing out of the soft eye which is almost always the primary focus for decomposition, would nourish the crab and provide bait for its prey. In that situation the crab might stay with the coconut indefinitely so that, eventually, all that remains is sand covering over the fibers of husk and fragments of shell. This would easily give the appearance of a burrow, a purposefully accumulated bed of fibers and a nut that had been intentionally peeled and cracked.

As soon as primitive man began to take an interest in the crab and the coconut, as food and drink, then the association between the two became less obvious. Man planted coconuts inland, where they did not naturally grow, and took them to islands which they could not reach by

floating. On small islands he might eat the crab into extinction. In each case, coconuts would eventually seem to grow where there were no crabs. Conversely, the crab is a successful life-form and can opportunely use floating logs for dispersal and mollusc shells for temporary protection (Reese 1968). It would, therefore, survive in the absence of the coconut palm. Unfortunately, man's early interest in the coconut crab stopped at its culinary qualities and his later curiosity was satisfied by the just believable—or almost unbelievable—feats attributed to it.

The new hypothesis can be tested by observation and experiment but, even if it turns out to be substantially correct, it will never entirely replace Darwin's intriguing account. Nor will it affect his conclusions—"I think this is as curious a case of instinct as ever I heard of, and likewise of adaptation in structure between two objects apparently so remote from each other in the scheme of nature, as a crab and a cocoa-nut tree" (p. 463).

Who Laughs Last

Three questions remain. Did Mr. Liesk really try to April Fool Charles Darwin? Did Darwin not know, or suspect, that the stories were nothing more than travellers' tales? Or did Darwin, in his turn and with tongue in cheek, publish the stories, knowing that many uncritical readers and fireside travellers would fail to see the significance of the date with which he opened his account?

Note: Professor Ernst S. Reese, Department of Zoology, University of Hawaii at Manoa, is presently working on a monograph and annotated bibliography on *Birgus*, while on sabbatical leave at the National Zoological Park, Smithsonian Institution, Washington, D.C.

Acknowledgments

This paper was prompted by a question from Herbert G. Baker, Department of Botany, University of California, Berkeley. The kind assistance of Richard B. Freeman, Department of Zoology, University College, London and the interest of R. Gerard Ward, Research School of Pacific Studies, Australian National University, Canberra are gratefully acknowledged.

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PALM LITERATURE

Coconut Product Development

Although often overshadowed these days by the more economically important oil palm, the coconut still furnishes the widest array of commercial products of any palm species. Development of new coconut products and technology has been the objective of the International Coconut Development Associations (ICDA), located in Stockholm. In 1978 it began a quarterly publication, *International Coir Development Newsletter*, devoted to research, industrial processing, and marketing of coir fiber. By its second year, articles on other coconut products were added and this led in 1981 to the adoption of the new name *Coconut Industries*. This periodical is now devoting most issues to feature topics such as coconut for food, coconut energy, or coconut oil, along with general information from other publications, industrial news, production figures, trade inquiries, and so forth. For anyone involved with the coconut industry, or interested in following future trends, this represents an indispensable source of current information.

The ICDA also is distributing two other documents issued in 1981. A 44-page report entitled "Coconut Fibre in Sweden," was prepared to promote the import of products from developing countries. "Introduction to Integrated Processing of Coconuts," 99 pages, is a comprehensive plan, designed by Scarab Development AB, for the simultaneous processing of coconuts to obtain oil, food products, coconut water, fiber, and charcoal.[1] This integrated processing procedure would increase both productive employment and export earnings in the countries where the coconuts are grown. Adoption of this technique on a large scale could signal the beginning of a new era for this palm which has so often been called the "tree of life."

A subscription to the periodical may be obtained for 20 pounds sterling per year in industrialized, and for 7 in developing countries. The first report is free of charge except postage and handling, the second costs $75 to subscribers. All can be ordered from ICDA, Box 7605, S-103 94 Stockholm, Sweden.

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[1] Integrated processing of coconuts in the Philippines was advocated by Vicente D. Gabriel, Sr. in *Progress and Prosperity in the Coconut Industry*, Philippine Inventors Commission, 1976, 56 pp.

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Etymology of Bentinckia condapanna

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Bentinckia was established by Berry, and commemorates William Henry Cavendish-Bentinck (Governor General of the East Indies, 1774–1839). The genus includes only two species, both native to different regions of India. One, *B. nicobarica*, is found in the Nicobar Islands, commonly associated with *Areca catechu*, *Pinanga manii* and *Rhopaloblaste augusta*.

The other species, *B. condapanna*, is native to Travancore and South Kerala, and grows on precipitous cliffs within its restricted range. The specific epithet comes from its local name. In Roxburgh's Flora Indica, 3: 621 (1832), in which Berry described the species, its spelling is given as "*condapanna*." However, various subsequent authors who have dealt with the species give their spellings variously as "*coddapanna*," "*condapanna*," "*codapanna*" and "*condapana*" (cf., Griffith 1850, Hooker 1894, Blatter 1926, Fischer 1931, Padmanabhan and Regupathy 1981). Among these, the first version is the commonest, although different from that originally given by Berry.

This species occurs in the border areas between the states of Kerala and Tamil Nadu. The language of Kerala is Malayalam while that of Tamil Nadu is Tamil. The specific name is a compound word derived from two words—"conda" and "pana." Both these words happen to occur in Malayalam as well as Tamil and have the same meaning in both languages. There is one more local name for this species, i.e., "vari-kamugu," meaning "hill-arecanut" in both languages. The word "pana" means palm. "Conda" is the word used to describe a characteristic, rather casual knot of hair (hair style) commonly worn by women in South India. The similarity between the "conda" hair style and the just-opened inflorescence of the palm is striking even from a distance, and hence the popular local name "conda + pana" for the plant, which when compounded together should become "condappana." The additional "d" in the spelling used by some authors is superfluous.

"Panna" is the name used (in Malayalam, and sometimes in Tamil also) to designate an altogether different class of

1. *Bentinckia condapanna* Berry.

plants, namely the ferns. Various types of "pannas" (ferns) such as "Arana panna" (*Aspidium splendens*), "Valli panna" (*Lygodium flexuosum*), "Weli panna" (*Polypodium* spp.), "Para panna" (*Asplenium* spp.), etc. had been described from this region as long ago as 1693 by Van Rheede in his Hortus Malabaricus. Even today the word "panna" means fern. Therefore, the latter half of the specific name of the palm ought not to have been "-panna," which would be misleading as the name of a palm; instead it should have been "-pana."

The difference in the spellings of the specific name of the palm given by different authors is evidently due to the disparity between its correct local name and its validly published binomial.

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A NEW VENTURE FOR THE PALM SOCIETY

For some time it has been evident that some means by which books on palms could be published or reprinted and made more accessible is greatly needed. At the last meeting of The Board of Directors in Florida in November, the Publications Committee was directed to investigate the possibility of a Palm Society Revolving Publications Fund. Such a fund would finance publications of new works on palms, reprint important and unobtainable books or papers, and support the continued publication of *Principes*. The fund would be revolving in that profits resulting from the sale of one work would finance the next publication.

At The Board Meeting it was realized that The Society has a unique opportunity to start a publication fund now by undertaking the publication of "Genera Palmarum: The Classification of Palms." This book representing Hal Moore's life work, will be a cornerstone of palm classification for many years to come. A conspectus of "Genera Palmarum" has been sent to all board members and their decision to go ahead with this venture was unanimous.

The advantages of publication of "Genera Palmarum" by The Society are that the book can be sold at a lower price and that any profits will be used for other publications on palms. A minimum of $50,000 will be required to print 2500 copies, and about $70,000 for 5000 copies. Some of the money may be raised by prepublication sales, but to go ahead with this project The Society must raise the minimum amount in advance. Members are invited to contribute toward the establishment of this fund. If we can print the larger number, the price of the book will be less. Chapters are urged to plan fund-raising activities during the coming year. Our target date is September 1, 1984. Each issue of *Principes* will give a report on progress.

RICHARD DOUGLAS

PALM SHOW AND SALE
South Florida Chapter,
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