



PRINCIPES

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THE INTERNATIONAL PALM SOCIETY

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Cover Picture

Inflorescence of *Bactris gasipaes* showing several thousand individuals of *Cyclocephala amazona*. Tens of thousands of *Phyllotrox* individuals are on the inflorescence in the interstices of the male flowers. See pp. 107-119.

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The Reproductive Biology of the Peach or "Pejibayé" Palm (*Bactris gasipaes*) and a Wild Congener (*B. porschiana*) in the Atlantic Lowlands of Costa Rica

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The reproductive biology of few of the 2,800 species of palms has been studied in detail so that we know very little about the modes of reproduction in this predominantly tropical family (Tomlinson 1979). Though palms were long thought to be largely wind-pollinated, their pollination is now known to involve several insect orders (Schmid and Schmid 1970, Moore and Uhl 1982).

Bactris is a monoecious, neotropical genus of 239 species, in the cocosoid palm group (Moore 1973). This paper presents observations made on two species: *B. gasipaes* H.B.K., the cultivated "pejibayé" palm, and *B. porschiana* Burret. Pejibayé, grown in plantations for its nutritionally valuable fruits (Figs. 1,2), has been recognized as an underexploited food plant, which has stimulated the development of germ plasm collections and breeding programs in Costa Rica and Brazil. Interest in developing new cultivated strains of pejibayé has now reached a high level, indicating the palm's future role as an increasingly important tropical food crop (Anonymous 1975, Clement and Mora Urpí 1982). Pejibayé's economic potential has led to research into its origin, genetics and reproduction by J. Mora Urpí (Univ. of Costa Rica), and C. R. Clement (INPA-Brazil) and co-workers. The results of this study complement and expand on some of their observations but also differ in some

aspects, e.g., with regard to the potential importance of scarab beetles as pollinators.

Habitat and Habit

Both *Bactris gasipaes* and *B. porschiana* were studied in 1978, 1979 and 1980 at the Organization for Tropical Studies' Finca La Selva field station located in northeastern Costa Rica at the confluence of the rios Sarapiquí and Puerto Viejo (140 m a.s.l.). The primary rain forest vegetation at La Selva is classified by Holdridge et al. (1971) as Tropical Wet Forest and Premontane Wet Forest.

Pejibayé, not known from the wild, formerly extended in cultivation from Honduras to Bolivia and Brazil in moist forests at low and middle elevations (Mora Urpí and Solís 1980). The study plants at La Selva are in an abandoned plantation contiguous with primary forest. Pejibayé clusters, producing sprouts from the base of the mature plant to form a tight clump of several reproductive stems, and grows to about 20 m in height (Fig. 1).

Bactris porschiana, a much smaller species, 5-10 m in height, is a primary forest understory tree native to La Selva. *B. porschiana* also sprouts at the base but produces multistemmed colonies of shoots rather than tight clumps like pejibayé (Fig. 11). Thirty inflorescences of

pejibayé and 14 of *B. porschiana* were observed during the study.

Inflorescence and Flower Morphology

The inflorescence of *Bactris* (Figs. 3,4,12) superficially resembles a "raceme of spikes," but is actually a morphologically complex structure of densely packed triads or cincinni of staminate and pistillate flowers (Moore 1973, Mora Urpí and Solís 1980). The inflorescence has many rachillae and is subtended by a large, heavily armed bract (spathe) which completely encloses it in bud. In both *Bactris gasipaes* and *B. porschiana*, staminate flowers greatly outnumber pistillate flowers (Table 1). Mora Urpí and Solís (1980) found small inflorescences of pejibayé that had staminate flowers only. The pistillate flower consists mainly of a large and hard ovary with inconspicuous rings of petals and sepals at its base (Figs. 3,13). Staminate flowers are smaller with sepals and a well-developed corolla of three valvate petals which enclose six stamens (Uhl and Moore 1977).

The inflorescences of the two *Bactris* species studied are morphologically simi-

lar and differ primarily in size. The pejibayé inflorescence (Fig. 3) has from 46 to 62 rachillae about 40 cm in length. The inflorescence of *B. porschiana* (Fig. 12) is smaller with 42 to 48 rachillae about 25 cm in length.

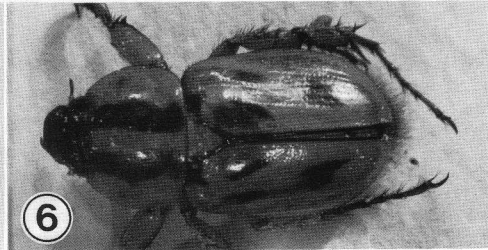
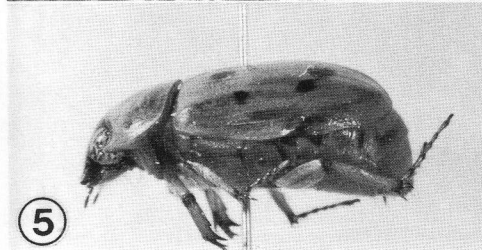
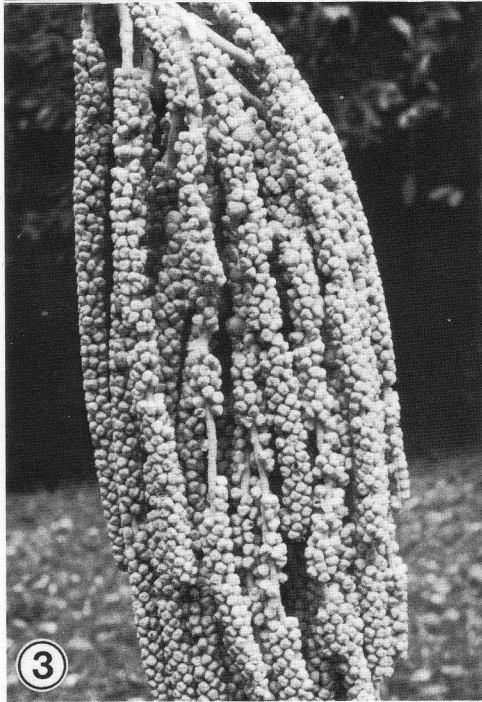
A potentially important difference in the floral morphology of the two species, and one which may differentiate pejibayé from non-cultivated species, is that the pistillate flowers of *B. porschiana* have exerted stigmatic lobes, whereas the stigmatic surface of pejibayé is recessed at the junction of the three connate carpels.

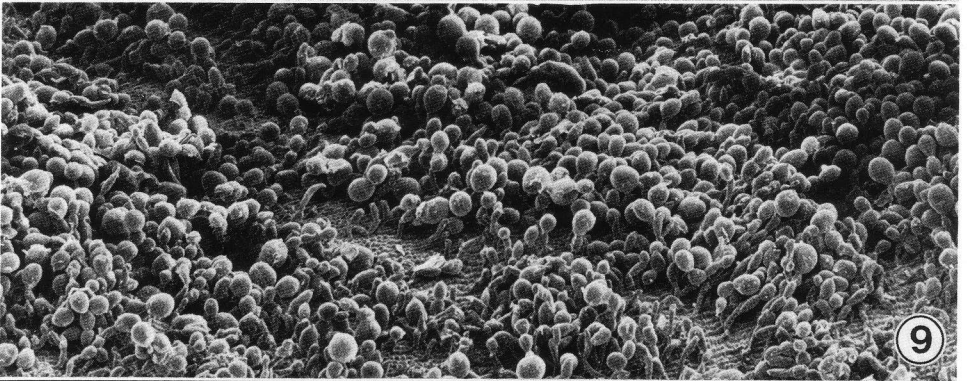
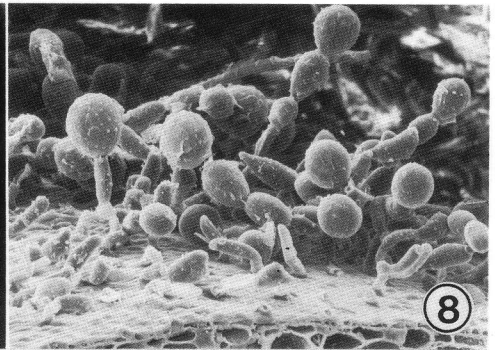
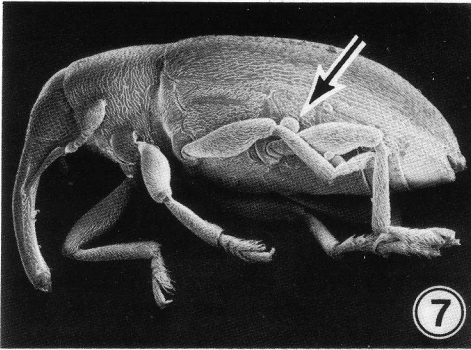
Both species of *Bactris* produce specialized, uniseriate, multicellular trichomes on the peduncle and rachillae of the inflorescence (Figs. 8,9). The distal segments of the trichomes are globose and range from 0.07 mm to 0.09 mm in diameter. The trichome cells have a very thick, lamellate wall and a small central lumen. They are easily detached from the epidermis of the inflorescence, and are eaten by visiting insects.

Phenology

Pejibayé flowers twice a year at La Selva. A major flowering episode occurs

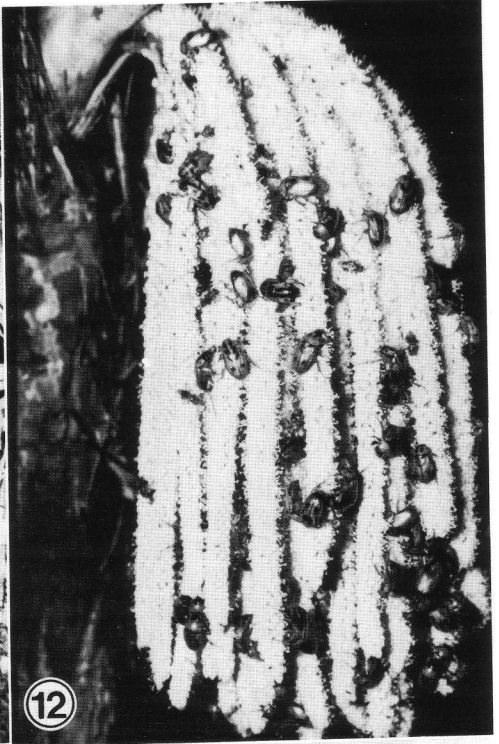
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1. Habit of *Bactris gasipaes* in a plantation at Finca La Selva. $\times 0.004$. 2. Infructescences of *B. gasipaes* with mature fruits. $\times 10$. 3. Inflorescence and flowers of *B. gasipaes* showing many rachillae. $\times 15$. 4. Pistillate phase inflorescence of *B. gasipaes* with two collared arçaris (*Pteroglossus torquatus*) feeding on *Cyclocephala* located inside the inflorescence branches. $\times 0.03$. 5. *Cyclocephala amazona*. The most important scarab beetle visitor to *B. gasipaes* and *B. porschiana* at La Selva. Side view. $\times 3.6$. 6. *C. amazona*. Dorsal view. $\times 4.0$.
 7. SEM side-view of *Phyllotrox megalops*, the most abundant weevil visitor to the inflorescences of both species of *Bactris*. Sphere at the base of hind leg (arrow) is a trichome segment (Fig. 8). $\times 39$. 8. SEM of the uniseriate, multicellular inflorescence trichomes from *B. gasipaes*. $\times 94$. 9. SEM of epidermal surface of *B. gasipaes* peduncle showing densely-packed trichomes. $\times 42$. 10. SEM of the head of *Cyclocephala amazona* showing many *Bactris* trichome segments in mouth cavity and on other parts of the body. $\times 36$.
 11. Habit of a young, mature individual of *Bactris porschiana* in the Arboretum at La Selva. $\times 0.03$. 12. Inflorescence of *B. porschiana* showing scarab beetles (*Mimeoma* and *Cyclocephala*). Photograph taken in the late afternoon of a Day 2 inflorescence after male flowers had opened but before they abscised. Scarabs are feeding on pollen from the open male flowers. $\times 37$. 13. Close-up view of a portion of a *B. porschiana* inflorescence during the pistillate phase, showing male and female (arrows) flowers. $\times 1.3$. 14. Top view of *Mimeoma acuta*, a common visitor to inflorescences of *B. porschiana*. $\times 2.8$. 15. Side view of *Mimeoma acuta*. $\times 2.8$.



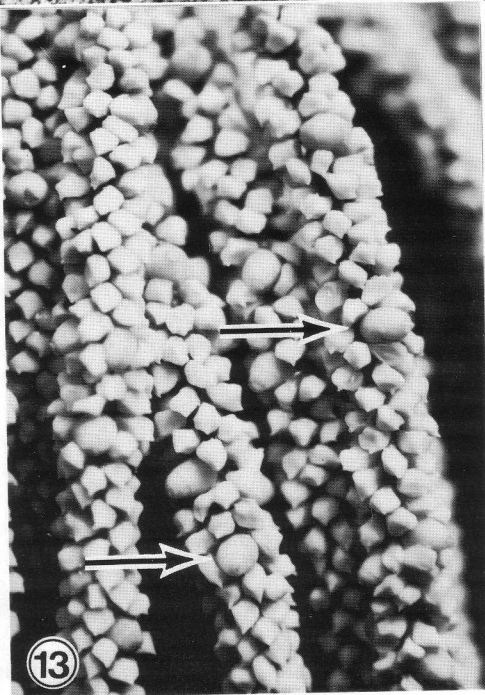




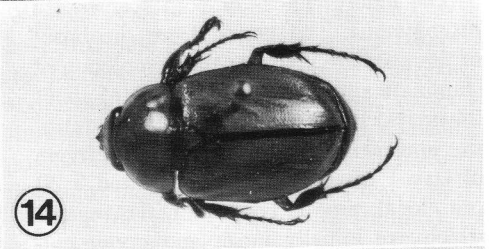
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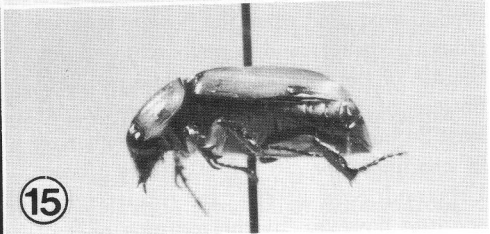
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Table 1. Flower number and sex ratio of flowers on inflorescences of *Bactris gasipaes* and *B. porschiana*.

| Species | Sample Size (# Infl.) | Staminate Flowers (Range) | Pistillate Flowers (Range) | Staminate: Pistillate (Range) |
|----------------------|--------------------------|-------------------------------------|----------------------------------|-------------------------------------|
| <i>B. gasipaes</i> | 6 | 8,622-31,248 \bar{x} = 20,119 | 52-573 \bar{x} = 253 | 40:1-217:1 |
| <i>B. porschiana</i> | 4 | 27,930-36,168 \bar{x} = 30,586 | 540-1,018 \bar{x} = 736 | 36:1-60:1 |

in May through early July with a minor flowering in January. Mora Urpi and Solís (1980) provide quantitative data on the flowering of the species in the Atlantic lowlands. Individual stems of pejibayé produce several temporally staggered inflorescences. Usually only one inflorescence per stem is active at a time, but because there were over 500 flowering stems in the La Selva plantation, several plants were in flower each day. *Bactris porschiana* has only one flowering episode per year from mid-August until mid-September.

The inflorescences of both species are protogynous. The period from the onset of the pistillate phase to the completion of staminate anthesis has a duration of about 24 hours. The inflorescence breaks out of the enclosing bract in the late afternoon of Day 1 usually between 4:00 and 5:20 pm (local time). The stigmatic regions which are initially moist and cream-colored are exposed when the flowers emerge from the bract, and remain exposed for the life of the inflorescence. The pistillate flowers of pejibayé are receptive for at least 24 hours and do not show any change in condition for 36 to 60 hours (Mora Urpi and Solís 1980). In *Bactris porschiana* however, by the morning of Day 2 they become increasingly brown, though the period of actual receptivity was not determined.

No nectar is produced by either palm. In both species, the petals of the staminate flowers remain completely closed for the first 24 hours until 4:30 to 5:00 pm of

the second day of the inflorescence, at which time they begin to open. In pejibayé the margins of the petals separate only slightly to form cracks through which the open anthers partially exert. Within a few minutes after opening, the staminate flowers begin to abscise from the rachillae and fall to the ground. In *B. porschiana*, the petals open much more widely and the stamens are fully exposed. The open staminate flowers remain on the inflorescence for about an hour before abscising. Staminate flowers fall until 6:30 pm, when all the flowers have dropped from the plant and the flowering activity is completed.

Insect Visitation to *Bactris gasipaes*

Day 1. When the bract opens in the late afternoon, the inflorescence produces a musky odor. In addition, heat is produced which makes the spadix several degrees warmer than the ambient air temperature (Schroeder 1978). Within a few minutes after opening, weevils 2 mm in length, of the genus *Phyllostox* (Fig. 7), fly into the inflorescence. Once on the inflorescence, the weevils walk down the sides of the staminate flowers and begin feeding on the succulent lower portions of the perianth. Within ten minutes most of the ten to twenty thousand staminate flowers on an inflorescence have weevils feeding at their bases. Weevils continue to arrive in large numbers during the early evening, eventually becoming packed in very densely around the bases of the sta-

Table 2. Flight times of *Cyclocephala amazona* ($n = 4$ nights).

| Time (pm) | Average Immigration Rate into an Ultra-Violet Light Source (# Immigrating Scarabs per H) |
|------------|--|
| 5-6 (dusk) | 0 |
| 6-7 | 74 |
| 7-8 | 88 |
| 8-9 | 35 |
| 9-10 | 6 |

minate flowers. An estimated 40,000 to 100,000 individuals of *Phyllotrox* come into each inflorescence.

A short time later, about thirty minutes before darkness, 2 cm long scarab beetles of the species *Cyclocephala amazona* (L.) (Figs. 5,6) begin to arrive at the inflorescence at the rate of 10 to 20 per minute. Many scarabs do not land directly on the flowers, but fly into other parts of the palm, especially dead, hanging leaves and the stem, before successfully locating the inflorescence. The beetles' response to missing the inflorescence is to drop immediately from the plant and fly once again back onto it. Once the scarabs land on the inflorescence, they make their way to its interior. At nightfall (6:00 pm), and for the next two to three hours, the scarabs continue to fly into the plant at a high rate. The flight activity of *Cyclocephala* after dusk was also monitored by noting their rate of immigration into an ultra-violet light source located in the pejobayé plantation. The number of flying beetles drops markedly after 9:00 pm (Table 2). Several hundred to several thousand scarab beetles accumulate on the inflorescence by the morning of the second day (Front Cover, Table 3).

Once on the inflorescence some scarabs attempt to copulate while others feed on the closed staminate flowers. Many beetles

Table 3. The number and sex ratios of *Cyclocephala amazona* collected from inflorescences of *B. gasipa*es.

| Infl. # | Total Beetles Collected | Male : Female (n) ^a |
|---------|-------------------------|--------------------------------|
| 1 | 5,652 | 1:2.2 (1,432) |
| 2 | 657 | 1:1.7 (137) |
| 3 | 1,239 | 1:2.6 (199) |
| 4 | 975 | 1:2.7 (232) |
| 5 | 587 | 1:2.7 (177) |
| 6 | 1,057 | 1:1.2 (173) |

^a Sex ratio determined from a random sample (n) of all beetles caught on the inflorescence.

go to the upper parts of the inflorescence and within one to two hours consume the densely-packed trichomes found on the surface of the peduncle (Figs. 8,9). Scarabs examined under magnification had their mouth cavities filled with the globose segments of the trichomes (Fig. 10). Intact trichome segments and pollen grains were also abundant in the frass of the scarabs. Weevils were never seen eating the globose trichome cells. Sample spikes taken from inflorescences during this time period and examined under a dissecting scope showed many weevils mating and a small number feeding on the succulent stigmatic tissues of the pistillate flowers. Most weevils feed on the petals of the staminate flowers throughout the evening and as a result bore small pits into the corolla bases. The damage does not seem to harm the plant as the insects do not penetrate into the central cavities of the still-unopened flowers.

During the morning of the second day, the stigmas show some minor damage from weevil feeding, and most stigmas have a small number of pollen grains and trichome parts adhering to them. As many as 25 individuals of *Derbe westwoodi* Fowler (Homoptera: Derbidae) and several *Ischnomela pulchripennis* Rehn (Tettigoniidae) were regularly seen feeding on the fleshy inner surfaces of the bract.

Ischnomela also feed on a small number of unopened staminate flowers during the first night.

Day 2. During daylight hours, the minute weevils remain on the bases of the male flowers. Before dawn, the scarabs usually retreat to the inside of the inflorescence, so that none is readily visible. Scarabs exposed during the day are often quickly eaten by birds or lizards. Even when scarabs are hidden deep within the *Bactris* inflorescence, birds, such as colored aracaris (*Pteroglossus torquatus*, Fig. 4) and oropendulas (*Zarhynchus wagleri*; Perry, 1980: p. 47), may land on the inflorescence, poke their bills in between the spikes and feed on the beetles.

There is little insect activity during the daylight hours of Day 2 until about 4:00 to 4:30 pm, when the weevils begin to leave the inflorescence before any apparent change in the staminate or pistillate flowers. At this time, a few hundred individuals of *Drosophila* (Diptera) land on the flowers. An increasing number of *Trigona* bees also come into the vicinity of the inflorescence. Twenty to 30 minutes after the weevils have begun to leave, the corollas of the staminate flowers begin to open, exposing the pollen. The scarabs inside the inflorescence become increasingly active and start to walk around on the inflorescence and feed on the pollen in the partially opened staminate flowers. Weevils continue to leave in large numbers with some pollen and trichome cells stuck to their bodies. Within a few minutes after the onset of anthesis, staminate flowers begin to abscise from the inflorescence and, by 4:30 to 5:00 pm, drop steadily, causing a "rain" of flowers. The activity of the drosophilid flies greatly increases and they lay eggs in the floral cavities of the staminate flowers a few minutes before the flowers drop from the inflorescence.

While the flies are ovipositing, 80 to 150 *Trigona* bees forage quickly on the

most exposed flowers on the outside rachillae of the inflorescence. The flies, several times smaller than the bees, attack the rear legs of the bees whenever they land on an inflorescence thus irritating the bees so that they can remain on the spike for less than a second. When the flies were experimentally removed from one inflorescence, the bees alighted and collected pollen without interruption for a much longer period.

Thirty minutes after the onset of staminate anthesis, most of the staminate flowers have fallen to the ground (5:30 to 5:50 pm). The majority of the scarabs, covered with pollen, have left the inflorescence by this time. In the pejiabayé plantation, scarabs could be seen flying from staminate-phase, second-day inflorescences to pistillate-phase inflorescences on neighboring plants. At nightfall, the bees and flies also leave the inflorescence.

Insect Visitation to *B. porschiana*

Day 1. With few differences, the phenology of *Bactris porschiana* and the behavior of its insect visitors are similar to that of pejiabayé. Unlike pejiabayé, the inflorescences of *B. porschiana* do not produce heat or any detectable odor when they first open but do so later in the evening. Very small weevils, predominantly *Phyllotrox megalops* Champion, along with *Grasidius longimanus* Champion and an unidentified species (Baridinae/Centrini) begin to migrate into the inflorescences during the late afternoon of the first day of the inflorescence. However, a majority of the weevils come into the flowers after nightfall when a slight odor can be detected. They approach the inflorescence from downwind. There are fewer weevils per inflorescence than on pejiabayé, but their behavior is the same.

Cyclocephala amazona and another dynastine scarab, *Mimeoma acuta* Arrow (Figs. 14,15), begin to arrive at the inflorescence from 6:10 to 6:30 pm, the same

Table 4. Scarab beetle visitors to *Bactris porschiana*.

| Infl. # | Total | Species on Infl. (Number) |
|---------|------------------|---|
| 1 | 108 | <i>Cyclocephala amazona</i> (80) <i>Mimeoma acuta</i> (28) |
| 2 | 207 | <i>C. amazona</i> (205) <i>M. acuta</i> (2) |
| 3 | 130 ^a | <i>C. amazona</i> <i>M. acuta</i> |
| 4 | 60 ^a | <i>C. amazona</i> <i>M. acuta</i> |

^a Total estimated based on the number of beetles captured and the number of beetles seen escaping. Both beetles were seen on the inflorescence but were not distinguished in total counts.

time that the weevil immigration reaches its peak. Scarabs were seen to come into the plants until 8:30 pm, but some may have arrived later. An inventory of scarabs found on four inflorescences is shown in Table 4.

The beetles are fairly active during the first night. Copulating pairs are seen and many others walk over the spikes contacting the exerted stigmatic lobes of the pistillate flowers. Other insects are also associated with the inflorescences during the night of Day 1, including up to about 40 small black weevils (*Baridinae*/*Centrinini*) which feed on the staminate flower tissues. As with pejibayé, several individuals of *Derbe westwoodi* Fowler and *Ischnomela pulchripennis* Rehn are usually present feeding on the smooth inner surface of the inflorescence bract. Large numbers of a minute unidentified species of Staphylinidae (Coleoptera) are also attracted to the inflorescence.

Day 2. There is little visible insect activity during the morning daylight hours of Day 2. Most of the scarab beetles are torpid, resting on the inner spikes of the inflorescence. At 4:40 to 5:10 pm, the staminate flowers open and insect activity increases. The weevils start to leave the inflorescence at this time. The scarabs

Table 5. Summary of reproductive events in *Bactris*.

| Day 1 | Day 2 |
|---|---|
| am | 6:00 am-4:00 pm |
| 1. Inflorescence closed | 1. Inflorescence remains in female phase |
| 2. No insect activity | 2. Little insect activity |
| 4:00-5:30 pm | 4:00-6:00 pm |
| 1. Inflorescence emerges from bract, female flowers receptive | 1. Male flowers open and abscise from inflorescence |
| 2. Scarabs and weevils begin to fly into the inflorescence | 2. Weevils leave inflorescence in dense swarms |
| 5:30 pm-6:00 am | 3. Scarabs feed on open male flowers, mate |
| 3. Scarabs mate and feed on trichomes and male flowers | 4. <i>Drosophila</i> oviposit into open male flowers |
| 4. Weevils feed on male flower bases | 5. <i>Trigona</i> collect pollen |
| | 6. Remaining male flowers fall from plant |
| | 7. Scarabs and weevils depart for another plant (scarabs leave in the pm of Day 3 in <i>B. porschiana</i>) |

become more active, feeding on pollen from the partially opened staminate flowers and continuing to mate. While doing this, they become covered with pollen. By 6:10 to 6:30 pm, all the staminate flowers are open, and begin to fall from the plant. *Trigona* spp. collect pollen before the flowers fall to the ground. *Drosophilid* flies are also present and behave as described above for pejibayé.

Unlike in pejibayé though, most of the scarabs do not leave the pendulous inflorescence at the end of the staminate phase, but walk up the rachillae to the base of the peduncle (where it attaches to the stem) and remain partially hidden there throughout the daylight hours of the next day. It is not until after nightfall, in the

early evening of Day 3 that the scarabs leave the plant. Table 5 contains a summary of the reproductive events in *Bactris*.

Discussion-Insect Behavior

The exceptional level of insect activity at the inflorescence of pejibayé and the diverse behavior of each of the visitors to the inflorescence makes the pollination biology of *Bactris* a composite of ecological interactions. Because of the abundance of pollen-carrying weevils (*Phyllostrox*) and scarabs (*Cyclocephala*), the relative importance of these two groups of beetles in the pollination of the palms is difficult to assess. The genus shows several features generally found in beetle-pollinated species, e.g., the protogynous reproductive cycle, and use of the inflorescence as an aggregation site for mating and for protection (Beach 1982, Gottsberger 1977, Meeuse and Schneider 1980, Prance and Arias 1975, Schneider and Buchanan 1980, Sohmer and Sefton 1978, Thien 1974, Valla and Cirino 1972).

The beetles are presumably attracted to the flowers by the musky odor produced by the inflorescence. Although the odor from inflorescences of *B. porchiana* was very weak, observations on isolated plants of that species revealed that both weevils and scarabs approach the inflorescence exclusively from downwind. According to Mora Urpí and Solís (1980), the attracting odor in pejibayé is produced by glands located on the petals of the staminate flowers. Heat produced by the inflorescence may function in volatilizing the attracting odor. Such an increase in temperature has been associated with odor production in other species (Smith and Meeuse 1966).

After alighting on the inflorescence, the scarabs eat the trichomes found on the peduncle and rachillae. The minute weevils never showed any gustatory interest

in them although Mora Urpí and Solís (1980) report that weevils ate trichomes on their study plants. Detached trichome segments frequently adhere to various regions of the bodies of the weevils (Fig. 7) and scarabs (Fig. 10).

How the scarabs benefit from eating the trichomes is unknown. Chemical analyses are incomplete but their relatively small size, thick, lamellate cell wall and small lumen, make them atypical morphologically as glandular trichomes. Examination of the frass of two *Cyclocephala* under a compound microscope showed that the globose trichome segments pass through the gut of the scarabs intact. This observation further obscures their putative nutritional significance.

The feeding activity of the weevils is largely confined to basal tissues of the unopened staminate flowers. Because of the extremely large number of feeding weevils, all of the male flowers have many small pits bored into their base. This does not appear to affect the function of the yet unopened staminate flowers. Uhl and Moore (1977) have correlated the feeding behavior of the weevils with the anatomy of the staminate flowers in *Bactris major*. They found thick, fibrous bundle sheaths along with cells containing protective raphides in the petals near the inner surface. Tannins, which are common in other parts of the flower and known to be distasteful to herbivores, were lacking in the outer petal tissue. The authors provide a transection of a staminate flower showing these small pits penetrating through the outer tissues of the petal but stopping at the fibrous bundle sheath layer. Thus, as Uhl and Moore point out, the histology of the staminate flower suggests that the outer tissue of the petals has evolved as a food source, while the positioning of the fibrous bundle and raphides serves to protect the pollen from the insects. Weevils are also known to use flowers for oviposition, but it was not established if this had occurred with *Bactris*. The weevils also infre-

quently feed on the succulent stigmatic tissues.

As Mora Urpí and Solís (1980) have previously reported, several additional insects visit the inflorescence during the brief period of pollen liberation, but probably play no role in the pollination of the palms. At La Selva, at least three species of flies descend onto the flowers during staminate anthesis. As mentioned above, *Drosophila* oviposit into the opened male flowers before they drop from the plant. Adult *Drosophila* were raised from male flowers that were caught while falling from staminate phase inflorescences. An additional unidentified dipteran was raised to the maggot stage in these flower cultures. Trigonid bees which are ubiquitous scavengers at La Selva visit the inflorescence to collect pollen. The drosophilid flies attack the bees which are several times their size. Mora Urpí and Solís (1980) reported that the flies were collecting pollen from the corbiculae on the legs of the bees. My observations indicate that they irritate the bees that land on the open male flowers, and chase them off the inflorescence. This aggressive behavior is presumably an attempt by the flies to keep the pollen-collecting bees away from their eggs which have been deposited in the male flowers. The bees and the flies rarely contact the stigma surface.

Discussion-Pollination

The reproductive biology of other wild species of *Bactris* in Costa Rica has received limited attention. Essig (1971) made observations over a four day period on the pollination of *B. major* and *B. guineensis* on the Pacific slope and described morphology and flowering phenology patterns similar to those of the present study. Although Essig admits that his observations on the insect visitors to the palms were very limited, he concluded that 2 mm long weevils and equally small nitidulid beetles are the most likely polli-

nators of the two species. Bullock (1981) studied the flowering phenology and insect visitors to *Bactris longiseta* and *B. wendlandiana* at La Selva. He also found the typical protogynous flowering pattern and documented both weevil and scarab beetle visitors to the inflorescences. Bullock does not provide quantitative data on the beetle visitors but lists *Cyclocephala stictica* Burmeister, *C. amazona* (L.), *C. brittoni* Endrodi, and *Mimeoma acuta* Arrow as visitors to *B. wendlandiana*, and *Mimeoma acuta* as a visitor to *B. longiseta*. These studies corroborate my observations on the flower morphology and phenology syndrome of the genus, but because of their limited scope, no firm conclusions can be made as to the importance of the various insect species in the pollination of the palms.

Mora Urpí and Solís (1980) examined pejibayé in two plantation localities in Costa Rica: in Guapiles near La Selva and in San Isidro del General, a much drier locality on the Pacific slope of the country. Their observations on the insects visiting at pejibayé in Guapiles largely agree with those of the present study, though they state that the importance of *Cyclocephala* "as a pollinating agent is secondary" because the scarab was not usually found in abundance in Guapiles and because it was absent altogether in San Isidro. They conclude that the weevils, which were found in large numbers in both localities, are the co-adapted pollinator of the palm. The authors also demonstrate that some pejibayé pollen is carried by the wind and that in plantations wind may be a pollinating agent.

Mora Urpí (1982) found very large numbers of weevils visiting the inflorescences of pejibayé and an unidentified *Bactris* species in Amazonian Brazil and Bolivia. He and C. R. Clement (pers. comm.) conclude that the curculionids are the most important pollinators of the palms.

The possibility that *Cyclocephala* or

allied scarab genera can be important pollinators of *Bactris* should not be underestimated. More information is needed from studies of *Bactris* in native habitats to ascertain the importance of the two types of beetles. Several questions need to be addressed. Do scarabs visit the inflorescences of *Bactris* in other parts of its range? Are the 2 mm long weevils capable of flying between conspecific plants in natural populations where palms are separated by distances of tens or hundreds of meters? How effective are the two types of beetles in contacting the stigmas of the pistillate flowers? Are the epidermal trichomes specialized food bodies of nutritional importance to the scarabs? Does the histology of the staminate flowers indicate that they have, in fact, evolved to serve as food source for weevils? Or are the weevils simply opportunistic herbivores? Is the pollination of pejibayé under conditions of cultivation qualitatively different from the pollination of *Bactris* in natural populations? If, as Mora Urpí and Solís found, *Cyclocephala* is uncommon in plantations which are far from the natural haunts of the scarabs and where inter-plant distances are but a few meters, then weevils or wind may become the most important pollinating agents. Additional studies of the reproductive biology of this interesting genus with the goal of answering these questions should allow us to determine with more certainty, the most effective agent of cross-pollination in *Bactris*, and its co-evolved pollinator type.

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LETTERS

To my knowledge, I have the largest growing viable-seed-producing betel nut palm (*Areca catechu*) in California. It all started back in 1966 when I collected seed from the University of Mayaguez Experimental Station in Puerto Rico. Of the many seedlings that sprouted, I selected the largest and fastest growing one and planted it in the ground of my 18' high heated greenhouse. It grew in the summer at a phenomenal rate, at least 2" every evening. It's at night that most palms seem to grow.

Within several years, the fronds began to push against the fiberglass ceiling and I was confronted with the prospect of either digging the palm up and repotting it, cutting it down and killing it, or cutting a hole in the ceiling to let it grow through. I opted for the latter. It was necessary to cut the fronds drastically and also insulate around the new palm spike with foam strips to keep the heat from escaping. It took another several years for the entire crownshaft to emerge completely through the roof. About the same time, I did the

very same thing with a single-trunked *Chrysalidocarpus lutescens* growing in the same greenhouse. Eventually I had two palms each with a full crown of leaves growing through the 18' high roof.

About four years ago, we in Southern California experienced about the coldest winter since I've moved here in 1961. I live in Westminster, Orange County, about seven miles from the coast on level ground and we had a 32 degree temperature in early winter, another one in late winter (both with heavy hail), and cold, cold weather in between. Shortly after, it became apparent that the *C. lutescens* had succumbed to the cold, while just 8' away, the *Areca catechu* remained unaffected. Today it is still thriving, with about five feet of bare trunk above the roof of the greenhouse. It sets viable seed and one of the seedlings from the tree was planted outdoors and is now growing beautifully through its third winter. It would appear I have accidentally made my own "Hardy Betel Nut Palm." I will every winter continue to hope so.

RALPH VELEZ

Observations on Pollination of *Cryosophila albida*

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ABSTRACT

Morphology, phenology, and insect visitors of *Cryosophila albida* inflorescences were observed in the tropical wet forest of Costa Rica. These observations, which included inflorescence temperature elevation, scent, protogyny, and beetle visitation, indicate that this species is cantharophilous.

The pollination of palms has long been discussed (see Schmid 1970b, for references), but only recently have detailed field investigations been undertaken (Uhl and Moore 1977). Although it was often assumed that the family was predominantly anemophilous, these investigations have shown a variety of previously unsuspected insect pollination mechanisms (e.g., Beach 1984, Schmid 1970a, b). Three genera of the least specialized coryphoid group have been studied. Read (1975) showed *Thrinax parviflora* to be wind pollinated; Shuey and Wunderlin (1977) showed *Rhapidophyllum hystrix* to be beetle pollinated; and Brown (1976) showed *Sabal palmetto* to be bee pollinated.

Cryosophila is a genus of approximately 8 species in the *Chelyocarpus* unit of the coryphoid group (Moore 1973). It is distributed from western Mexico to northern Colombia. While the generic relationships (Moore 1972) and floral anatomy (Uhl 1972) of the genus are relatively well known, the species are not. Croat (1978) considered that *C. albida* Bartlett could not be distinguished on key characters (Allen 1953) from *C. guagara* Allen or *C. warszewiczii* (Wendl.) Bartlett.

Until now little was known of the reproductive biology of the genus. Moore (1972) stated, "A possibly specialized mode of pollination is suggested by the arrangement of the anthers at anthesis." Both Uhl (1972) and Read (1965) suggested the genus was protandrous. Bullock (1981) listed *C. albida* as beetle pollinated.

Materials and Methods

The study site was the Organization for Tropical Studies' La Selva Field Station, situated near Puerto Viejo on the Atlantic Coastal Plain of Costa Rica. Holdridge et al. (1971) classified the life zone as Tropical Wet Forest.

Twelve inflorescences were observed from 27th July-2nd August, and 25th August-4th September, 1983. Morphology was studied in the field, and in the laboratory using a dissecting microscope. Representative collections of flowering material were preserved as herbarium specimens. Pollen reference slides were prepared according to the method of Beaty (1971). A photographic record of inflorescence development was made.

Inflorescence phenology was observed throughout the study period. Stigma receptivity was tested with peroxidase paper. Inflorescence temperature was measured with a digital thermometer (Thermistor Series 44, Atkins Technical Inc., Gainesville, Florida 32608).

Insect visitors and their behavior were noted, and representative specimens preserved in ethanol.

Morphology

At La Selva *C. albida* was a frequent component of the understory, occurring in isolated populations, often on sloping ground or in valley bottoms. It had a solitary trunk, up to 6 m tall and 10 cm in diameter, covered with branched root-spines and supported by a cone of prickly stilt roots. The spreading crown contained up to 25 induplicate palmate leaves.

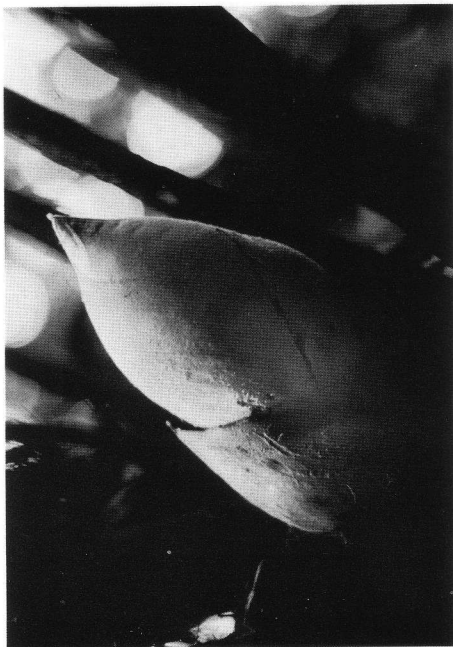
The pendulous inflorescences were interfoliar, reaching 50 cm long. The peduncle bore a green, sheathing, persistent prophyll, and 4 sheathing, persistent peduncular bracts. The rachis bore up to 25 once-branched primary branches, and each of these was subtended by a deciduous rachis bract; these rachis bracts became progressively smaller, ranging proximally from 15 cm to distally 2 cm long. The outward-facing surface of both peduncular and rachis bracts was covered with cottony, intertwined trichomes.

The flowers were perfect, borne singly in spiral rows along the rachillae. The proximal rachillae bore up to 120 flowers, the distal up to 60. The flowers were sessile, each subtended by a minute bracteole. The 3 ovate sepals were 3 mm long and connate basally. The 3 imbricate petals were 4 mm long. The filaments were connate basally into a tube and free above. When exerted, the 6 anthers spread at an angle of 90° to the filaments. They were dorsifixed, and dehisced laterally by longitudinal slits. There were 3 separate carpels, with narrow stigmas 1 mm long.

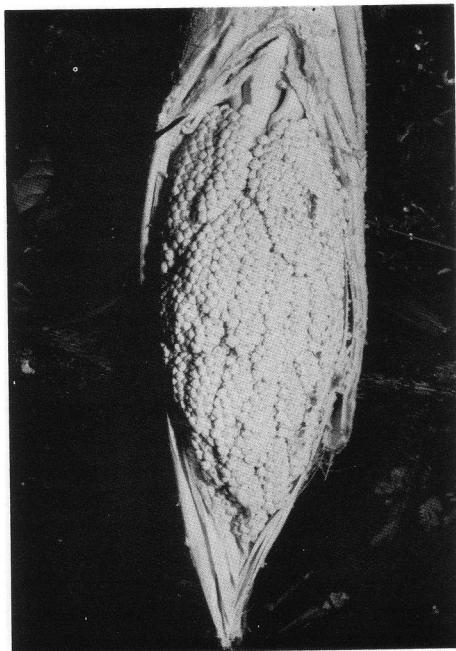
All inflorescence parts were ivory colored, except the prophyll.

Inflorescence Phenology

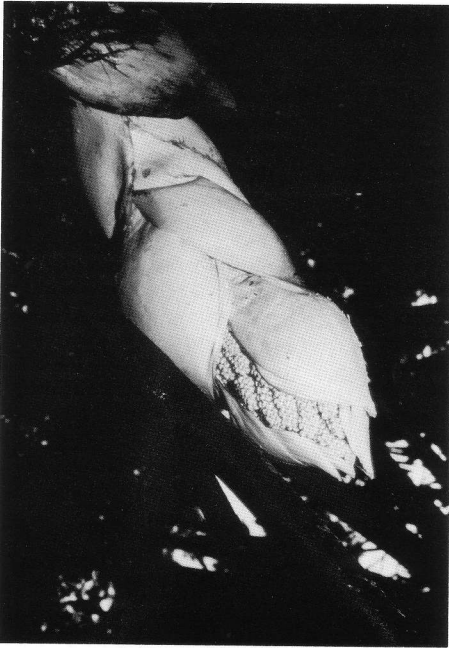
Frankie et al. (1974) listed *C. albida* as flowering in June. Beach (pers. comm.) reported flowering in July and August. In the present study, of 80 plants with trunks over 2 m censused, 2 were flowering at the end of July, and 14 at the end of August.



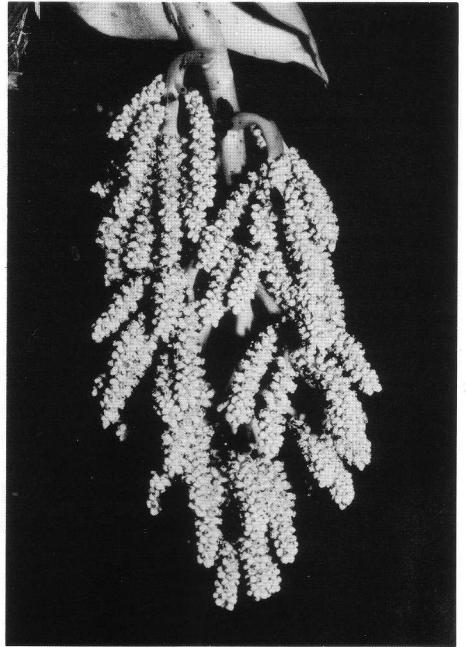
1. Inflorescence bud covered by prophyll and sterile bracts.



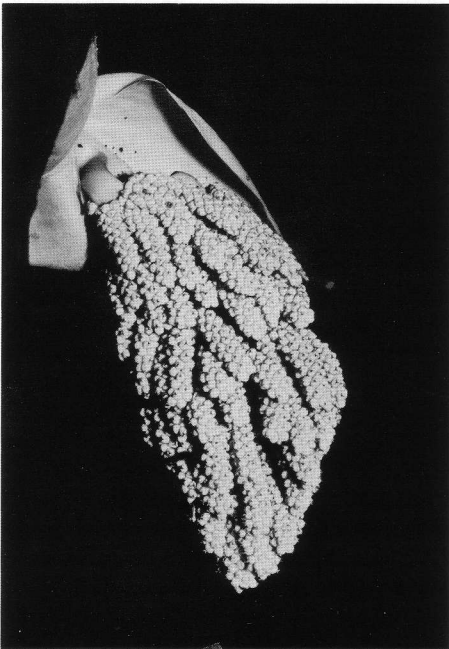
2. Inflorescence bud with sterile and fertile bracts cut away, showing flowers at pistillate anthesis with white receptive stigmas.



3. Inflorescence bud on morning of opening. Distal fertile bracts have fallen off and folded rachillae are visible. Stigmas brown and no longer receptive.



5. Inflorescence on second morning of opening, showing outer flowers at staminate anthesis.



4. Inflorescence with all fertile bracts fallen and rachillae still folded.



6. Inflorescence with rachillae in their final position.

The developing inflorescence buds were tightly enclosed; firstly, up to 12 cm long, by the prophyll; then, up to 20 cm long, by prophyll and peduncular bracts (Fig. 1); and finally, up to 30 cm long, by prophyll, peduncular and rachis bracts. ('Inflorescence bud' was defined as the developing inflorescence enclosed by its bracts, and 'bud opening' as the time when internal pressure pushed the bracts apart, making the flowers visible.)

At least 36 hours prior to opening, the temperature inside the bud rose. The average difference between bud and air temperature during the day (0600-1800) was 2.2° C, and the average difference during the night (1800-0600) was 3.2° C. Concomitant with temperature elevation, the bud gave off a strong scent, similar to that of lilac but also slightly unpleasant. Pistillate anthesis also took place at least 36 hours prior to bud opening. The white, glistening stigmas were exerted and receptive on all flowers within the closed bud (Fig. 2).

Bud opening took place gradually during the early morning, before dawn. Distal rachis bracts parted at the apex, forming an opening into the inside of the inflorescence. Temperature rose steeply during this period, reaching a maximum recorded difference of 7.6° C at 0900.

During the morning of bud opening the rachis bracts gradually fell from the bud, starting distally, revealing the closely bunched and folded rachillae (Figs. 3,4). As soon as flowers were visible, the stigmas were found to be brown, shrivelled, and no longer receptive. Staminate anthesis began during mid-morning. The first anthers to become exerted and dehiscence were on flowers located at the base of rachillae, and thus 'hidden' in the center of the inflorescence. Exserted anthers were at an angle of 90° to their filaments, positioning the anthers to dehiscence in the limited space available. By midday the center of the inflorescence bud was covered with pollen, although none was visible exter-

nally. Staminate anthesis continued on internal flowers throughout the day.

During the night following bud opening rachillae started to move from their original folded position parallel to the rachis, and began to straighten up. The following morning staminate anthesis took place on outward-facing flowers (Fig. 5). Rachillae continued straightening, finally reaching a position at right angles to each other (Fig. 6). Large numbers of flowers began dropping from the inflorescence.

The above events, recorded on the most closely observed inflorescence, and corroborated on others, appeared to represent the general pattern of phenology. However, on two inflorescences there was a slightly different sequence of events. Following bud opening, not all visible stigmas were brown, but approximately 5% were still white and receptive, and remained so for 24 hours. Staminate anthesis was also delayed for 24 hours following bud opening, by which time the rachillae had nearly reached their final position perpendicular to the rachis.

It was observed that many individuals in the same population flowered together, but sequentially so that different stages in development overlapped.

Insect Visitors

The following insects were observed visiting inflorescences:

COLEOPTERA

| | |
|---------------|----------------------------------|
| Curculionidae | <i>Derelominus</i> sp. |
| Nitidulidae | <i>Mystrops</i> sp. |
| Staphylinidae | Unidentified sp. |
| Scarabaeidae | <i>Cyclocephala amazona</i> (L.) |

DIPTERA

| | |
|-----------|----------------------|
| Canopidae | Unidentified sp. |
| Syrphidae | <i>Volucella</i> sp. |

DERMAPTERA

| |
|------------------|
| Unidentified sp. |
|------------------|

ISOPTERA

Termitidae *Nasutitermes corniger* (Motsch.)

HYMENOPTERA

Apidae *Trigona* spp.
Formicidae *Paraponera* sp.
(Ponerinae)

ORTHOPTERA

Tettigoniidae Unidentified sp.
(Decticinae)

LEPIDOPTERA Unidentified larvae

HOMOPTERA Unidentified sp.

During the 36 hour period prior to bud opening numerous curculionids, fewer nitidulids, and some scarab beetles were observed on the inflorescence bud. They arrived during the night, and crawled over the bud, apparently trying to enter it. During daylight hours they congregated under the prophyll. *Trigona* spp. and canopid flies were occasional daytime visitors to the bud. *Paraponera* sp. also visited, and one was observed capturing a bee. Unidentified caterpillars were seen boring a hole into one inflorescence bud, eventually causing it to blacken and rot. Similar damage was seen on two other plants.

By dawn of the morning of bud opening hundreds of weevils and small beetles were present on, and inside, the bud. Fewer scarabs were present, and a maximum of six were seen on any one inflorescence. During the day, as staminate anthesis began, small flies and bees became more numerous. Bees were observed crawling inside the bunched rachillae in order to collect pollen from internal flowers. During the daylight hours all Coleoptera hid inside the center of the inflorescence, or under the peduncular bracts, perhaps in order to escape predators.

During the night following bud opening two unidentified Orthoptera were observed feeding on exserted parts of the flower buds.

On the second day following bud opening, as the rachillae began straightening,

it was observed that most Coleoptera had left the inflorescence. Extensive insect damage could be seen at this time. Most stigmas and anthers had been eaten off, rachis and rachillae had sections stripped from them, and both peduncular and rachis bracts showed signs of damage, including areas in which trichomes had been eaten away.

Termites, *Nasutitermes corniger*, were observed building a nest under the persistent peduncular bracts of one immature infructescence.

Discussion

The small sample size and short study period limit a detailed analysis of *C. albida* pollination. However, inflorescence phenology and morphology preclude self-pollination and wind pollination, respectively. Correlation of morphology, phenology, and insect visitors indicate that this species is beetle pollinated, and the following mechanism is suggested.

The nocturnal pattern of inflorescence bud temperature elevation during the 36 hour pre-opening period causes, or works in conjunction with, scent production. Night-active Coleoptera, especially curculionids, are attracted by this scent. The inflorescence bud acts as a source of food. During the night of bud opening, incoming Coleoptera have access to the inside of the inflorescence bud, through the entrance formed by the parting of the distal rachis bracts. Once inside the bud, they come into contact with flowers at pistillate anthesis, and must crawl over these to reach the center of the bud. During the daylight hours following bud opening, Coleoptera hide in the center of the bud, in the spaces formed by the folded rachillae. Staminate anthesis at this time on internal flowers ensures that Coleoptera become covered in pollen. During the following night, as the rachillae begin to straighten, and scent and temperature decrease, pollen-covered Coleoptera leave the inflorescence and fly to another one.

If they arrive at an inflorescence bud at pistillate anthesis, they will pollinate it. Of the 4 species of Coleoptera observed, by far the most numerous were curculionids, and for this reason *Derelominus* sp. is considered the major pollinator. The nitidulids, *Mystrops* sp., collected were all females. Few scarabs were observed or collected, and were considered too large to be effective pollinators. Other insects were either pollen robbers, or fed on inflorescence tissue.

Essig (1973) also found curculionid pollination in a New Guinea palm, *Hydriastele*. He reported that the pollinator was a member of the pantropical tribe Derelomini, and that this tribe probably occurred exclusively on palm flowers. He considered that this specificity raised interesting questions about the apparent pantropical co-evolution of palms and weevils. Study of *Cryosophila* supports Essig's findings. Mora Urpí and Solís (1980) and Mora Urpí (1982) also found a member of this tribe, *Derelomus palmarum*, pollinating *Bactris* in Costa Rica and South America. Beach (1984) studied *Bactris* pollination in Costa Rica. He found curculionids, but also stressed the role of a scarab, *Cyclocephala amazona*, as co-evolved pollinator.

Uhl and Moore (1977) correlated inflorescence structure and floral anatomy in six genera of palms. Is there any correlation between *Cryosophila* structure and anatomy, and its proposed pollination mechanism? Uhl (1972) described the floral anatomy of the genus. She found that the perianth parts formed a 'protective fence' around the inner organs. Petals and sepals contained frequent tannin cells, abundant raphides, and vascular bundles with fibrous caps. Since *Cryosophila* pollination involves beetle feeding on inflorescence tissue and pollen, there does appear to be a correlation between pollination and anatomy. Although beetles are attracted, and feed on inflorescence tissue, anthers and ovules are protected by

the perianth. Field observations supported this. No insect damage was seen to sepals or petals, although inflorescence branches and bracts all suffered damage. The trichomes covering the peduncular and rachis bracts appeared to be a major food source.

Another protection device, to balance the attraction of the inflorescence as a food source, are the peduncular and rachis bracts covering the bud at pistillate anthesis. Also, as Uhl and Moore (1973) pointed out, the root spines on the stem prevent other predators reaching inflorescences, or infructescences.

What is the significance of the proposed pollination mechanism for *Cryosophila*? The mechanism fits Eames' (1961) suggestion that palms may have been primitively beetle pollinated. Gottsberger (1977) distinguished between an unspecialized beetle pollination syndrome and a specialized one. *Cryosophila* pollination agrees well with the specialized syndrome of small flowers crowded together on the inflorescence. However, the relatively advanced *Bactris*, in the cocosoid group, has been shown by Mora Urpí and Solís (1980), Mora Urpí (1982) and Beach (1984) also to be beetle pollinated in Costa Rica, and to have some features in common with *Cryosophila*. *Bactris* exhibits protogyny, temperature elevation (Schroeder, 1978), and beetle visitors at night. The similarity in pollination which the coryphoid *Cryosophila* shares with the cocosoid *Bactris* and coryphoid *Rhaphidophyllum*, and the way in which it differs from the coryphoid *Thrinax* and *Sabal*, emphasizes the difficulty of trying to assign primitive pollination types. In the Atlantic lowland forest of Costa Rica over 100 different plants in various families are known to be beetle pollinated (Schatz, pers. comm.). *Cryosophila albida* is part of this cantharophilous flora.

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Palm Adventures in Costa Rica

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I had thought about a trip to the "land of the stilt palms" for sometime but found myself continually putting it off. Finally, at the urging of Chester Skotak, a long time friend and plant collector who had recently moved down there, my wife Cynthia and I scraped up the necessary funds to spend our 1982 Christmas break in the Costa Rican rain forest.

Upon our afternoon arrival in San José, we were seconds away from our first palms. The city was filled with *Chamaedorea costaricana*, both indoors and out. We spent the first night in San José sampling the night life of the town. Our guide, Chester, seemed quite adept at locating all the bars with nice palm plantings in view.

We awoke the next morning to begin a more serious palm hunt, starting at the town square. At the corners of the square were very old and towering *Roystonea*, with *Phoenix* and *Elaeis* planted below. After a quick look around and a tour of the magnificent National Theatre, we walked through the city to the National Zoological Gardens. We could see the tall fan palms of the gardens from quite a good distance, which hurried our pace considerably. At the gate of the zoo, we paid our 10¢ entrance fee and began wandering down the paths lined with tropical plants and animals.

Introduced species of palms in the zoo include *Livistona saribus*, *Arecatum romanzoffianum*, *Chrysalidocarpus madagascariensis* and *Trachycarpus fortunei*. We were most excited about the Costa Rican species planted here: large *Euterpe*, hedges of bright green *Chamaedorea* and beautiful specimens of *Syne-*

chanthus warscewiczianus loaded with red and orange fruit clusters. After a long tour through the zoo's interesting collection of Costa Rican animals, we returned to a more conventional line of sightseeing in San José.

Our second morning in San José, we rose at 4:00 a.m. for an all day bus ride through the mountains toward Panama. The bus left San José just as the sun was topping the volcanoes ahead in the distance. We rose steadily in elevation for about two hours and the flora changed as rapidly as the altitude. These high mountains were almost palmless, so we focused our attention on the magnificent tree ferns, cyclanths and bright red bromeliads. As we approached the top of the Cordillera de Talamanca, we were able to see both the Pacific and the Caribbean through our bus windows. This unbelievable sight was typical of the beautiful scenery we encountered all along the route. The sights more than justified the high speed, daredevil driving and less than comfortable seating arrangements on the bus.

Before we knew it we had careened down out of the mountains and back into palm country. At about the halfway point of our trip, we entered San Isidro, a beautiful town which marked the real beginning of our excitement as we saw palms in every direction. The coconut palms of San Isidro are quite distinct and interesting, with many upright leaves held at an angle of about 45° from the trunk.

As soon as we left the town proper, we passed dozens of roadside homes with yards completely filled with palms. Each yard had a few coconuts, a clump of peach



1. *Astrocaryum standleyanum* on the banks of Rio Terraba at Paso Real.

palms (*Bactris gasipaes*) and an oil palm or two. It was a thrill for us to see people actually using palms for their livelihood rather than for landscaping their boulevards. For the next few hours the palm scenery remained unchanged as we continued southeast on the Pan-American Highway.

At the three-quarter mark in the trip, just after noon, we turned off the main highway at Paso Real and headed toward San Vito de Jaba. From this point on, the roads were dirt, but the palm scenery was fantastic! We dropped slightly in elevation as we entered the river valley of the Rio

Grande de Terraba. We took a primitive ferry across the river and waiting on the other bank were several nice stands of *Astrocaryum standleyanum*. As there was no time to collect seed, we had to settle for photos. The *Astrocaryum* lined the road until we climbed out of the river valley. We gradually ascended into rolling hills, about 500 meters in elevation, and began to see an occasional *Scheelea rostrata*. As we climbed higher, they became more frequent, and near the town of Sabanilla, the groves of the massive *Scheelea* completely covered the hills. Between Sabanilla and San Vito, we rose



2. *Asterogyne martiana* at Finca Las Cruces.



3. *Euterpe macrospadix* at Finca Las Cruces.



4. *Hyophorbe indica* at Finca Las Cruces. Photo by Cynthia Ford.

further in elevation and saw an occasional patch of montane rain forest which had yet to be cleared for agriculture. Out of the tops of these forest patches, sprang tall *Iriartea gigantea* and *Euterpe macrospadix*. Seeing the *Iriartea* for the first time made all the bruises of the bus trip worthwhile. The stilt palms are certainly among the most magnificent of all Neotropical plants. They were distinct from quite a distance as they towered above the low forest canopy. Soon the road started dropping in elevation, leaving the forest patches behind for a more arid landscape. Eight hours after our departure from San José, we pulled into San Vito de Jaba, a small town only a few miles from Panama.

We quickly bought the necessary supplies and headed out of San Vito. We hired a land cruiser and drove due south, right up the side of the mountains towards Panama. After forty-five minutes of climbing

the rock road, we returned to the montane forests and cooler elevations. The driver dropped us off at the entrance of Finca Sal Si Puedes, Chester Skotak's Costa Rican home. After a short tour of the house and gardens, we walked through virgin rain forests to Finca Las Cruces, the home of long time plant enthusiasts, Bob and Catherine Wilson.

The building and development of Las Cruces Tropical Botanical Garden has been previously documented in *Principes* by W. H. Hodge. In the short time since his visit, the palm collection has grown considerably. It now consists of about 700 species planted throughout the acreage and contains not only the choicest of Central American rain forest palms, but also a good selection of Oriental rarities as well. Many of the palms grown at Las Cruces are very rare in cultivation and several species are as yet undescribed.

The American palms growing at Las



5. Young *Socratea durissima* and author. Photo by Cynthia Ford.

Cruces include extensive collections of *Chamaedorea* and *Geonoma* as well as Costa Rican and Panamanian species of *Asterogyne*, *Oenocarpus*, *Raphia*, *Sabal*, *Bactris*, *Euterpe*, *Prestoea*, *Reinhardtia*, *Neonicholsonia*, *Calypstrogyne*, *Iriartea*, *Socratea*, *Synechanthus* and others.

Among the palms from the Eastern tropics cultivated at Las Cruces, are species of *Nenga*, *Basselinia*, *Dictyosperma*, *Hyophorbe*, *Licuala*, *Pinanga*, *Ptychosperma*, *Neodypsis*, *Chrysalidocarpus*, *Trachycarpus*, *Daemonorops*, *Normanbya*, *Pigafetta*, *Rhapis*, *Areca*, *Corypha* and *Caryota*.

The altitude of the garden allows cultivation of many palm species that do not survive the summer temperatures of southern Florida, Texas or California. Las Cruces is ideally suited to grow many of the New Caledonian and New Guinean species which will probably never be successfully grown outdoors in the U.S. As Bob Wilson and his assistants are actively engaged in the expansion of the palm collection, Finca Las Cruces should soon become the premier location for palm study in this hemisphere.

Our plans allowed us only four days at Las Cruces, but palmwise they were by far the most exciting. The hospitality of the Wilsons made the stay even more enjoyable. All too soon we were back on the bus to San José, but not before we had made plans for several return trips.

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Know Your Palms

A. *Morattia cerifera*; B. *Eugeissona utilis*; C. *Pigafetta filaris*; D. *Schippia concolor*.

Principes, 28(3), 1984, pp. 132-137

Tapping Patterns in the Nipa Palm (*Nypa fruticans* Wurmb.)

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Today the nipa palm is found in the eastern tropics stretching from Southeast Asia through Borneo, Irian Jaya and Papua New Guinea to North Australia (Tralau 1964). It forms pure stands with a closed canopy and is found in mixed vegetation with other mangrove species in estuary lowlands which are subject to frequent flooding by brackish tidal waters (Paijmans 1976, Fig. 1A). Nipa differs from other palm species in that it lacks a distinct erect stem (Fig. 1B). It has a stout dichotomously branching rhizome which gives rise to the upright fronds and the flower stalks. The length of fronds is from 3 to 13 meters depending on the locality (Dugros 1933, Amio et al. 1979, Päivöke et al. 1982). Throughout the eastern tropics the fronds of the nipa palm are used for the construction and thatching of village houses (Fig. 1A). From the young leaflets and midribs mats, baskets, sunhats and brooms can be manufactured. The base of the central apical bud is eaten as "cabbage."

Under natural conditions 30% of nipa palms produce flowers and one flowering palm produces 1-2 stalks yearly (Amio et al. 1979). In Papua New Guinea the average weight of a mature infructescence is about 15 kg, ranging from 6 to 30 kg (Päivöke 1984). It comprises tightly wedged 1-seeded nuts (Fig. 1C). The seeds of the nuts are edible when young (Tralau

1964, Percival and Womersley 1975). The length of the flower stalks, which are sources of sweet sap, is reported to vary from about 0.6 to 2.2 meters (Amio et al. 1979, Päivöke 1984, Fig. 2A-D).

Nipa Sap

The sap of the nipa palm has been used as a source of an alcoholic beverage in Far-East Asia since the earliest times. Sugar or syrup and vinegar can also be manufactured from the sap.

The estimated yields of sap from the nipa palm vary from one source to another. Gibbs (1911) states that about 1.25 liters/palm/day can be extracted. Thus an average plant will yield about 50 liters of sap/tapping season equalling about 440 liters of sap/ha/day and about 78,500 liters/ha annually. A more recent estimate from the Philippines is about 126,000 liters of sap/ha/year (Amio et al. 1979). In Papua New Guinea investigations have revealed that about 169,000 liters of sap may be produced annually per hectare of the nipa palm (Päivöke 1984).

The sugar content of the fresh nipa sap is known to be an average of 14-17% w/v depending on the locality (e.g., Pratt et al. 1913, Päivöke 1984). Therefore, an alcohol content of about 6-7% w/v may be taken as the average for the fully fermented nipa sap (e.g., Päivöke 1984).

In the early decades of the 20th century palm saps were major sources of alcohol in the Philippines: in 1910 about 93% of the total amount of alcohol and

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A



B



C

1. A. A thick wall of nipa bordering a river in Baimuru district of the Gulf Province in Papua New Guinea. Nipa is also used as a construction material: a temporary nipa-hut on floating logs. B. A close view into a nipa thicket. C. The infructescence of the nipa palm comprises 1-seeded, tightly packed nuts.

alcoholic beverages were distilled from palm saps. But due to changed conditions and the increasing availability of molasses the utilization of palm extracts declined and in 1920 only about 35% of the alcohol in the Philippines was produced from this source (Cole 1922). However, research into the potential of the nipa palm as a source especially of sugar continued. It was noticed that under conditions of cultivation the percentage of flowering of the nipa palm is higher than in its natural state. Furthermore, in plantations the nipa was reported to produce up to 16 stalks per plant (Hofstede 1929). Ambitious plans for utilizing the nipa palm as a source of fuel alcohol and sugar were based on the assumption that all the stalks produced by one plant may be tapped simultaneously. Dennett (1927) mentions tapping of two stalks per plant, and Hofstede (1929) four. Today in the Philippines the tappers warn against tapping more than one stalk of the entire nipa palm colony; otherwise the plants may die. Tapping of all the stalks of each palm is carried out in Borneo today, although the sap yields are apparently smaller than the average for the nipa palm (Päivöke et al. 1982).

Obvious disagreement exists in the literature regarding the tapping of several stalks per plant or all the stalks of the nipa colony, i.e., the tapping of all the plants produced vegetatively by the dichotomous branching of the rhizome. Because of this, some investigation was made into this matter in conjunction with a 3-year feasibility study conducted at Baimuru in the central area of the Gulf Province of Papua New Guinea by the Department of Minerals and Energy (Newcombe et al. 1980).

Tapping Yields in Papua New Guinea

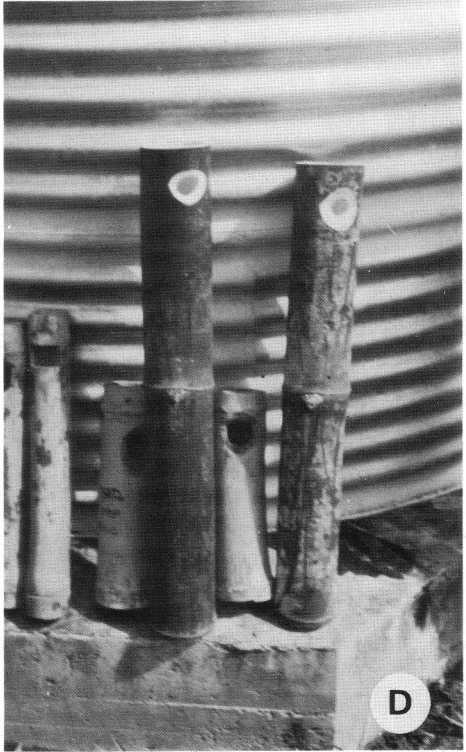
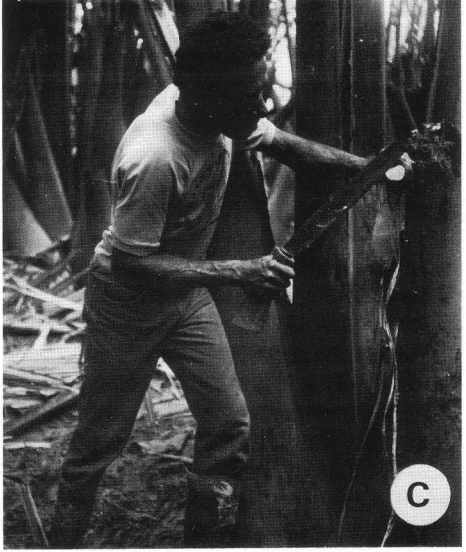
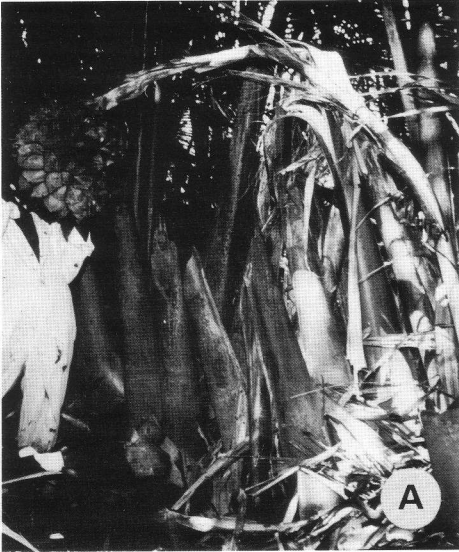
Tapping of the nipa was performed during 1980–1983 in seven villages of

Baimuru district located 1.5–23 km from the sea. The average yield of sap/palm in the district was found to vary from 0.6 to 1.8 liters/palm/day.

Tapping of Two Stalks Per Plant

The tapping site of Lavipaka included two adjacent plots of about 30 × 30 m each. They were located about 12–15 km from the sea on a side creek of Pie River.

Palm number 235 in the Lavipaka village area had two stalks, which were treated and eventually tapped simultaneously. One stalk was tapped for only one month after which it dried, and the second stalk yielded sap for 2.5 months, after which it too dried. During the first month, when both stalks were tapped simultaneously, stalk number one gave an average of 711 ± 140 ml/24 hours, and number two an average of 706 ± 89 ml/24 hours, totalling $1,417 \pm 229$ ml/24 hours for the whole plant. Consequently during this month about 43 liters of sap were collected from the whole plant. Stalk number two was tapped for an additional one and a half months. During this time the stalk yielded 548 ± 92 ml/24 hours of sap. Calculated as the total yield of sap per plant in the 2.5 month tapping period, the whole plant produced about 70 liters. The average tapping period in Lavipaka area, when only one stalk per plant was tapped, was 3–4 months; i.e., stalks yielded sap until they had to be abandoned as they were too short for shaving (Fig. 2C). The average sap yield in the two seasons in Lavipaka, when only one stalk per plant was tapped, was $1,200 \pm 79$ ml/24 hours and if the minimum tapping season is taken as 3 months the average sap production per plant in this area totals about 108 liters. Therefore, tapping two stalks in this example decreased the average sap yield per season by about 35% and slightly shortened the tapping period.



2. A. The flower stalks of the nipa palm in Baimuru district may attain a considerable length. The stalk is covered by numerous spathes. B. The spathes are removed at first when stalks are worked for sap extraction. C. After the required pretreatment of the stalks the infructescence is cut off. Thereafter, the stalk must be shaved twice a day to ensure sap flow. D. Bamboo joints of single or double internode lengths are used for sap collection. The end of a stalk is inserted in the bamboo through the hole.

Table 1. *Tapping of members of the same nipa colony. Comparison of yields.^a*

| 1st month of tapping | palm 203 (mother plant) | | | | | |
|--|--|----------|------------------|----------|---------------------|----------|
| | palm 201 (daughter) | | am (ml) | pm (ml) | palm 202 (daughter) | |
| | am (ml) | pm (ml) | 348 ± 61 | 123 ± 11 | am (ml) | pm (ml) |
| | 579 ± 78 | 191 ± 19 | | | 1,125 ± 132 | 244 ± 25 |
| | 770 ± 97 ml/24 h | | 471 ± 72 ml/24 h | | 1,369 ± 157 ml/24 h | |
| | Total yield per 3-palm colony: 2,610 ± 326 ml/24 h | | | | | |
| 2nd and 3rd months of tapping | am (ml) | pm (ml) | — | — | am (ml) | pm (ml) |
| | 1,454 ± 116 | 282 ± 18 | | | 1,633 ± 113 | 351 ± 21 |
| | 1,736 ± 134 ml/24 h | | — | | 1,984 ± 134 ml/24 h | |
| | Total yield per 3-palm colony: 3,720 ± 268 ml/24 h | | | | | |
| Increase in flow after the 1st month; only two members tapped of 3-palm colony | am | pm | | | am | pm |
| | 60% | 32% | | | 31% | 30% |
| | Total flow: 42.5% | | | | | |

^a Standard errors indicated. Abbreviations: am (ml) = ml of sap collected during the night (about 17 hours), pm (ml) = ml of sap collected during the day (about 7 hours).

Similar cases were also recorded in other sites where tapping was carried out.

Tapping of Members of the Nipa Colony

The vegetative propagation of the nipa palm is known to start about one year after germination and thereafter the rhizome branches dichotomously about every second year (Pratt et al. 1913, Tomlinson 1971). At about 10 years of age the nipa palm fronds attain their full length and the rhizome reaches a stable state of continuous growth, i.e., division at one end and decay at the other. As a consequence, older nipa palms grow in colonies of several plants. In the course of a 3-year study conducted in the Gulf Province of Papua New Guinea, it was repeatedly observed that palms which apparently grew in short colonies with only one stalk tapped produced higher yields than several palms of a long colony tapped simultaneously. The example of palms number 201, 202 and 203 offer an illustration of this.

In Lavipaka tapping site, palms number 201, 202 and 203 formed a cluster so that 203 represented the point of dichotomous branching; i.e., the mother plant, and 201 and 202 were daughter plants. The palms were about one meter from each other in a triangle-like formation. During the first month of tapping, plant number 202 gave the highest yield, about 1,370 ml/24 hours, number 203 the lowest, about 470 ml/24 hours, and palm number 201 yielded about 770 ml/24 hours of sap (Table 1). The average yield per palm in the 3-palm colony was then about 870 ml/24 hours, which is about 27% lower than the average in this area, which was about 1,200 ml/24 hours. After the first month of tapping, palm number 203 (the mother plant) ceased to flow and dried up, after which there was an increase of about 60% in the night-flow and about 32% in the day-flow in plant number 201, and about 30% increase in the day- and night-flows of palm number 202. The average yield per plant now becomes about 1,860 ml/24 hours

and the total yield of the 3-palm colony was now about 3,720 ml/24 hours. This may be compared with an average of 2,610 ml/24 hours during the first month of tapping, an increase of about 42.4% in the total flow, when only the daughter plants were tapped (Table 1).

In the Lavipaka tapping site the average sugar content of the sap varied from about 13 to about 18% w/v depending on the season, length of the stalk, yield, etc. It was noticed that the sugar content was slightly lower than the average of 16.4% w/v in the district (Päivöke 1984) if the yield of sap was very high. However, the decrease was not significant.

The nipa palm is known to be capable of producing sap 5–6 years after germination and is productive for approximately another 45 years (Anon. 1922). In view of the examples presented here, one explanation of the poor yields in old nipa palm groves (Pratt et al. 1913) may be the tapping of members of one colony which are too close together. Further investigations into the "family relationships" of the nipa palm are needed in order to optimize the sap yields.

Conclusions

In the course of a 3-year study conducted in the Gulf Province of Papua New Guinea it became clear that if two stalks per palm were treated and tapped simultaneously it may decrease the total yield per plant and also shorten the tapping period. Furthermore, the study supports the view that selective tapping of only some members of one entire nipa colony may increase the total sap yield. As the nipa palm resources today are receiving increasing interest in Far-East Asia and South Pacific countries as a potential source of alternative energy, as well as of sugar or syrup, the observations presented here may be of interest in maximizing the daily sap yields per plant, as well as in stimulating further research into the optimum mode of tapping this palm species.

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Nutritional Value of Palms

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Literature on palms is rich in descriptions of their economic and cultural importance. The work of Corner (1966) is extensive in its coverage, going far beyond the few genera (*Cocos*, *Elaeis*, *Phoenix*, perhaps *Raphia* and those serving as sources of commercial "palm hearts") which have become important in international trade. Much of this importance depends on the food or drug value of the palm; Corner (l.c.) gives notes on 27 genera selected for such attention by diverse criteria, yet two-thirds of these genera are noted by him to have nutritional value.

But just what nutritional value do they have? How can they be compared with each other and with other plants as food sources? Some may assert that a group of people resident long enough in a pre-industrial setting have probably put everything available to its best use; but prospects still exist for transfer of information beyond the range of such technologically simple societies—for example, the wider production and use of a palm product (no better example exists than the establishment of the great oil palm plantations outside Africa). Such prospects remind us of the need for analysis which makes comparison and evaluation possible.

Corner was writing a work on natural history, and although his felicitous interpretation included the role played by palms in human societies, we look in vain to him for the kind of chemical analyses which would enable us to illuminate the similarities and differences among nutritionally notable palms. A more recent, non-nutri-

tional, review of palm products is that of Kitzke and Johnson (1975). Likewise, the work of von Reis Altschul (1973), based on herbarium label annotations, lists 23 species of palms, of which 17 are clearly reported to be used as food; yet nutritional analysis was completely beyond the scope of the book. Hodge (1975) dealt with oil yield and distribution rather than chemical analysis. Duke's (1977) article mentions biomass and starch yields, adding information on sugar content, as well as potential ethanol production by subsequent fermentation, since he was not concerned exclusively with oil. Purseglove (1972), in his wide-ranging treatment of tropical crops, reports incidental information on 23 genera without nutritional analyses, though he does mention the use as food of species of 15 of these genera. In addition he cites more detailed information on *Areca*, *Cocos*, and *Elaeis*, including data on chemical composition of edible parts and products. Some products differ as to method of production and so are excluded from Table 1 (see below). The coverage varies greatly among the three major components of endosperm and sap being analyzed in his one source for *Cocos* (Menon and Pandalai 1957), but only a single undocumented range is given for fat content in *Elaeis* mesocarp, and only approximate, undocumented figures for *Areca* endosperm. (No criticism is intended here of Purseglove; his broad survey of nearly all tropical crops did not emphasize nutritional analyses, and is nevertheless an indispensable reference for tropical agriculturists.)

For the great majority of palms, then, data on nutritional value lie buried in obscure compendia or scattered throughout the literature, in neither case available for ready reference and comparison by those most interested in palms. Fortunately, one of the components of the Agricultural, Geographic, and Ecological Information System (AEGIS) of the Germplasm Resources Laboratory, USDA/ARS, is a file of such data computerized in such a way that it is possible to isolate data for particular plant groups. Just such a retrieval has been performed for palms, with results for 29 genera given in Table 1.

This table is based on reports in several sources for the nutritional content of *plant parts*, not processed products. This is because processing techniques may vary, affecting the nutritional composition and are often undocumented in reports so that comparison becomes impossible. Perhaps the most conspicuous example of this among palms is sago. The literature contains abundant references to the nutritional composition of this product (e.g., Gohl 1981, and Whitten and Whitten 1981) but since it is processed almost entirely under uncontrolled, unmonitored conditions, many references are not incorporated in our data base. The reference just cited, for example, differ in calcium and ash content and it is impossible to tell whether differences in processing or natural variation among the plants is the cause. Where laboratory analysis of unaltered starch appears to be reported, the special part code "PS" is used for sago. It is believed that such laboratory methods do not so differ as to account for variation in proximate analyses of unprocessed plant parts and that such variation could be attributed to the genetics of plant populations. Such variations clearly have value for palm germplasm work, such as the conservation of more nutritious strains.

A few comparisons of palm nutritional value with that of other crops from trop-

ical and subtropical regions may be instructive. The following are drawn (on a zero-moisture basis) from Table 1 and other entries in our database: Seed of *Cocos nucifera* has about twice the protein value of, and over fifty times as much fat, as the root of *Manihot esculenta*, and about twice as much protein as the ripe fruit of *Mangifera indica*. The bud of *Cocos nucifera* has over twice as much protein as the average reported for the ripe fruit of *Carica papaya*, over seven times as much fat, almost three times as much phosphorous, and over twice as much niacin, although it has only about a tenth as much ascorbic acid and—presumably, since no data are reported here—has relatively little carotene. (The palms are generally reported to be relatively low in ascorbic acid compared to *Capsicum* spp. and *Carica* spp., as well as many other tropical and subtropical sources of that nutrient.) However, *Elaeis* oil seems to be a source of carotene richer than ripe *Carica papaya* fruit, and at least comparable to the fruit of *Capsicum* spp. as reported by several sources. Interestingly, the bud of *Geonoma edulis* is reported to be over four times as rich in protein as that average ripe fruit of *Carica papaya*.

Such intriguing comparisons, which will, it is hoped, become more accurate as the database expands, suggest a potential usefulness of palms in developing countries. Confirming the existence of this potential would appear to require intensive, standardized analysis which adequately explores variation in populations. The full range of ecological factors which influence the variation in time and space of nutritional value must also be investigated. Such additional information could best be integrated and applied by the intelligent use of automated data processing. In this connection, it should be pointed out that the database drawn upon here was not set up with palms specifically in mind; the author acknowledges that many more sources

Table 1. Proximate Analysis of Palm Parts.

| Plant Name | Refer- ence | Part Code | Cal- ories/ 100 g | Water % | Protein % | Fat % | Carbo- hydrate % | Fiber % | Ash % |
|--|----------------|--------------|-------------------------|------------|--------------|----------|------------------------|------------|----------|
| <i>Acrocomia mexicana</i> | 3 | SH | 315 | 0 | 19.4 | 3.2 | 67.7 | 5.6 | 9.7 |
| <i>Acrocomia mexicana</i> | 3 | F | 479 | 0 | 9.1 | 28.6 | 57.9 | 27.8 | 4.4 |
| <i>Areca catechu</i> | 2 | SH | 316 | 0 | 24.3 | 2.2 | 66.2 | — | 7.4 |
| <i>Areca catechu</i> | 2 | S | 449 | 0 | 6.8 | 12.3 | 79.1 | 18.1 | 1.7 |
| <i>Areca catechu</i> | 5 | S | — | 31.3 | 4.9 | 4.4 | 47.2 | — | 1.0 |
| <i>Arecastrum romanzoffianum</i> | 19 | S | — | 0 | 12.8 | 64.7 | — | — | — |
| <i>Arenga pinnata</i> | 2 | SH | 358 | 0 | 1.9 | 3.8 | 92.5 | 9.4 | 1.9 |
| <i>Astrocaryum standleyanum</i> | 3 | F | 352 | 0 | 6.0 | 2.5 | 86.5 | 20.3 | 5.0 |
| <i>Bactris guineensis</i> ¹ | 3 | F | 343 | 0 | 5.9 | 1.0 | 87.3 | 10.3 | 5.9 |
| <i>Borassus flabellifer</i> | 18 | L | — | 0 | 13.3 | 4.6 | 74.7 | 38.0 | 7.4 |
| <i>Borassus flabellifer</i> | 1 | F | 347 | 0 | 6.5 | 0.8 | 87.9 | 16.1 | 4.8 |
| <i>Borassus flabellifer</i> | 1 | IS | 401 | 0 | 5.1 | 0.6 | 92.7 | 7.9 | 1.7 |
| <i>Borassus flabellifer</i> | 2 | SH | 338 | 0 | 8.9 | 0.7 | 87.2 | 7.2 | 3.3 |
| <i>Borassus flabellifer</i> | 5 | F | — | 0 | 3.1 | 0.9 | 93.4 | — | 3.1 |
| <i>Borassus flabellifer</i> | 5 | S | — | 0 | 8.1 | 1.4 | 85.1 | — | 3.5 |
| <i>Butia capitata</i> | 21 | S | — | 0 | 15.7 | 56.5 | — | — | — |
| <i>Butia eriostachya</i> ² | 19 | S | — | 0 | 12.9 | 44.1 | — | — | 1.8 |
| <i>Calamus ornatus</i> | 2 | F | 376 | 0 | 2.9 | 5.7 | 88.6 | 2.4 | 2.9 |
| <i>Chamaedorea</i> sp. | 3 | — | 300 | 0 | 26.7 | 4.7 | 55.3 | 8.0 | 13.3 |
| <i>Chamaerops humilis</i> | 20 | S | — | 0 | 5.0 | 8.7 | — | — | — |
| <i>Chrysalidocarpus lutescens</i> | 20 | S | — | 0 | 6.9 | 7.2 | — | — | — |
| <i>Chrysalidocarpus madagas- cariensis</i> var. <i>lucubensis</i> ³ | 20 | S | — | 0 | 2.9 | 8.2 | — | — | — |
| <i>Cocos nucifera</i> | 1 | S | 676 | 0 | 6.3 | 67.9 | 24.0 | 11.5 | 1.7 |
| <i>Cocos nucifera</i> | 1 | IS | 625 | 0 | 6.3 | 54.4 | 36.6 | 11.6 | 2.8 |
| <i>Cocos nucifera</i> | 2 | S | 646 | 0 | 6.6 | 58.4 | 33.1 | 6.2 | 1.9 |
| <i>Cocos nucifera</i> | 2 | IS | 481 | 0 | 8.8 | 22.5 | 64.4 | 2.5 | 4.4 |
| <i>Cocos nucifera</i> | 2 | SH | 353 | 0 | 13.2 | 9.6 | 66.9 | 7.4 | 10.3 |
| <i>Cocos nucifera</i> | 3 | S | 652 | 0 | 7.7 | 59.9 | 30.2 | 8.4 | 2.2 |
| <i>Cocos nucifera</i> | 3 | IS | 656 | 0 | 10.2 | 64.0 | 21.5 | 3.8 | 4.3 |
| <i>Cocos nucifera</i> | 4 | SA | 705 | 0 | 7.1 | 71.9 | 19.1 | 8.1 | 1.8 |
| <i>Cocos nucifera</i> | 5 | Z | — | 0 | — | — | — | — | 5.9 |
| <i>Cocos nucifera</i> | 23 | S | — | 36.3 | 4.5 | 41.6 | 13.0 | 3.6 | — |
| <i>Corypha utan</i> | 2 | F | 326 | 0 | 3.7 | 0.5 | 93.7 | 6.8 | 2.1 |
| <i>Elaeis guineensis</i> | 18 | F | — | 0 | 7.9 | 54.0 | 36.4 | 3.9 | 1.7 |
| <i>Elaeis guineensis</i> | 19 | S | — | 0 | 9.9 | 54.4 | — | — | 1.6 |
| <i>Elaeis guineensis</i> | 1 | F | 732 | 0 | 2.6 | 79.1 | 16.9 | 4.3 | 1.4 |
| <i>Elaeis guineensis</i> | 3 | F | 746 | 0 | 2.2 | 81.9 | 14.6 | 3.8 | 1.3 |
| <i>Elaeis guineensis</i> | 3 | O | 882 | 0 | 0.0 | 99.6 | 0.4 | 0.0 | 0.0 |
| <i>Erythea</i> sp. | 19 | S | — | 0 | 5.8 | 6.6 | — | — | — |
| <i>Erythea</i> sp. | 21 | S | — | 0 | 5.6 | 9.2 | — | — | — |
| <i>Euterpe oleracea</i> | 3 | F | 449 | 0 | 5.8 | 20.7 | 71.5 | 30.5 | 2.0 |
| <i>Geonoma edulis</i> | 3 | SH | 297 | 0 | 27.1 | 2.5 | 59.3 | 12.7 | 11.0 |
| <i>Hyphaene thebaica</i> | 1 | S | 420 | 0 | 4.1 | 6.8 | 85.7 | 10.0 | 3.3 |
| <i>Hyphaene turbinata</i> | 19 | S | — | 0 | 8.1 | 13.4 | — | — | 2.3 |
| <i>Jubaea chilensis</i> | 3 | S | 714 | 0 | 8.2 | 75.3 | 15.5 | 6.8 | 1.0 |
| <i>Manicaria saccifera</i> | 25 | PS | — | 63.5 | 1.6 | 0.6 | 5.1 | 24.7 | — |
| <i>Mauritia vinifera</i> | 3 | F | 526 | 0 | 11.0 | 38.6 | 46.0 | 41.9 | 4.4 |
| <i>Metroxylon</i> sp. | 2 | HE | 411 | 0 | 1.60 | 0.2 | 98.80 | 0.20 | 0.5 |
| <i>Metroxylon</i> sp. | 5 | HE | — | 0 | 0.20 | 0.2 | 99.20 | — | 0.3 |
| <i>Metroxylon</i> sp. | 24 | PS | 285 | 27.0 | 0.2 | 0.0 | 71.0 | 0.3 | — |
| <i>Orbignya cohune</i> | 19 | S | — | 0 | 6.9 | 52.2 | — | — | — |

Table 1. Continued

| Plant Name | Refer- ence | Part Code | Cal- ories/ 100 g | Water % | Protein % | Fat % | Carbo- hydrate % | Fiber % | Ash % |
|--|----------------|--------------|-------------------------|------------|--------------|----------|------------------------|------------|----------|
| <i>Orbignya cohune</i> | 19 | S | — | 0 | 1.2 | 0.5 | — | — | — |
| <i>Orbignya speciosa</i> | 19 | S | — | 0 | 9.4 | 62.9 | — | — | — |
| <i>Orbignya speciosa</i> | 19 | S | — | 0 | 16.2 | 0.2 | — | — | — |
| <i>Phoenix dactylifera</i> | 18 | F | — | 0 | 2.9 | 1.0 | 90.4 | 6.5 | 5.7 |
| <i>Phoenix dactylifera</i> | 18 | S | — | 0 | 5.8 | 7.1 | 85.3 | 30.0 | 1.8 |
| <i>Phoenix dactylifera</i> | 1 | F | 357 | 0 | 4.0 | 1.5 | 92.0 | 8.3 | 2.5 |
| <i>Phoenix dactylifera</i> | 3 | F | 353 | 0 | 2.2 | 0.7 | 94.3 | 4.2 | 2.7 |
| <i>Phoenix dactylifera</i> | 3 | F | 354 | 0 | 2.2 | 0.6 | 94.8 | 4.3 | 2.4 |
| <i>Phoenix dactylifera</i> | 4 | F | 354 | 0 | 2.8 | 0.6 | 94.1 | 3.0 | 2.5 |
| <i>Phoenix dactylifera</i> | 5 | S | — | 0 | 5.6 | 7.4 | 85.9 | 14.8 | 1.0 |
| <i>Phoenix dactylifera</i> | 5 | F | — | 0 | 3.0 | 0.5 | 94.1 | 4.6 | 2.5 |
| <i>Phoenix farinifera</i> | 19 | S | — | 0 | 7.5 | 9.3 | — | — | 1.4 |
| <i>Phoenix reclinata</i> | 1 | S | 395 | 0 | 3.1 | 0.3 | 93.7 | 5.1 | 2.8 |
| <i>Prestoea longepetiolata</i> ⁴ | 3 | SH | 289 | 0 | 6.2 | 19.2 | — | — | — |
| <i>Pseudophoenix sargentii</i> ⁵ | 19 | S | — | 0 | 6.4 | 21.4 | — | — | 1.3 |
| <i>Pseudophoenix vinifera</i> | 19 | S | — | 0 | 1.6 | 1.6 | — | — | 0.8 |
| <i>Pseudophoenix vinifera</i> | 19 | S | — | 0 | 5.9 | 1.6 | — | — | 1.4 |
| <i>Ptychosperma macarthurii</i> ⁶ | 19 | S | — | 0 | 8.7 | 1.1 | 79.9 | 9.1 | 10.3 |
| <i>Raphia hookeri</i> | 1 | S | 365 | 0 | 1.8 | 0.0 | 95.0 | — | 3.2 |
| <i>Salacca zalacca</i> ⁷ | 2 | F | 345 | 0 | 4.1 | 1.3 | — | — | 1.5 |
| <i>Vetchia merrillii</i> ⁸ | 19 | S | — | 0 | 4.9 | 1.8 | — | — | 1.6 |
| <i>Zombia anomala</i> ⁹ | 19 | S | — | 0 | 2.8 | 0.6 | — | — | 0.6 |
| <i>Zombia anomala</i> ¹⁰ | 19 | S | — | 0 | — | — | — | — | — |

may exist, and welcomes contributions from any interested readers.

Acknowledgments

The author thanks Drs. James Duke and Dennis Johnson for calling attention to the need for this paper. Dr. Johnson and the editors also helped update the binomials. Mr. Michael Woodbridge performed some of the data retrieval and proofread the Table.

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Table 1. *Extended.*

| Calcium mg/ 100 g | Phos- phorus mg/ 100 g | Iron mg/ 100 g | Sodium mg/ 100 g | Ascorbic Potassium mg/ 100 g | Carotene μ g/ 100 g | Thi- amine mg/ 100 g | Acid mg/ 100 g | Niacin mg/ 100 g | Ribo- flavin mg/ 100 g |
|-------------------------|---------------------------------|----------------------|------------------------|---------------------------------------|-------------------------------|-------------------------------|----------------------|------------------------|---------------------------------|
| — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — |
| 85.4 | 879.4 | 15.1 | — | — | 364.3 | — | 75.4 | 13.57 | — |
| 125.9 | 74.1 | 3.2 | — | — | 246.9 | 0.17 | 14.8 | 1.48 | 0.12 |
| 94.9 | 45.9 | 1.1 | — | — | 63.3 | 0.14 | 1.6 | 0.16 | 0.13 |
| 76.1 | 81.3 | 3.9 | 1.3 | 836.1 | 38.7 | 0.12 | 0.0 | 2.84 | 0.13 |
| — | — | — | — | — | — | — | — | — | — |
| 141.7 | 59.0 | — | — | — | 30.7 | 0.01 | 3.5 | 1.06 | 0.02 |
| — | — | — | — | — | — | — | — | — | — |
| 55.7 | 97.6 | 8.2 | — | — | — | 0.00 | — | — | — |
| 955.6 | 877.8 | 8.9 | — | — | 0.00 | 0.44 | 188.9 | 7.78 | 1.00 |
| — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — |
| 1,699.1 | 309.8 | — | — | — | — | — | — | — | — |
| 127.3 | 81.8 | 19.1 | — | — | 0.00 | 0.18 | 9.1 | — | — |
| — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — |

NOTES: Part Code, F, fruit; HE, heart, pith; IS, immature or "green" seed; J, juice; O, oil; PS, sago; S, seed; SH, shoot or vegetative bud; W, immature seed; Z, leaf stalk.

Reference codes, 1, Wu Leung et al., 1968; 2, Wu Leung et al., 1972; 3, Wu Leung et al., 1961; 4, Watt and Merrill, 1963; 5, C.S.I.R., 1948-76; 19, Earle and Jones, 1962; 20, Jones and Earle, 1966; 21, Barclay and Earle, 1974; 22, Sood et al., 1982; 23, Mehon and Pandalai, 1957; 24, Peters, 1957; 25, Wilbert, 1976.

¹ As "*Bactris minor*"; ² as "*Butia capitata* × *eriospatha*"; ³ as "*Chrysalidocarpus lucubensis*"; ⁴ as "*Euterpe longepetiolata*"; ⁵ as "*Pseudophoenix saonae*"; ⁶ as "*Actinophloeus macarthurii*"; ⁷ as "*Salacca edulis*"; ⁸ as "*Adonidia merrillii*"; ⁹ as "*Oothenax anomala*"; ¹⁰ as "*Oothenax anomala*."

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NEWS OF THE SOCIETY

News from Arizona

On March 4th the bimonthly meeting of the Arizona Chapter was held at Arizona State University in Tempe; Professor Vic Miller conducted a tour of the many palms growing on the campus. At this meeting members of the Chapter began to prepare a list of palms that are growing out of doors in the ground in Arizona.

The May Meeting was scheduled for the Tucson home of Vice President Harrison Yocum, who will include a tour of his large collection of palms.

News from Southern California

On January 28th the Annual Banquet of the Chapter was held at Sam's Seafood Restaurant in Seal Beach. Dr. Mardi Darian showed examples of herbarium specimens and discussed their preparation. Sponsorship of a palm herbarium, to be located in Southern California, is being considered. The feature event was a slide show on collecting high-altitude palms of the Andes by Dale Motiska, Cindy Anderson, and Garrin Fullerton of the Northern California Chapter (See *Principes* April 1984).

On March 25th, the Chapter met at the home of Ski Torzeski in El Cajon, San Diego County. The Torzeski garden is new, but huge specimens of *Arecastum*, *Phoenix reclinata*, and *Chamaerops* planted only a year ago already screen the house. El Cajon is basically frost free and with the protection of an 18' roof over a semi-open air house, and in a completely enclosed greenhouse 20' high, the Torzeskis are able to grow many palms that usually do not flourish in the area. Approximately 60 people attended and enjoyed refreshments, a palm sale, and an auction.

News from Texas

The Houston Area Chapter met on March 26th at Palma. Jim Cain discussed the Palm Show and Sale scheduled for May 5th and 6th at the Houston Arboretum in Memorial Park. Plans were made for exhibits and sales.

Plans were also made for a Palm Society booth at the Houston Flower and Garden Show on March 21-25th in the Astrohall. This was very successful. During the show, much interest was shown in the booth which provided information on palms, and on the activities of the local Chapter and The International Society.

Damage to palms during the past extremely cold winter was also discussed. *Phoenix canariensis*, *Trachycarpus fortunei*, *Rhapidothymum hystrix*, most *Sabal* species, and *Washingtonia filifera* appear to have survived. *Livistona*, many *Sabal palmetto*, and the entire population of *Washingtonia robusta* were lost.

Madame Ganna Walska Dies

Madame Ganna Walska, Polish opera singer, renowned socialite, and since 1941, owner and developer of the beautiful estate Lotusland in Montecito, died on March 2, 1984. She was 91. On several occasions she opened her garden to The Palm Society and members enjoyed the large specimens of many palms and the unusual designs and plantings of the garden. Madame Walska has left a legacy for the maintenance of Lotusland, but because of legal problems, the garden will not be opened to the public for several years.

Biennial

Those attending the 1984 Biennial in Northern California should read about palms and the microclimates of the San Francisco Bay area in April *Principes*.

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BOOKSTORE

| | | | |
|--|---------|--|-------|
| A MANUAL OF THE RATTANS OF THE MALAY PENINSULA (J. Dransfield 1979, 270 pp.) | \$25.00 | SECRET OF THE ORIENT DWARF <i>Rhapis excelsa</i> (L. McKamey 1983, 51 pp.) | 3.95 |
| COCONUT PALM FROND WEAVING (Wm. H. Goodloe 1972, 132 pp.) | 3.95 | SUPPLEMENT TO PALMS OF THE WORLD (A. C. Langlois 1976, 252 pp.) | 25.00 |
| CULTIVATED PALMS OF VENEZUELA (A. Braun 1970, 94 pp. and 95 photographs.) | 4.50 | THE GENUS <i>PTYCHOSPERMA</i> LABILL. (F. B. Essig 1978, 61 pp.) | 5.50 |
| FLORA OF PANAMA (Palms) (R. E. Woodson, Jr., R. W. Schery 1943, 122 pp.) | 17.00 | THE INDIGENOUS PALMS OF SURINAME (J. G. W. Boer 1965, Part of Flora, 172 pp.) | 42.00 |
| FLORA OF PERU (Palms) (J. F. MacBride 1960, 97 pp.) | 8.00 | THE MAJOR GROUPS OF PALMS AND THEIR DISTRIBUTION (H. E. Moore, Jr., 1973, 115 pp.) | 4.50 |
| FLORIDA PALMS, Handbook of (B. McGeachy 1955, 62 pp.) | 1.95 | THE MINIATURE PALMS OF JAPAN (U. Okita, J. L. Hollenberg 1981, 135 pp.) | 19.95 |
| HARVEST OF THE PALM (J. J. Fox 1977, 244 pp.) | 16.50 | THE PALM FLORA OF NEW GUINEA (F. B. Essig, 1977, 46 pp.) | 6.50 |
| INDEX TO PRINCIPES (Vols. 1-20, 1956-1976, H. E. Moore, Jr., 68 pp.) | 3.00 | PALM PAPERS (Postage Included) | |
| MAJOR TRENDS OF EVOLUTION IN PALMS (H. E. Moore, Jr., N. W. Uhl 1982, 69 pp.) | 6.00 | FURTHER INFORMATION ON HARDY PALMS (J. Popenoe 1973, 4 pp.) | 1.25 |
| PALMS (A. Blombery & T. Rodd 1982, 192 pp., 212 colored photographs) | 25.00 | NOTES ON PRITCHARDIA IN HAWAII (D. Hodel 1980, 16 pp.) | 2.00 |
| PALMS FOR THE HOME AND GARDEN (L. Stewart 1981, 72 pp., some color) | 10.95 | RARE PALMS IN ARGENTINA (reprint from <i>Principes</i> , E. J. Pingitore 1982, 9 pp., 5 beautiful drawings) | 2.75 |
| PALMS OF BRITISH INDIA & CEYLON (Blatter 1926, reprinted in India 1978, 600 pp.) | 75.00 | THE HARDEST PALMS (J. Popenoe 1973, 4 pp.) | 1.25 |
| PALMS OF THE LESSER ANTILLES (R. W. Read 1979, 48 pp.) | 8.00 | The palm books listed above may be ordered at the prices indicated plus \$1.25 extra per book to cover packaging and postage. (California residents please add 6% sales tax.) Foreign checks must be in US dollars and payable on a USA bank. In some countries it is possible to send International Money Orders through the Post Office. Send check payable to The International Palm Society to Pauline Sullivan, 3616 Mound Avenue, Ventura, CA 93003, U.S.A. ALL SALES FINAL. | |
| PALMS OF MALAYA (T. C. Whitmore 1973, 132 pp.) | 16.95 | | |
| PALMS OF SOUTH FLORIDA (G. B. Stevenson 1974, 251 pp.) | 7.95 | | |
| PALMS OF THE WORLD (J. C. McCurrach 1960, 290 pp.) | 19.00 | | |
| PALM SAGO (K. Ruddle, D. Johnson, P. K. Townsend, J. D. Rees 1978, 190 pp.) | 7.50 | | |

The Annual Palm Show

The sixth annual Palm Show at the San Diego Wild Animal Park (see Fig. 1), staged on the weekend of October 22 & 23, 1983, was an unqualified success. Individual potted palms, collections of palms, and artistic arrangements made exclusively from palm materials were included; large award ribbons, specially embossed and dated for the show, were

awarded within each of the five sections of the show.

So far as we know, this annual event is the only judged Palm Show on earth in which all palm species are eligible for awards. (In the judged palm shows which are staged in Japan, only *Rhapis* palms are eligible for awards.)

As always, it was Pauleen Sullivan, The Palm Society's secretary, who manned the membership desk and the palm book dis-



1. During every Autumn season at the San Diego Wild Animal Park, all the lower leaves of the young palms up on the new hilltop palm garden become unevenly scalloped. And exactly what is the cause of this very seasonal symptom? When all the more tender grass is dried up or eaten, the native rabbits and deer voluntarily tidy up the palms.

play at the Palm Show. Those new Palm Society members which she signed up during the Palm Show, in addition to the 55 new Palm Society members who joined on the previous Sunday at the benefit event at Mardy Darian's palm garden in Vista, very surely combine to make the Southern California Chapter both the fastest-growing and also the largest in membership of all the chapters of the Society. (We reluctantly concede, however, that we are not quite so large—geographically speaking—as is that new upstart outfit which is named the Northeast U.S. Chapter!)

The judges for the 1983 Palm Show very rightly awarded the huge "Best of Show" ribbon to a perfectly groomed seven-foot-tall specimen of *Licuala spinosa*, entered by Walt Frey. However, most of the passers-by didn't know one palm from another, and most of them admired the palm artistic arrangements more than the palm specimen plants. A frequently heard comment from those who admired the floral arrangements was that they didn't even realize, previously, that palms ever had bloomstalks! But on the other hand, there were appreciative comments from very erudite horticulturalists who are familiar with all the plant societies

and with the shows which they stage; they noted that The Palm Society is the one and only plant society which displays artistic arrangement with all plant material exclusively limited in origin to the plant which the relevant society espouses. (In the artistic arrangement sections of shows staged by other plant societies, their rules require that within the floral component the blossoms of their particular plant group must "predominate"; nothing more! And in consequence, the background foliage in shows staged other than by The Palm Society seems never to be that of the society which sponsors the show!)

It is of particular note to emphasize here that palms are neither deciduous nor seasonal. In the climate of coastal southern California, our outdoor palms can provide us with beautiful bloomstalks and with beautiful foliage all through the year, for which reason we quite confidently note that we here are able to stage a Palm Show during any month of any year. We think that no other presently organized plant society could say the same!

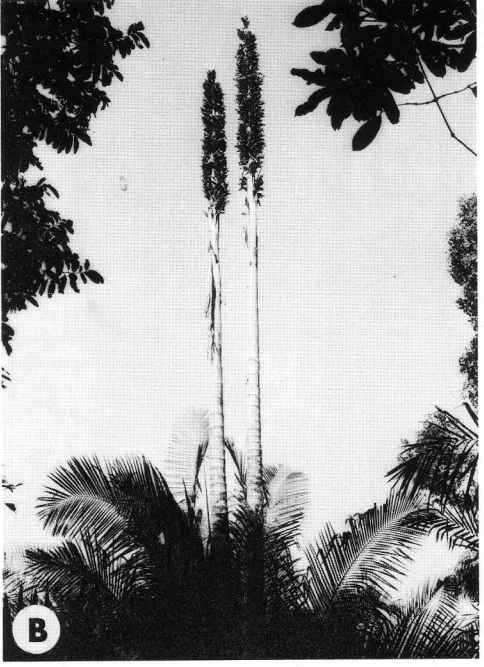
The date for the 1984 Palm Show at the San Diego Wild Animal Park already has been set for the weekend of August 18 & 19, 1984. Members of The Palm Society who live elsewhere than in southern California, and who contemplate a 1984 California vacation, are urged to time their schedule so as to be in San Diego at that time. Bring your camera and get pictures to show to the membership of your own Chapter—with a view toward having your own Chapter schedule a Palm Show in 1985!

For a one-year subscription to the 24-page quarterly palm publication which features non-technical palm articles and which provides advance information on all the numerous palm events in California, send name, mailing address, and a \$3 check to P.O. Box 27, Forestville, CA 95436.

BILL GUNTHER

Principes, 28(3), 1984, p. 147

KNOW YOUR PALMS



Can you name these palms? See p. 131 for answers.

Watch our Palmeter RISE!

HELP!

HELP!

HELP!

75,000

70,000

65,000

60,000

55,000

50,000

45,000

40,000

35,000

30,000

25,000

20,000

15,000

10,000

5,000

Our "Palmeter" must have a fungus disease or a deficiency? It's quit growing! There are so many different reasons causing stunted growth - We need diagnostic help!

Should we use - BANROT?
BENLATE?
TERRACLOR?

If it's a deficiency - do we need
IRON?
ZINC?
MANGANESE?

One layman's guess is that it's a deficiency of
"DOUGH"

DON'T LET OUR PALM DIE!

Please Donate \$10.00--- up--- up--- UP

First Venture: Co-publish Genera Palmarum:
The Classification of Palms, by Moore,
Dransfield and Uhl.

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