



PRINCIPES

Journal of The Palm Society

October, 1973
Vol. 17, No. 4

THE PALM SOCIETY

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JOURNAL OF THE PALM SOCIETY

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Cover Picture

An enlarged view of the third specimen of *Phoenix roebelenii* at the Palacio Nacional in Guatemala City figured on page 169.

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JOURNAL OF THE PALM SOCIETY

An illustrated quarterly devoted to information about palms and published in January, April, July and October by The Palm Society, Inc.

Subscription price is \$6.00 per year to libraries and institutions. Membership dues of \$10.00 per year include a subscription to the Journal. Single copies are \$1.50 each. The business office is located at **1320 S. Venetian Way, Miami, Florida 33139**. Changes of address, undeliverable copies, orders for subscriptions, and membership dues are to be sent to the business office.

Second class postage paid at Miami, Florida and at additional mailing offices.

Mailed at Lawrence, Kansas
December 27, 1973

The Protection of Pollen and Ovules in Palms

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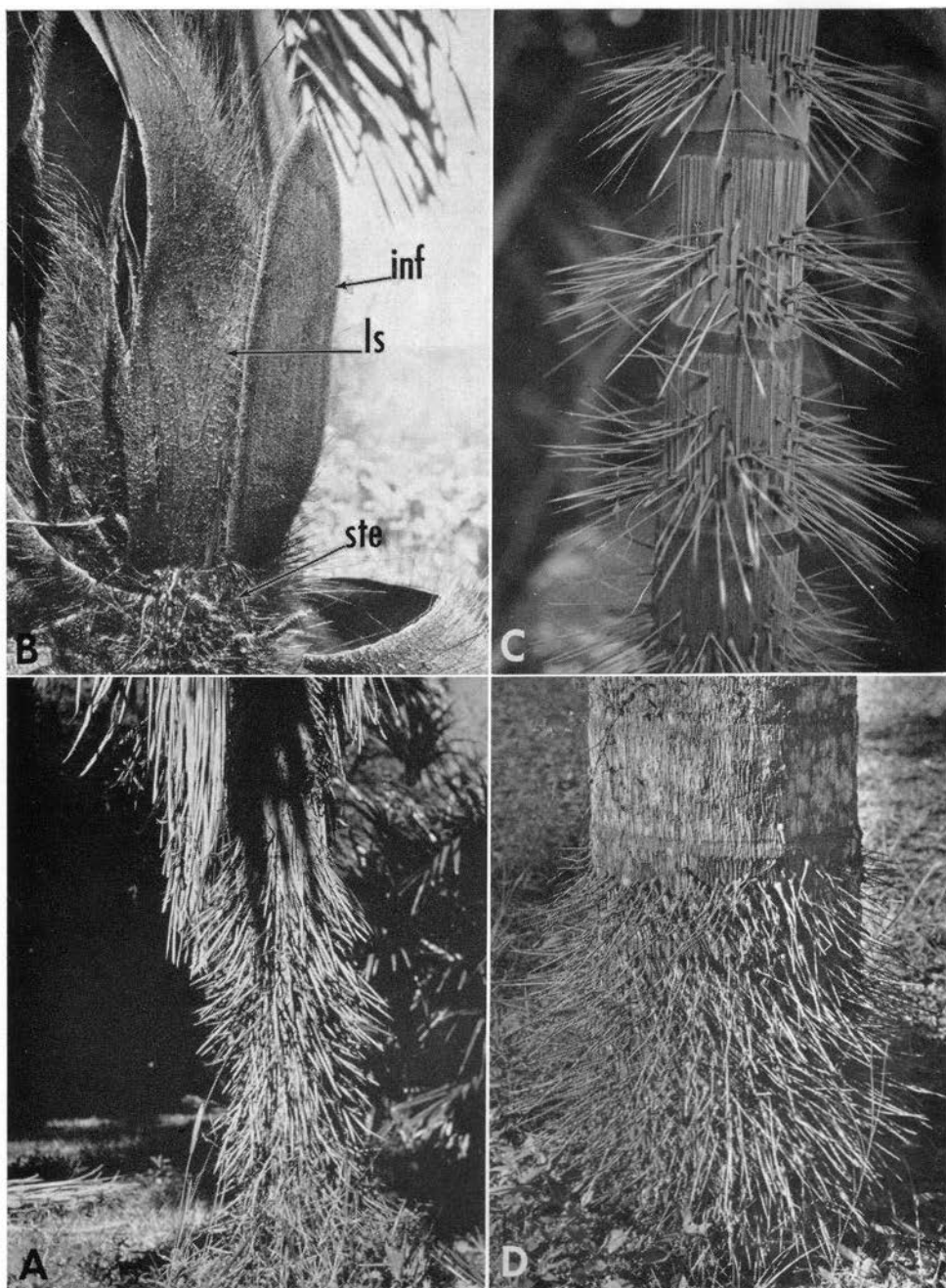
Abstract

An impressive number of structural features in palms appear related to protection of pollen and ovules. These include physical attributes and less evident cellular and intracellular specializations. Leaf sheaths, inflorescence bracts, and many protective mechanisms in floral organs are identified, characterized, and related to general levels of specialization among groups of palms. It is suggested that protection has involved selection for and coordination of characters at different structural levels. Observations suggest long coevolution with chewing insects, but attention is called to the critical need for careful field observations on phenology, floral biology, and general animal-palm interrelationships.

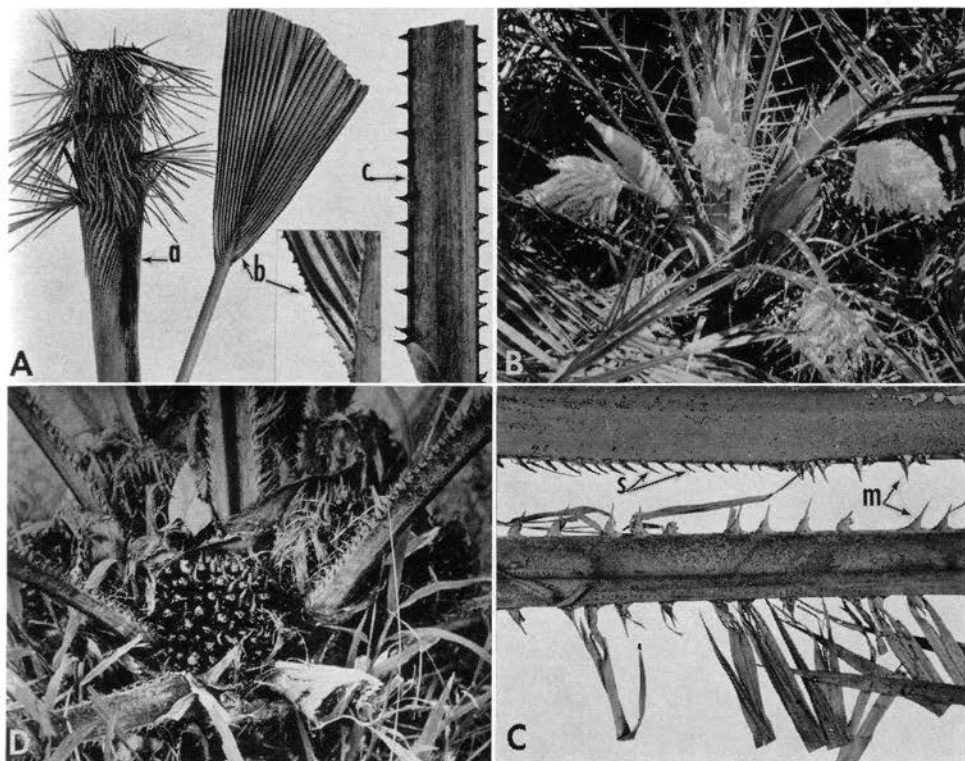
An impressive array of structures protect pollen and ovules in palms; indeed, the diversity of protective mechanisms associated with flowers is probably greater in palms than in any other family of seed plants. Protection may be by physical or chemical means, or by a combination of physical and chemical features. Many of the physical defenses of palms have long been recognized. The literature abounds with references to the size, hardness, and the fierce armature of some. Other protective mechanisms, however, such as specialized sepals and petals, and appropriately located fibers, sclereids, crystals, and tannin layers, become evident only after detailed study. When all aspects of protection are considered, it is apparent that pollen and ovules in some palms are protected by one or two structural mechanisms only, while protection in other palms is achieved by a sequence of mechanisms at different structural levels. How the specific protective fea-

tures of each palm relate to pollinators, predators, or disseminators can be determined only by careful field observations.

An understanding of these structural adaptations is essential to studies of floral biology, ecology, and evolution. That plants have coevolved with insects and animals seems evident, but many of the complex chemical relationships between plants and insects, and plants and other animals have not yet been worked out. Plants have been considered to provide food and shelter for insects or other animals, and to receive transport of pollen or of fruits in return (Southwood, 1973). The structure of flowers is correlated with pollination, the structure of fruits with methods of dispersal. Indeed, the few modern studies of pollination and fruit dispersal that we have for palms reveal a very exact and intricate relationship between the structure of the flower or fruit and the insects or mammals involved (Essig, 1971; Janzen, 1971; Schmid, 1970a,b). As we shall demonstrate, some structures present in the flower continue to protect the developing fruits and seeds, at least for a time. Our major purpose in this paper is to identify the structures that protect pollen and ovules at flowering time. It must be emphasized, however, that more than just protection of pollen and ovules is actually accomplished by the structures to be considered. For example, if pollen is to be transferred, potential vectors must be attracted, and predators satisfied, thwarted, or re-



1. Spines. **A**, Root spines on base of stem in *Cryosophila warscewiczii* (Moore 6017). **B**, Spines on stem (ste), leaf sheaths (ls), and inflorescence (inf) in an undescribed genus of the *Oncosperma* alliance (Moore, Guého & Vaughan 9925). **C**, Spines on a young stem of *Deckenia nobilis*, botanical garden, Victoria, Mahe, Seychelles Islands. **D**, An older trunk of *Deckenia nobilis* with large basal spines in the same botanical garden.



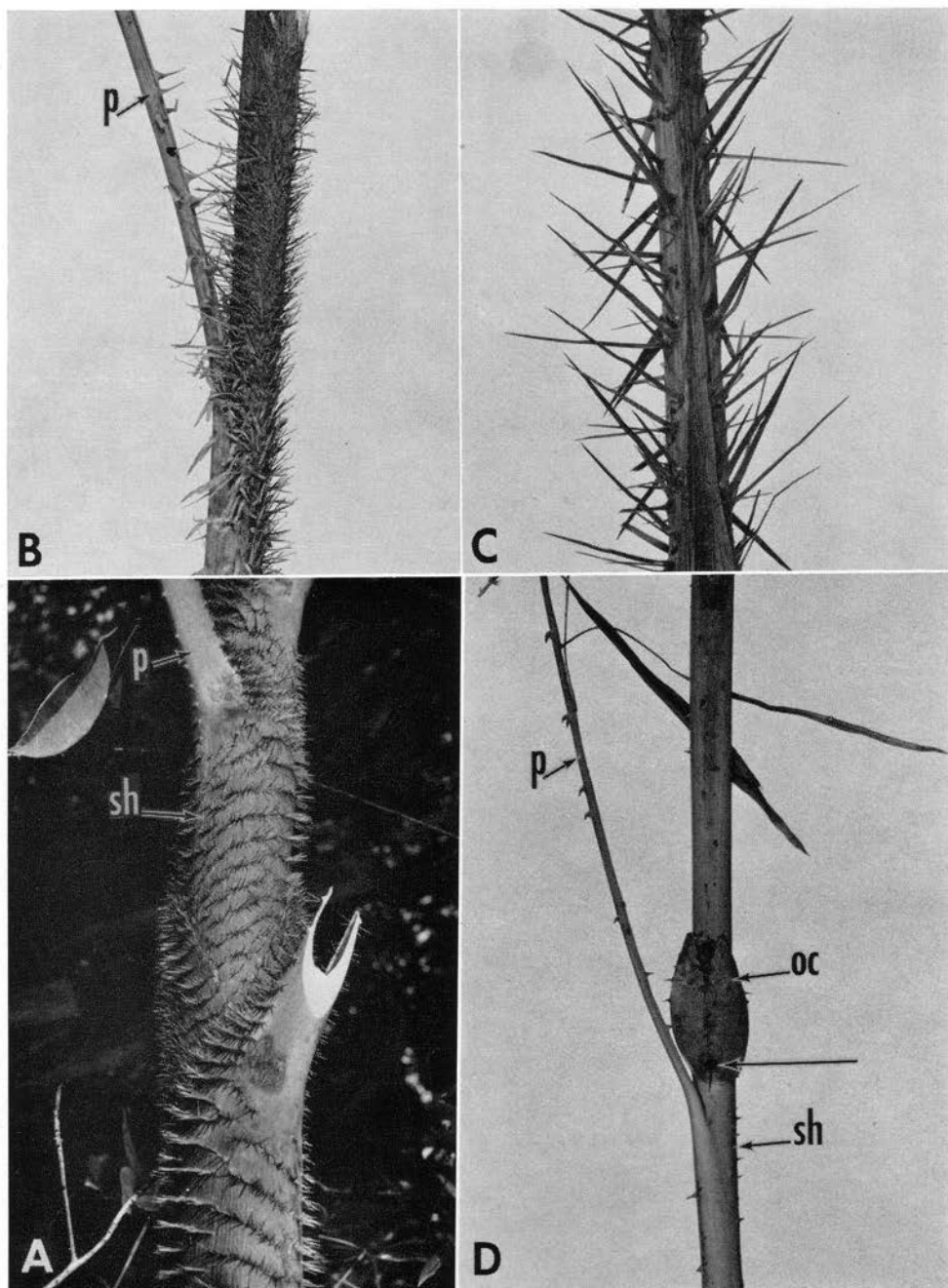
2. Spines. **A**, Coryphoid palms: **Aa**, spines formed from fibrous tips of leaf sheaths in *Zombia antillarum* (Bailey 301); **Ab**, teeth on the petiole and leaf margin of *Johannesteijsmannia altifrons* (Dransfield s.n., a. 1967); **Ac**, petiolar teeth of *Corypha elata* (Bailey 522). **B**, Spines formed by modified pinnae in *Phoenix reclinata*. **C**, Petiolar segments of *Elaeis guineensis* (Read 904) showing spines (s) formed by partial disintegration of the leaf sheaths and spines higher on the petioles (m) formed by the hard, basally swollen midribs of pinnae. **D**, Crown of *Elaeis guineensis* cultivated in Ecuador; note spines formed by pointed tips of rachillae in the center of the fruit bud and two other types, enlarged in C, on petioles.

pulsed. A second objective of this paper is to emphasize the need for information on how insects and other animals function in the natural history of each palm.

Some of the structures to be described occur mainly in certain groups of palms as delimited by Moore (1973); others, such as pits and spines, are structurally different in different groups of palms and obviously represent parallel developments. Maturation sequences are variable in palm reproductive systems and are intricately correlated with structure at all levels. Where flowers are enclosed in bracts or in pits in an axis until

nearly at anthesis, generally few physical protective features are seen in their sepals and petals. The reverse is also true—if bracts are shed or are exceeded by an elongating inflorescence axis when flowers are in early bud, sepals and petals may, in turn, take over the defense of developing pollen and ovules, and may then be tough and fibrous. Even when other organs appear to provide major protection, pistillate flowers are usually more heavily protected than staminate.

In addition to pollen and ovules, the stem apex, the immature leaf bases, and



3. Spines of lepidocaryoid palms. **A**, Spines on trunk and leaf bases of *Plectocomia muelleri* (Moore & Meijer 9158): sheath (sh); petiole (p). **B**, Spines on petiole (p) and stem of *Korthalsia ferox* (Moore & Meijer 9194). **C**, The fiercely armed petiole of *Salacca edulis* (Moore 6804). **D**, A portion of the stem of *Korthalsia scaphigera* (Moore, Chai & Smythies 9084) showing a petiole (p) with recurved spines and the ocrea (oc) formed by the upper part of the leaf sheath (sh), an ant hole marked by unlabeled arrow.



4. Spines formed from lateral roots. **A**, An enlargement of the stilt roots of *Socratea exorrhiza* (Moore, Salazar & Smith 8458) bearing short spines formed by lateral roots. **B**, Base of same plant showing the several large stilt roots of one tree.

the embryo are tender and vulnerable parts of palms. The first structures to be considered—leaf sheaths, and various kinds of spines—usually shield one or more of these vulnerable areas as well as young inflorescences. As will be evident, however, all aspects of protection must be considered if one is to understand the mechanisms operating in a specific palm.

Leaf Sheaths

The young palm inflorescence is at first tightly surrounded by a number of stiff leaf sheaths. The variety of sheath or leaf base structure in palms is sufficient to have merited a separate paper (Tomlinson, 1962b) which does not purport to have exhausted the subject. Two modifications of leaf bases may be mentioned in particular. The tubular leaf sheaths of the royal palm (*Roystonia*), or genera of the *Ptychosperma* and *Clinostigma* alliances, and of other alliances of the arecoid group, as well

as in the iriarteoid group and *Hypophorbe*, sometimes form a spectacular crownshaft which may function in part to protect inflorescences. The sheath is produced above the petiole as an ant-inhabited ocrea in *Ancistrophyllum* (Moore, personal observation) and *Korthalsia* (Beccari, 1884–1886; Dransfield, 1973). The ocrea of a few species of *Calamus* in New Guinea may be supposed to be similarly inhabited and the basal pinnae of *C. amplexans* Becc. in Borneo were described as forming an ant gallery. Ants also inhabit galleries formed by interlocking prickles or spines on the sheaths of several species of *Daemonorops*. The association of ants with these lianes suggests the possibility of a relationship similar, at least in part, to that of ants and species of *Acacia* in Mexico and Central America (see references to papers by Janzen in Southwood, 1973), but the detailed natural history of this relationship has yet to be learned for palms.

Spines

Two aspects of palm spines are particularly interesting because they suggest that spininess has originated several times within the family: (1) spines include three different structural forms; and (2) they occur in several different palm groups. The dual function of some spines which also function as grappels has been pointed out by Tomlinson (1962a). Spines may be modified organs, modified parts of organs, or autonomous structures unrelated to other organs (Tomlinson, 1962a). The familiar spines on leaves of *Phoenix* (Fig. 2B) are modified pinnae which belong to the first category. These spines have been described as a major and unique protective mechanism for the stem apex in *Phoenix* (Tomlinson, 1962a). That they also defend inflorescences seems evident in Figure 2B. It is noteworthy that only one bract, a prophyll, encloses each inflorescence in *Phoenix*, and that protective mechanisms in floral organs are relatively few. Other spines which are modified organs are the root spines of *Cryosophila*, shown covering the lower part of the trunk in Figure 1A, and short spines formed from branch roots in *Socratea* (Fig. 4). Two examples of spines which are modified parts of organs can be seen side by side in the oil palm, *Elaeis guineensis* Jacq. (Figs. 2C,D). Spines at the base of each petiole are formed by hard fibers from partly disintegrated leaf sheaths, but higher on the petiole, special spines with bulbous bases represent the basal parts of the midribs of disintegrated pinnae.

Emergences formed by epidermal and

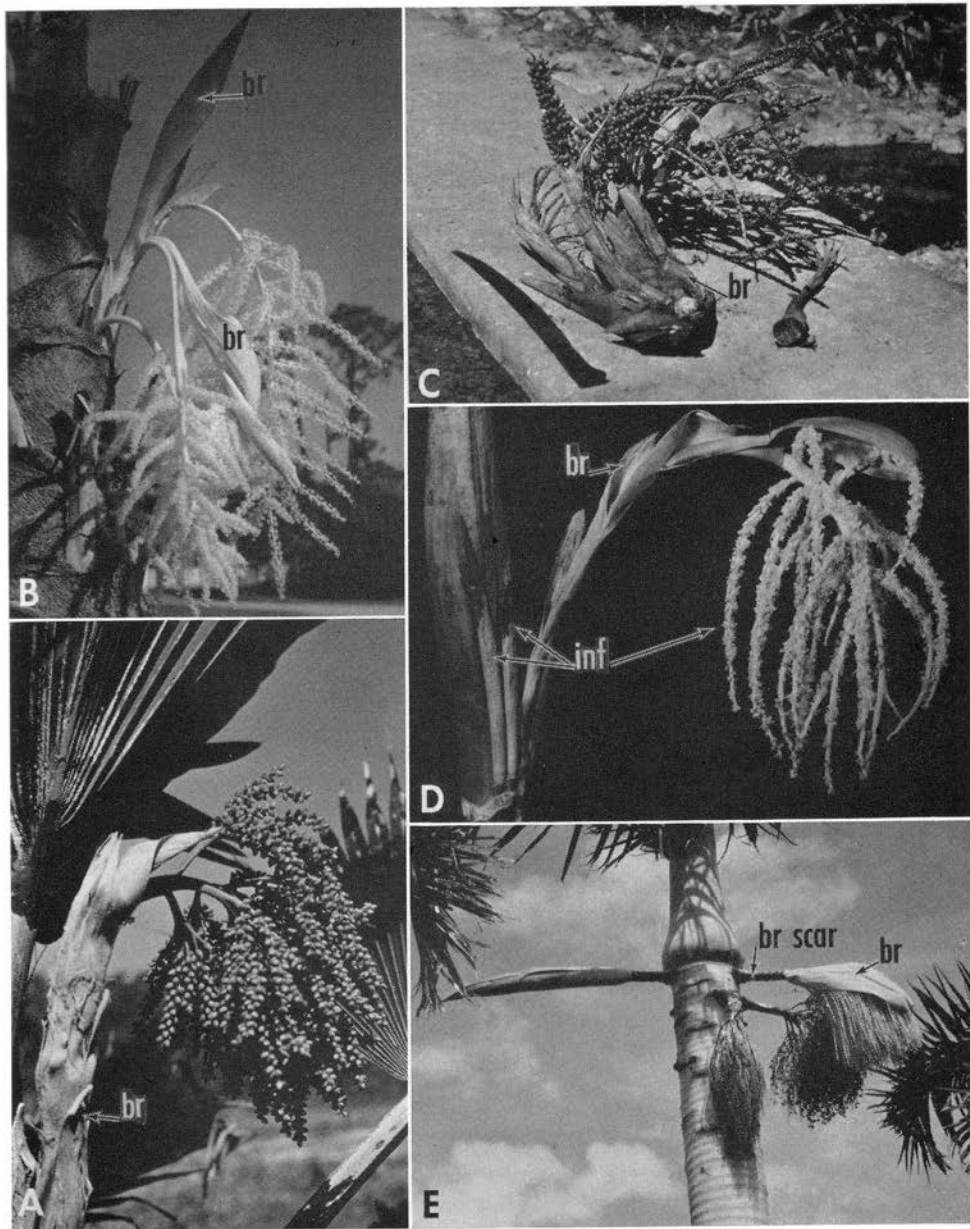
peripheral layers of various organs are the fiercest spines produced and are found most abundantly on stems, leaves, and bracts in three groups of palms—the *Bactris* alliance of cocosoid palms, the *Oncosperma* alliance in the arecoid group, and on various genera among the lepidocaryoid palms. As for other protective mechanisms, how spines function must be determined for each taxon. The large spiny bract appears to shield an inflorescence in fruit as well as in bud and flower in *Bactris* (Fig. 7A). Cocosoid and lepidocaryoid palms occur in regions where possible avian or mammalian predators are or have been present. The selective advantage of spines in genera of the *Oncosperma* alliance on islands (Mascarenes and Seychelles) devoid of obvious predators, however, is not evident.

For those interested in the evolution of palms, it may be noted that all three morphological types of spines occur in the presumably primitive coryphoid group. Emergences, perhaps not fully comparable to those noted above, occur on petioles and occasionally on leaf margins as teeth (Figs. 2Ab,Ac); fibers of long-persistent leaf sheaths form spines in *Zombia* (Fig. 2Aa); and spines representing modified organs are found in the root spines of *Cryosophila* (Fig. 1A). Generally, however, protection is light in the coryphoid palms—the more highly advanced palms have more spines and other protective mechanisms (Table 1).

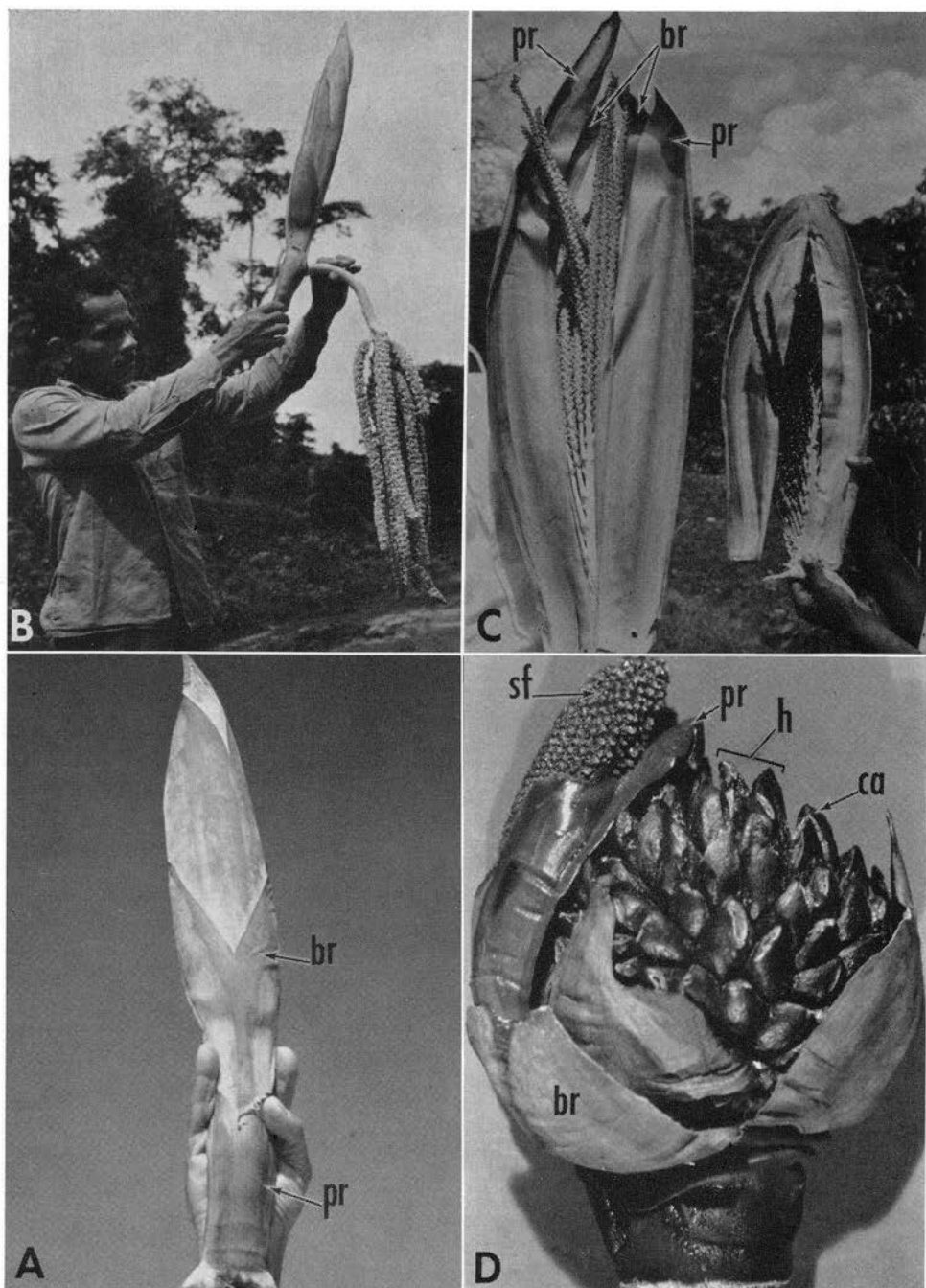
Bracts

The first protective mechanisms to be considered on the reproductive system are bracts—organs which have been

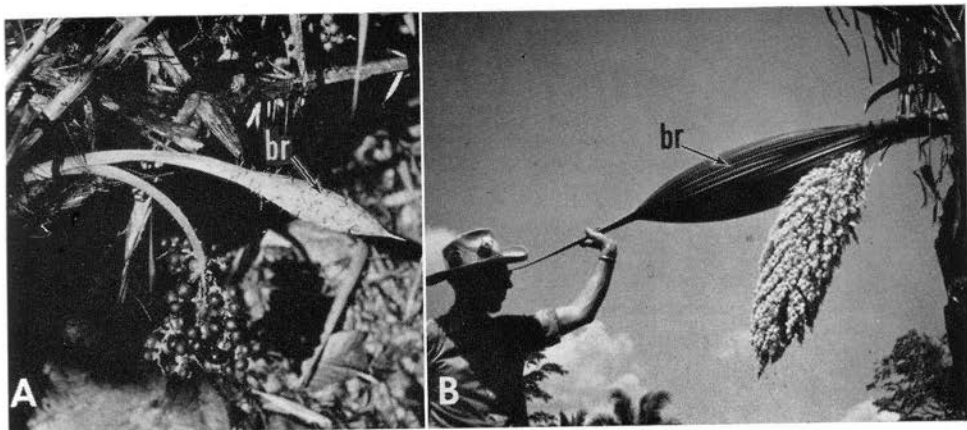
5. Bracts. **A**, Several fibrous overlapping bracts (br) on an inflorescence branch of *Pritchardia pacifica* at Fairchild Tropical Garden, Miami, Florida. **B**, Thinner bracts (br) which open rapidly



on an inflorescence of *Coccothrinax* sp. at Fairchild Tropical Garden; the arrow from the upper br indicates a peduncular bract which enclosed the whole inflorescence; the lower br indicates a bract that enclosed a lateral branch. **C**, A multiple inflorescence of *Arenga undulatifolia* (Moore 6094) with several fibrous overlapping bracts (br) on each axis. **D**, In *Morenia linearis* (Moore, Salazar & Smith 8354), two inflorescences (inf) are enclosed in bracts and a third is exerted showing a number of bracts (br) on the peduncle. **E**, Bracts on *Hyophorbe verschaffeltii* at the University of Mauritius, Reduit, Mauritius are shed in succession, each leaving a circular scar (br scar) on the peduncle; the last bract on inflorescence at upper right has opened to release flowering axes.



6. Bracts. **A**, The inflorescence of *Socratea exorrhiza* (Moore 9550) is enclosed in about seven tubular bracts; prophyll (pr); first peduncular bract (br). **B**, Bracts in **A** split abaxially to release the pendulous flowering axes. **C**, Only two relatively thin bracts, a prophyll (pr) and a sterile peduncular bract (br), enclose the rachillae in two inflorescences of *Dictyosperma album*



7. Bracts in cocosoid palms. **A**, A spiny bract appears to shield the infructescence in *Bactris brongniartii* (Moore, Salazar & Smith 8404). **B**, The large bract of *Scheelea rostrata* (Moore 6540) is woody and plicate.

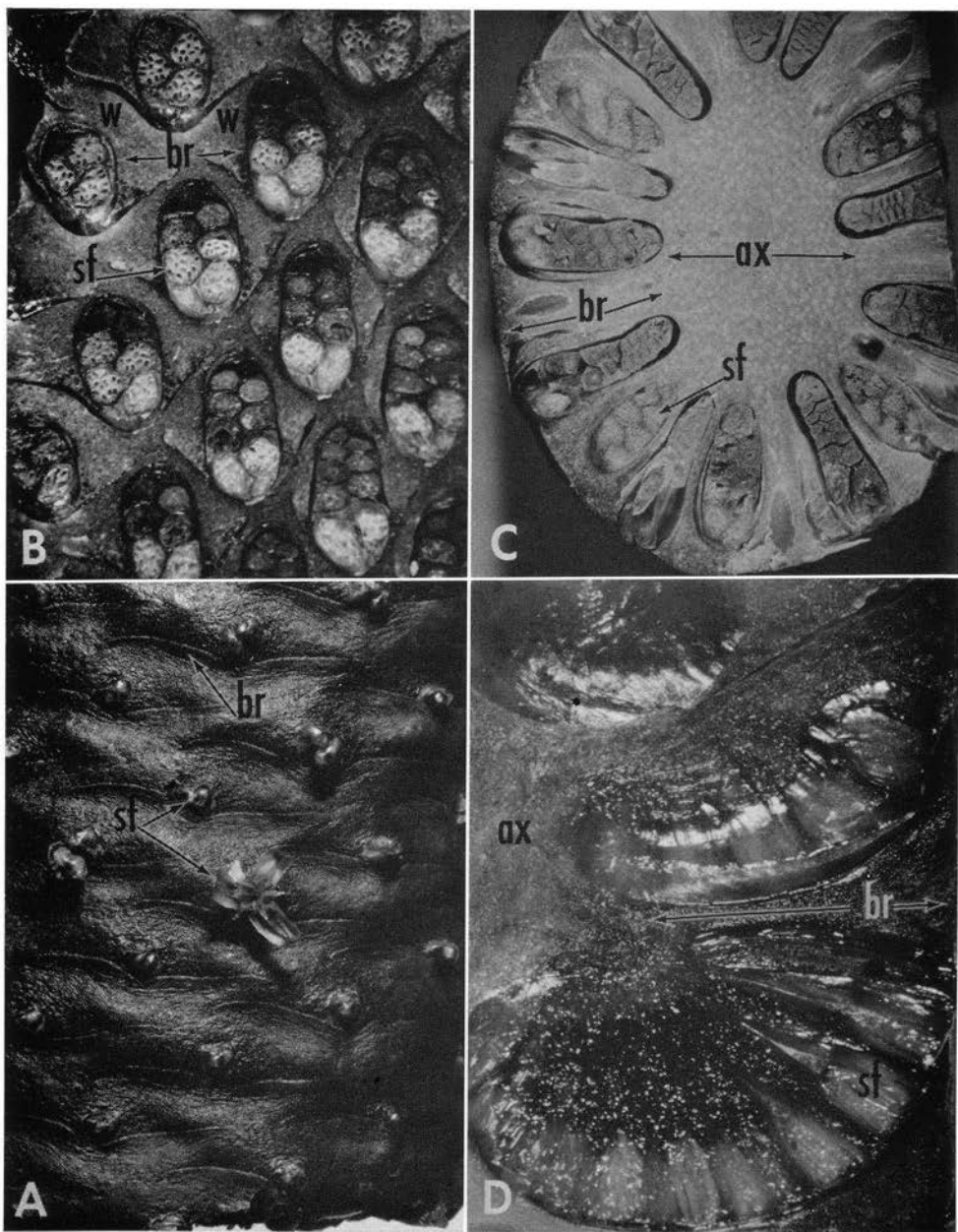
demonstrated in two groups of palms to be structurally reduced and modified leaves (Tomlinson, 1971; Tomlinson and Moore, 1968). The large bracts of many palm inflorescences were too unwieldy for early collectors and only recently has information been amassed on characters and distribution of bracts within the family (Moore, 1973). In the majority of palm groups, several bracts, one borne above the other, are present on the main axis or peduncle of each inflorescence and form a multi-layered sheath around the flower-bearing branches. The several spirally inserted bracts which envelop an inflorescence branch in *Pritchardia pacifica* Seem. & H. Wendl. can be seen in Figure 5A. The bracts may persist on the inflorescence as in *Morenia* (Fig. 5D), or may be shed in succession as in *Hyophorbe* (Fig. 5E), where the last bract remains on the recently expanded inflorescence

to the right of the stem illustrated, and scars of preceding bracts can be seen on the peduncle.

A seemingly more complex situation, both with respect to number and position of bracts and to their opening, occurs in the mangrove palm, *Nypa fruticans* Wurmb (Fig. 6D; Uhl, 1972). Each branch of the inflorescence is enclosed in a prophyll and subtended by a bract which also completely encloses the main axis and all subsequent branches. In many other palm inflorescences, the bracts subtending lateral branches and the prophylls of lateral branches are small or lacking (Figs. 5A,D,E; 6B,C). The terminal pistillate head and the ultimate lateral branch, partially exerted from its prophyll, are shown in a *Nypa* inflorescence in Figure 6D. *Nypa* is protogynous—the pistillate head is exposed before the lateral branches are released from their bracts.

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(Moore & Guého 10101, 10102) from Mauritius. **D**, Three sterile bracts are shown near the base of the terminal pistillate head (h), and the ultimate lateral axis ending in a staminate flower cluster is partially exerted from its keeled prophyll (pr) in *Nypa fruticans* (Moore 5846): carpel (ca); staminate flower (sf).



8. Pits in the staminate inflorescence of *Borassus flabellifer* (Read 716). **A**, The surface of the axis with single buds or flowers (st) exposed, each subtended by a broadly V-shaped ridge (br) representing the outer edge of the subtending bract. **B**, A tangential section of the axis exposing the flower clusters situated in elongate pits formed by partly united bracts: a bract (br) subtending one cluster (indicated by arrows) is shaped, in tangential section, like a butterfly; each lateral wing (w) of the bract forms the lateral side of a lower pit; a staminate flower (sf) is seen in transection. **C**, A transection of the axis shows the radial extent of the many flower-containing pits: arrows indicate the extent of bract tissue (br) and of axis tissue (ax); staminate

In the arecoid and cocosoid palms, there are usually only two principal bracts, a prophyll and one sterile peduncular bract, and bracts which subtend lateral axes within the inflorescence are small or absent (Fig. 6C). A major part of floral protection in the arecoid group appears to be provided by sepals and petals: in many arecoid alliances (e.g., *Ptychosperma*), floral organs are extremely tough and sclerenchymatic. The most bizarre bracts in palms are those of the cocosoid group, where again only two major bracts are present. The large woody bract characteristic of many cocosoid genera, however, is not the first but the second peduncular bract—the prophyll remains obscured by the leaf sheath. In some cocosoid alliances, as illustrated in *Scheelea rostrata* (Oerst.) Burret (Fig. 7B), the large bracts are also plicate. In sum, there may be one, two, or several major bracts enclosing each inflorescence in palms. The bracts may be thin or thick, and papery, fleshy, fibrous, or woody in texture. Number and texture and the time and method of opening are related to the maturity of the flowers within, and certainly also to the climate, insects, and other animals of the palm's particular habitat. Information on details of bract opening is still needed for many palm genera.

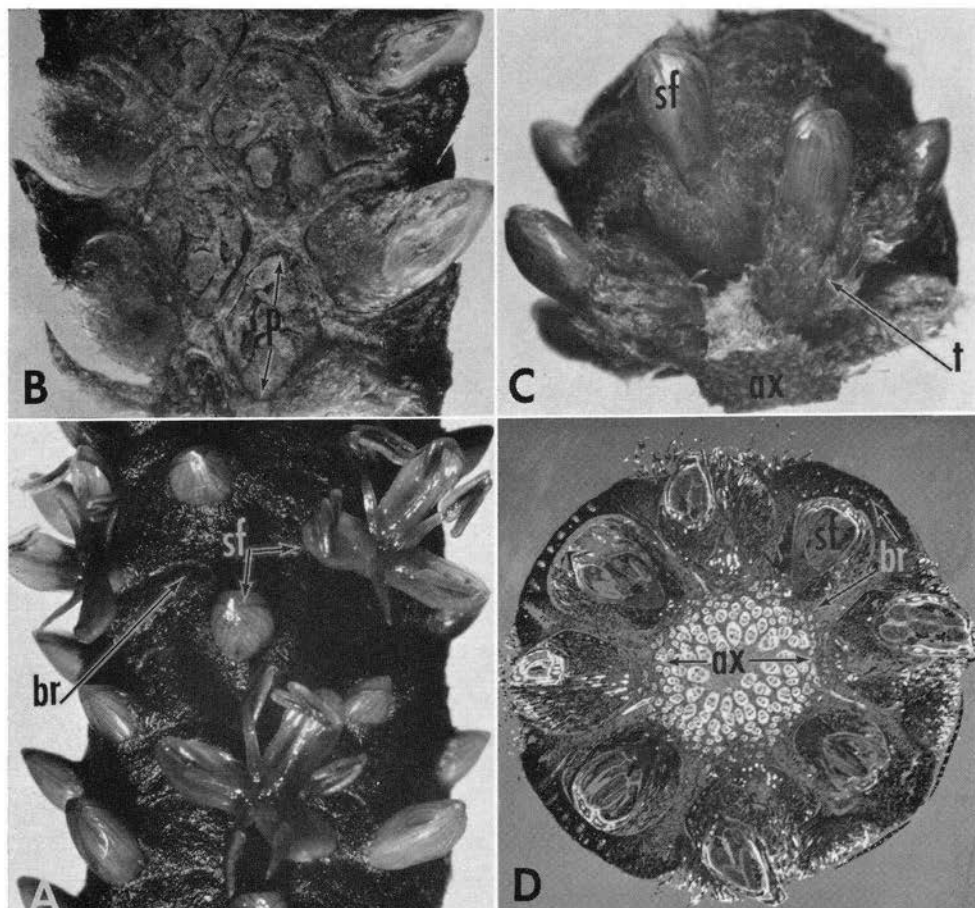
Pits

Borassoid inflorescences exhibit an unusual protective feature—a special cavity or pit in an inflorescence branch in which single flowers or whole flower clusters are partially or completely enclosed. Whole flower clusters in bud are completely concealed in such cavities in

borassoid and geonomoid palms. In other groups, pits are bowl-like, surrounding only the lower parts of the flowers. Structurally, the cavities are formed in three ways: (1) by bracts which may be free (Fig. 10C) or united (Fig. 10D); (2) by a depression in the branch in which the flowers are partially submerged (Figs. 11B,C,D); and (3) by a combination of a depression in a branch and a covering bract (Fig. 12B). The largest pits containing the most flowers are found in the staminate inflorescences of the *Borassus* alliance—specifically in *Lodoicea*. Structurally similar but somewhat smaller pits can be seen in the staminate rachilla of *Borassus* (Fig. 8). One would not suspect from a casual look at the surface of the inflorescence (Fig. 8A) that each single flower protruding from an apparently shallow bract is only one of a cluster of ca. 30 flowers (Figs. 8B,C,D). Each enclosed flower cluster is a reflexed branch (a cincinnus) appearing cocoon-like (Fig. 8D), with the youngest flowers nearest the center of the axis. The bract which subtends each flower cluster can be seen as a shallow curved ridge below each flower or bud in Figure 8A. The unusual “butterfly” shape of each bract is apparent in the tangential section (Fig. 8B). The upper curved surface of each bract forms the floor of one pit; the upper extremity of each “wing” of the bract is fused to the center of the lower side of an upper bract; and the outer margins of each “wing” form the lateral walls of two slightly lower pits. A transection of the branch (Fig. 8C) shows a number of pits cut at different levels and a central group of bundles in the axis. The pits are largely

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flower (sf). D, In radial section, flower clusters appear cocoon-like with the youngest flowers of the reflexed branch toward the center of the axis (ax): br indicates extent of bracts, sf, a staminate bud in longitudinal view.

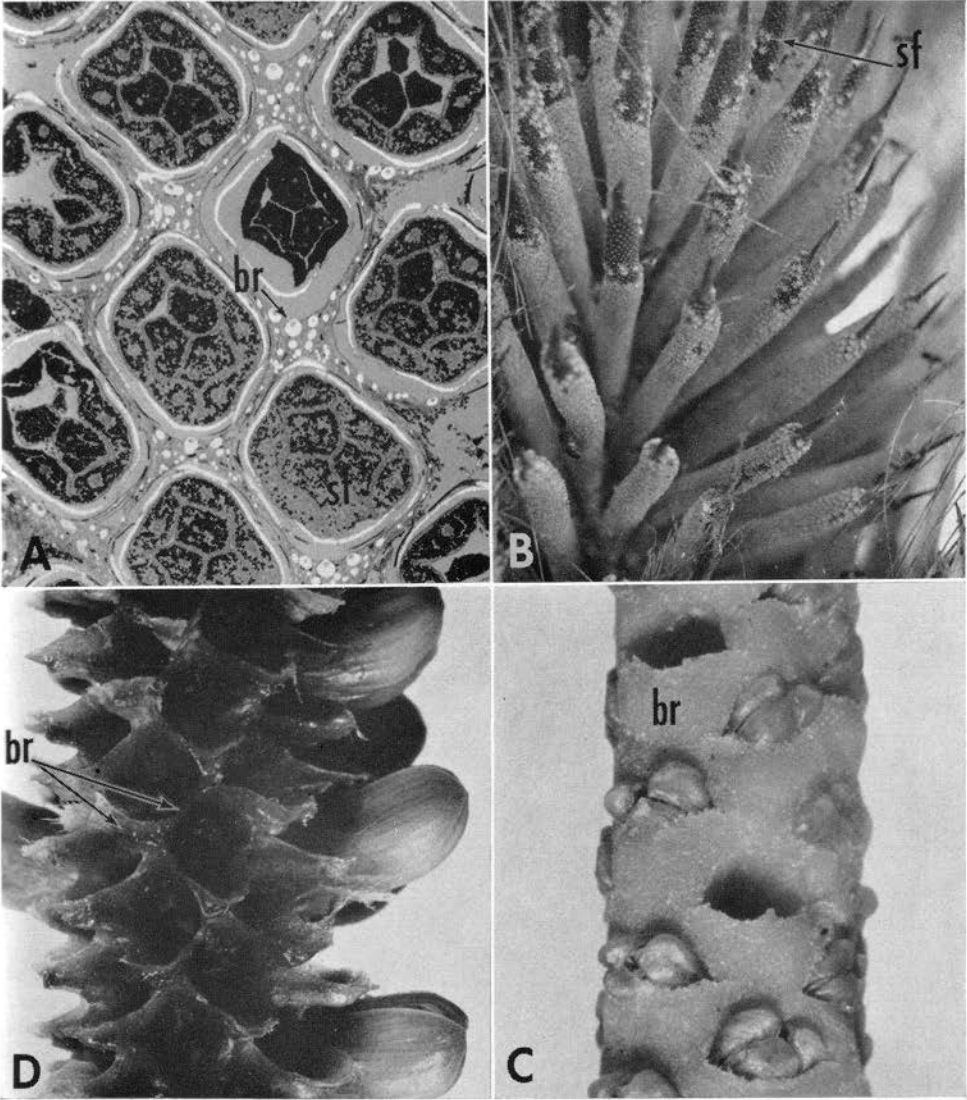


9. Pits in the staminate rachilla of *Hyphaene schattan* (Read 720). **A**, A surface view of the rachilla with a bud or flower (sf) exerted from each pit. **B**, In tangential section, pits (p) are crowded with flower bases and bracts. **C**, When outer bracts are dissected away, a collar of trichomes (t) can be seen surrounding each flower: axis (ax); staminate bud (sf). **D**, Pits formed by united bracts (br) make up about two-thirds the diameter of the inflorescence in transections: ax, extent of the axis; sf, a staminate bud in longisection.

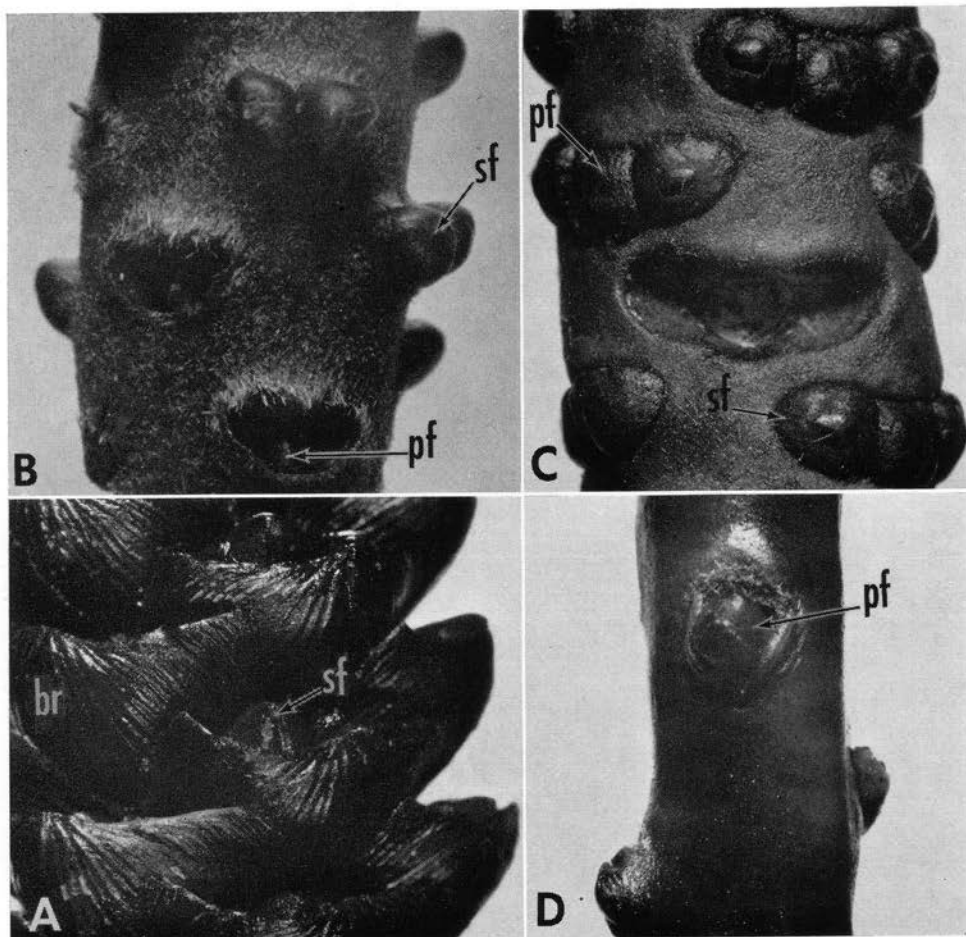
formed from fused bracts—the inner edge of each pit extends only slightly into the central bundle-containing axis (Fig. 8C). One advantage in exposing a single male flower at a time may be the production of pollen over a long period—undoubtedly important in a dioecious genus. Pits are also formed from bracts in the related genus *Hyphaene* (Fig. 9) where bracts are thinner but similar to those of *Borassus* in shape. In *Hyphaene*, only three flowers occur

in each pit, and a collar of large trichomes surrounds the base of each flower (Fig. 9C).

Open pits formed by free or fused bracts occur in some lepidocaryoid and cocosoid palms. Those of *Eleiodoxa* (Fig. 11A) consist of heavily fibrous bracts with straight sides. Staminate flowers of *Acrocomia* are borne in cup-like pits (Fig. 10D) with ragged edges consisting of united bracts. Pits in *Astrocaryum* (Fig. 10C) are of essen-



10. Pits of cocosoid palms. **A**, Pits formed from fused bracts enclose the base of each staminate flower in an oil palm, *Elaeis oleifera* (Read 1388): in this tangential section, bract traces are cut transversely and a large midvein (br) is evident directly below each pit. **B**, Staminate rachillae of *Elaeis guineensis* cultivated at Antalaha, Madagascar, end in spines and the pits formed by united bracts appear "honeycomb"-like distally: sf, a staminate flower protruding from a pit. **C**, Pits are of fleshy but essentially free bracts (br) in *Astrocaryum sciophilum* (Wessels Boer 1429). **D**, Pits with fimbriate edges, also formed by fused bracts, shield the bases of staminate flowers in *Acrocomia* sp. (Cook s. n., a. 1904).

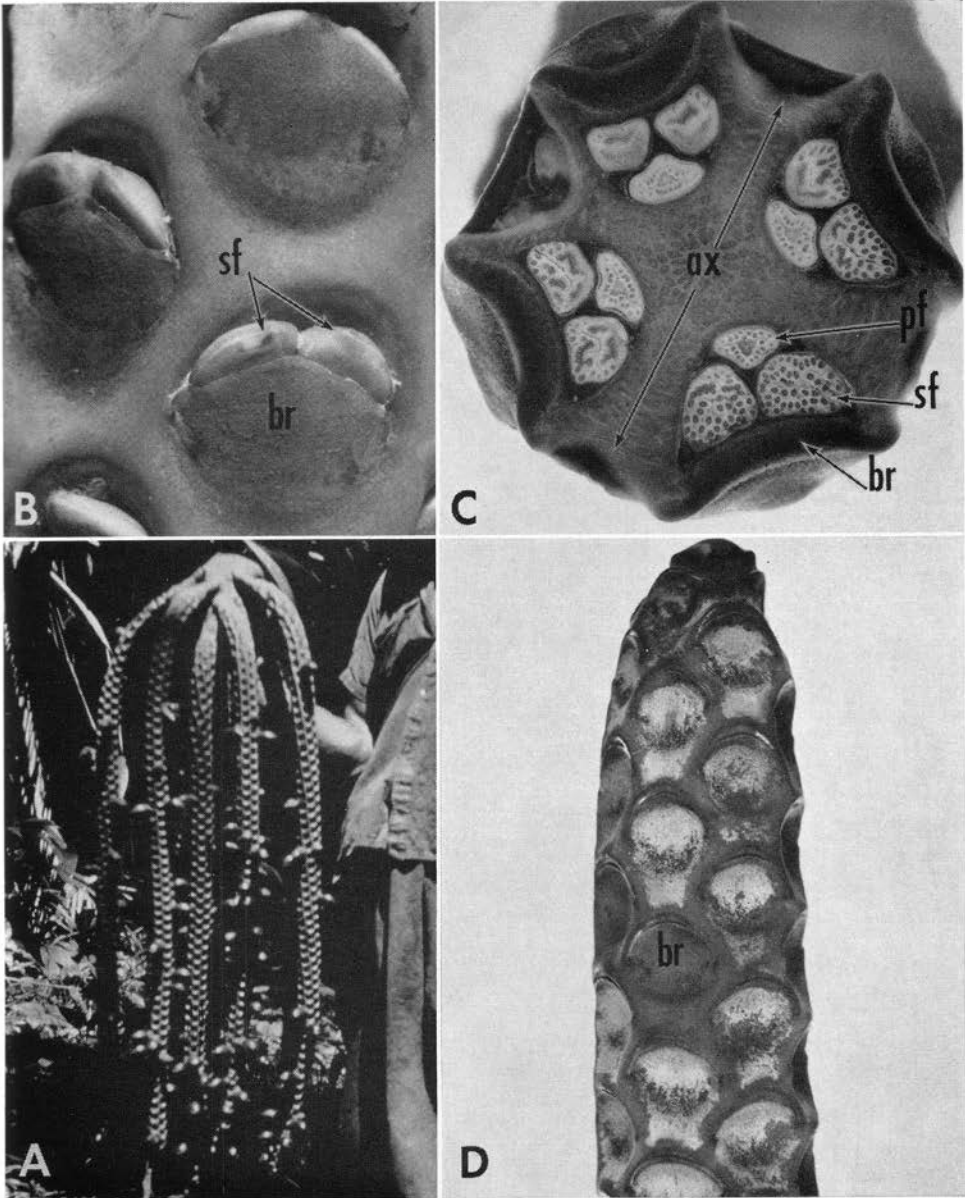


11. Pits. **A**, Pits formed by fibrous bracts (br) in a staminate rachilla of *Eleiodoxa conferta* (Dransfield 757): sf, a staminate bud. **B**, Pits of the strange African palm *Podococcus barteri* (Moore & Enti 9900) are overhung by large trichomes: pf, pistillate bud, staminate buds (sf) removed. **C**, Pits in an undescribed genus from New Caledonia (Moore, Brinon, Schmid & Veillon 9957) are mouthlike depressions with no evidence of associated bracts: pf, pistillate bud; sf, staminate bud. **D**, A pistillate bud (pf) protrudes from a pit of *Bentinckia nicobarica* (Moore 6097): the pit is an opening in the axis with no apparent associated bract.

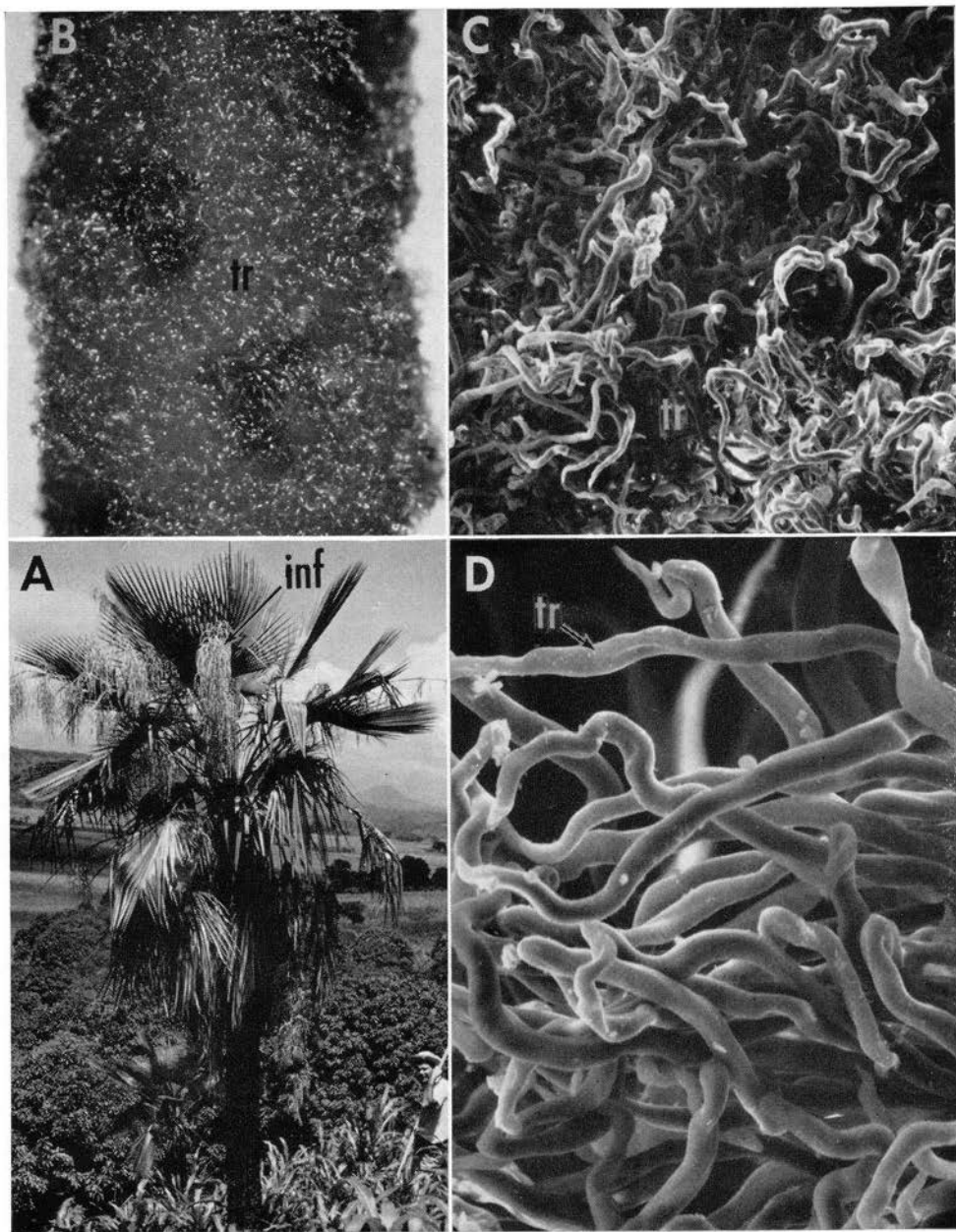
tially free but fleshy bracts. The staminate flowers of the oil palm, *Elaeis guineensis* (Fig. 10B), are situated in pockets in a "honeycomb"-like axis. That cavities are constructed of completely fused bracts can be seen in the tangential section (Fig. 10A), which shows the row of bract traces below each flower.

In certain palms (*Podococcus* and

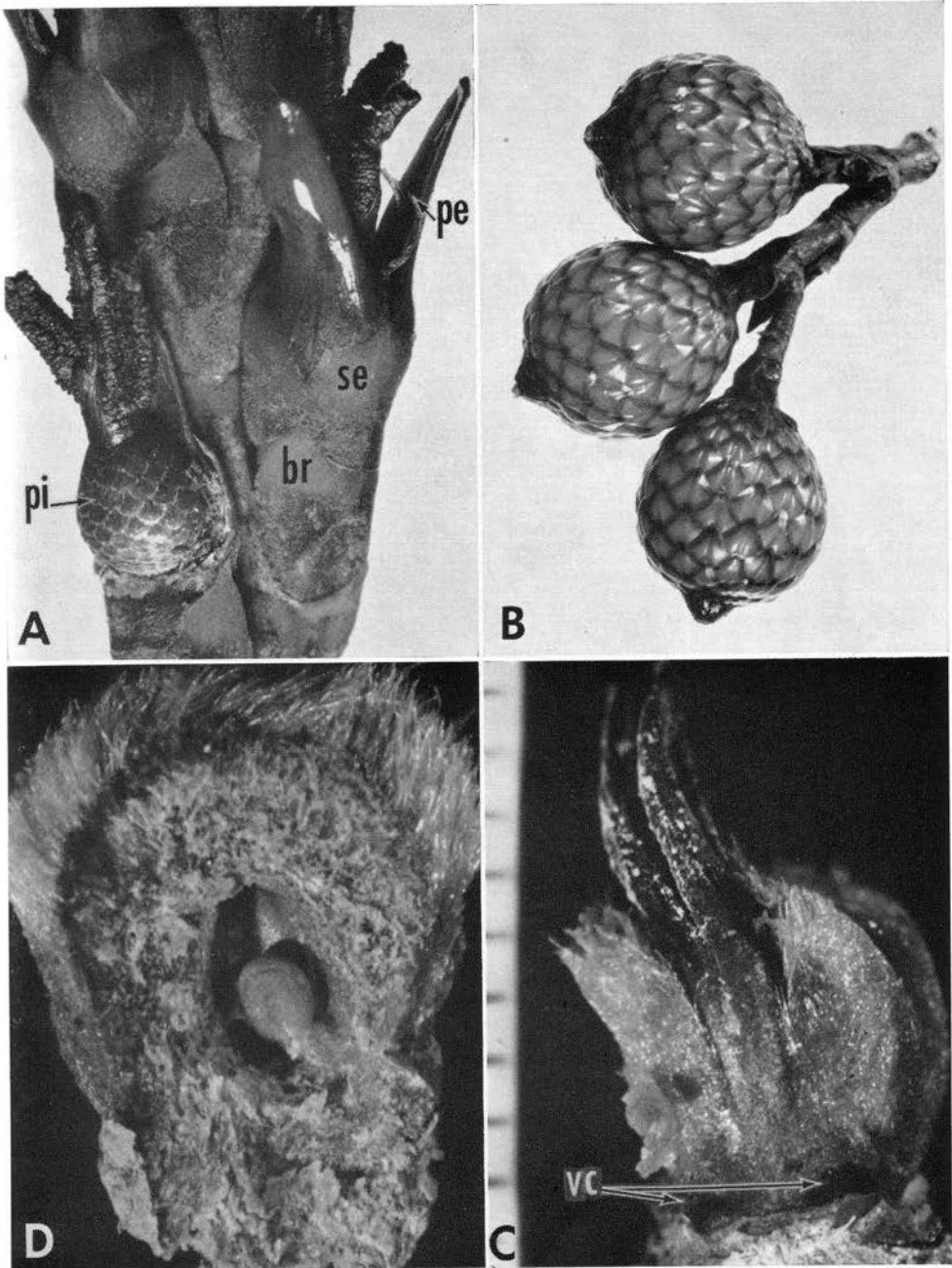
many arecoid genera), pits are cavities in inflorescence axes with any associated bracts reduced or apparently absent. Pits of *Podococcus* (Fig. 11B) are overhung by large trichomes and show little external evidence of any bracts. Anatomy, however, reveals a row of large fibrous bundles representing bract traces along the lower edge of each pit. The staminate flowers in *Podococcus* mature



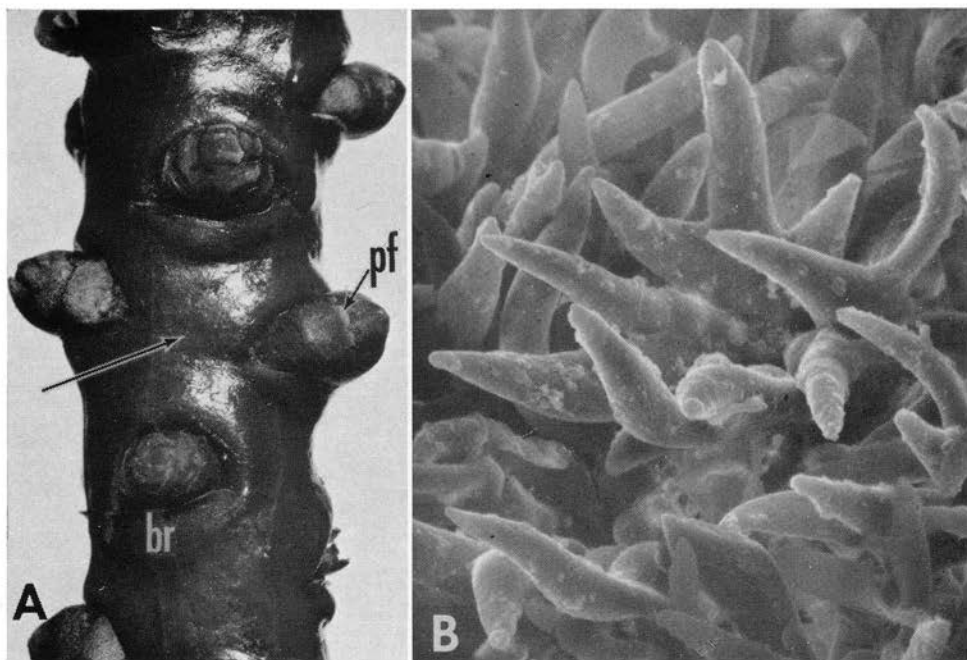
12. The geomomoid pit in *Welfia georgii*. **A**, An inflorescence in fruit from Moore 6557. **B**, A close-up of a rachilla (Moore & Parthasarathy 9412) with staminate buds (sf) protruding from each pit: staminate flowers will open before the pistillate. **C**, A transection of the axis in B exposing the triads of flowers in four pits: the axis (ax) extends between pits; bracts (br) are different histologically from tissues of the axis and appear darker; pf, pistillate flower; sf, staminate flower; dark circles and splotches in flower sections are tannin sheaths surrounding the single bundles in each stamen and staminode. **D**, Part of an inflorescence branch in bud with bracts closing pits (Moore & Parthasarathy 9412).



13. Trichomes of *Brahea calycarea* (Uhl 109). **A**, This palm grows in a valley near Jalcomulco, Veracruz, Mexico: white inflorescences, apparently in flower, protrude from the crown. **B**, A close-up of the rachilla shows that the flowers (dark spots) are actually in bud and are covered by a mass of woolly trichomes (tr), $\times$ ca. 25. **C**, The trichomes, when viewed with the scanning electron microscope, are long and have thick, fibrous walls, $\times$ ca. 120. **D**, A higher magnification of the trichomes, $\times$ ca. 420.



14. Trichomes and scales. **A**, *Daemonorops rubra* (Moore 9947 A), part of a rachilla with perianth removed from a flower at left to expose the pistil (pi)—note that scales decrease in size and maturity toward the base of the pistil: br, bract; pe, petal; se, sepal. **B**, Fruits of *Daemonorops calicarpa* (Dransfield s.n.) show shiny reflexed scales. **C**, Trichomes clothe the fertile carpel of *Wettinia* sp. (Moore & Parthasarathy 9485): vc, arrows, indicate the ovarian parts of the two sterile carpels. **D**, A longitudinal section of the fertile carpel in *Wettinia* shows the ovule shielded by a thick, fibrous wall and by long trichomes.

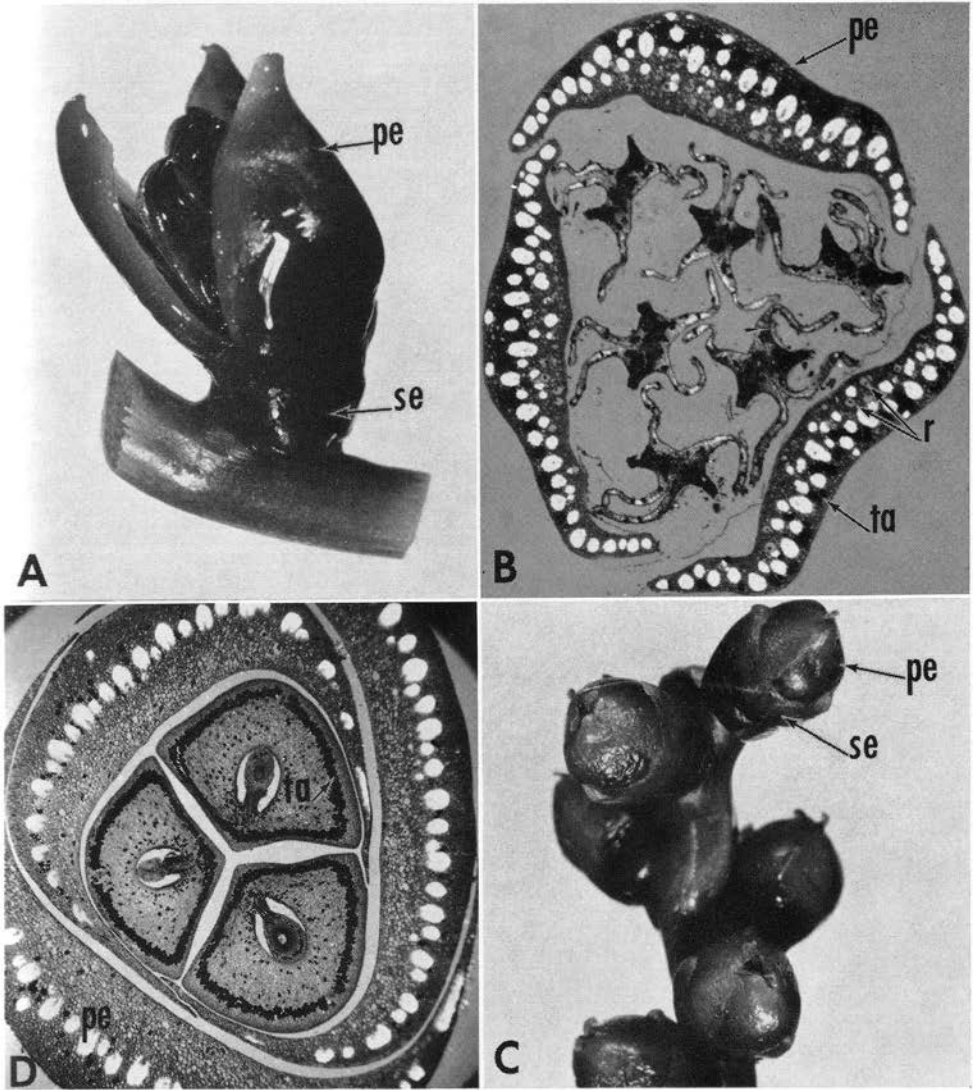


15. "Invisible" trichomes. **A**, The axis of *Burretio kentia vieillardii* (Moore, Schmid & Veillon 9955) appears smooth to slightly grainy. **B**, The scanning electron microscope reveals a thick cover of stellate trichomes in the region indicated by the unlabeled arrow in **A**, $\times$ ca. 600.

first and are shown in late bud in Figure 11B. Staminate buds have been removed from two lower pits in Figure 11B to show the small central pistillate buds which at this stage are shielded by the enlarging male buds and by the walls of the pits. No evidence of pit-associated bracts has been found in *Bentinckia nicobarica* (S. Kurz) Becc. (Fig. 11D), nor in an undescribed genus from New Caledonia distinguished by mouth-shaped pits, enclosing horizontally elongate triads of flowers (Fig. 11C).

The most intricate pits found in palms are those of the geonomoid group illustrated by *Welfia* (Fig. 12). Our work on this group has shown that the cortex of the inflorescence axis expands differentially so that arms of the axis extend between triads of flowers partly enclos-

ing the triads and the lower parts of the bracts that subtend them (Fig. 12C). The transection of a branch (Fig. 12C) shows four pits, each with two outer staminate and the inner pistillate flower. Extensions of the axis are evident between the pits (Fig. 12C). The pits are covered by bracts, which are different histologically and appear darker than the tissues of the axis (Fig. 12C). In early bud, the flowers are completely covered by the partly submerged bracts (Fig. 12D). Staminate flowers mature first (Fig. 12B), while the pistillate bud remains deep in the pit. Studies by Schmid (1970a,b) on *Asterogyne* have shown that syrphid flies are the chief pollinators in that genus, although 26 different insects visited the palm, suggesting that this superb protection may be directed against insect predators.

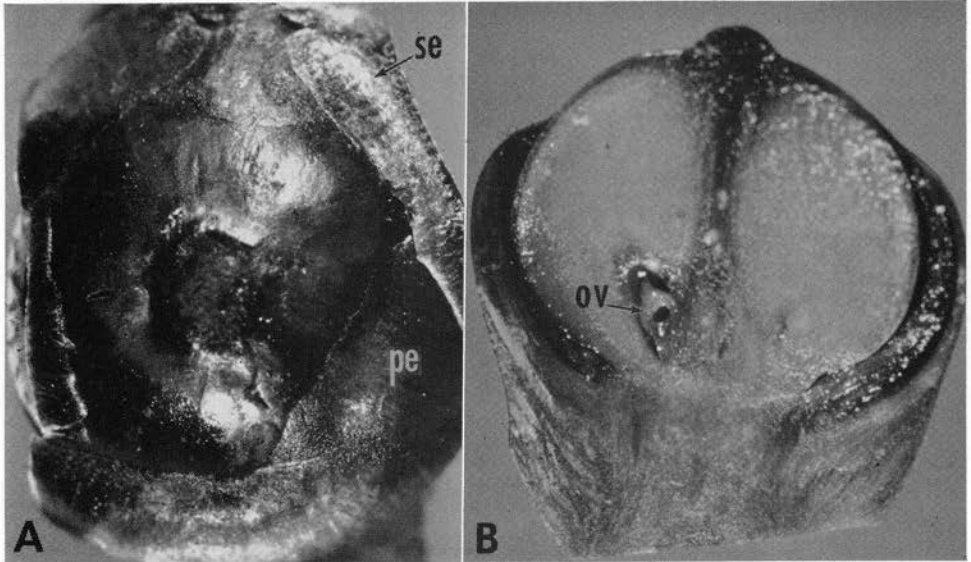


16. Floral mechanisms in *Phoenix caespitosa* (Moore, Germeaux & Martin 9897). **A**, Staminate flower—sepals (se) form a low cup enclosing the bases of the fleshy petals (pe). **B**, A transverse section of **A** shows petals are fibrous with groups of tannin cells (ta) blocking the spaces between fibers, and raphides (r) present along the inner surfaces: note tannin in the connectives and walls of the open anthers in the center of the section. **C**, Pistillate flowers have fleshy sepals (se) and tightly imbricate petals (pe) slightly open distally to expose the stigmas. **D**, A transection of the pistillate flower (**C**) shows a row of traces with large fibrous caps in the thick, imbricate petals (pe) and a layer of tannin (ta) in the wall of each carpel.

Trichomes and Scales

Trichomes and scales occur in seemingly endless variety on many organs of palms. A survey of these structures

under a scanning electron microscope is certain to be most profitable. Their possible role in plant defense has been discussed recently by Levin (1973) who



17. Floral mechanisms in the pistillate flower of *Latania verscaffeltii* (Read 1386). **A**, Sepals (se) and petals (pe) are imbricate, leathery in texture, and extremely fibrous, forming a double sheath around the base of the globular pistil. **B**, In longitudinal section, the pistil is largely parenchymatic but has a peripheral layer (not apparent in this section) of sclereids: these and the thick wall also protect the basal ovules (ov).

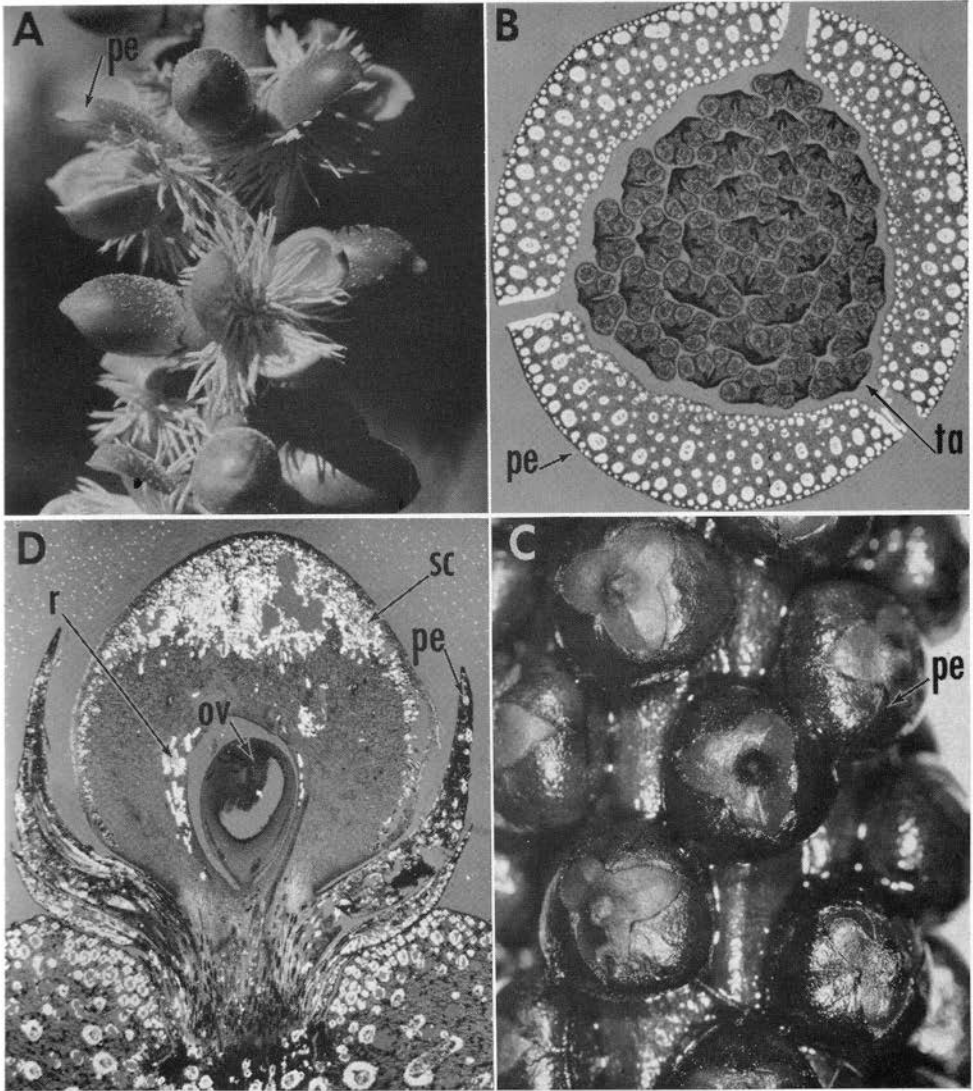
considers that they function mainly against phytophagous insects. Their location on many reproductive organs in palms suggests that they provide protection: for developing buds in the pits of *Hyphaene schattan* Bojer ex Damm. (Fig. 9C), and on the rachillae of *Brahea calcareae* Liebm. (Fig. 13); for the gynoeceum and later fruit in *Wetinia quinnaria* (Cook & Doyle) Burret (Figs. 14C,D); and perhaps for the inflorescence axis in *Burretiokentia* (Fig. 15). In *Brahea calcareae*, the large white inflorescences appear to be in flower when seen from a distance (Fig. 13A), but when collected were found to have young buds densely covered with thick whitish trichomes (Fig. 13B). These trichomes, when viewed with the scanning electron microscope (Figs. 13C,D), somewhat resemble spaghetti but are actually fibrous in texture.

Trichomes and scales vary in shape and size. The rachilla of *Burretiokentia*

vieillardii (Brongn. & Gris) Pichi-Sermolli appears only slightly grainy to the naked eye, but is actually covered with stellate trichomes as evident with the scanning electron microscope (Fig. 15B). The scales on the surface of the gynoeceum in *Orbignya speciosa* (Mart.) Barb. Rodr. are irregular (Figs. 27C,D). The scales on lepidocaryoid fruits (Fig. 14B) mature first on the upper surface of the pistil (Fig. 14A) and shield the young ovules in the flower from an early stage. These scales have been considered to represent reduced inflorescences (Eames, 1961) but appear to be homologous to the trichomes of *Wetinia* and, like some prickles, are emergences formed from an epidermal and some underlying cell layers.

Floral Organs

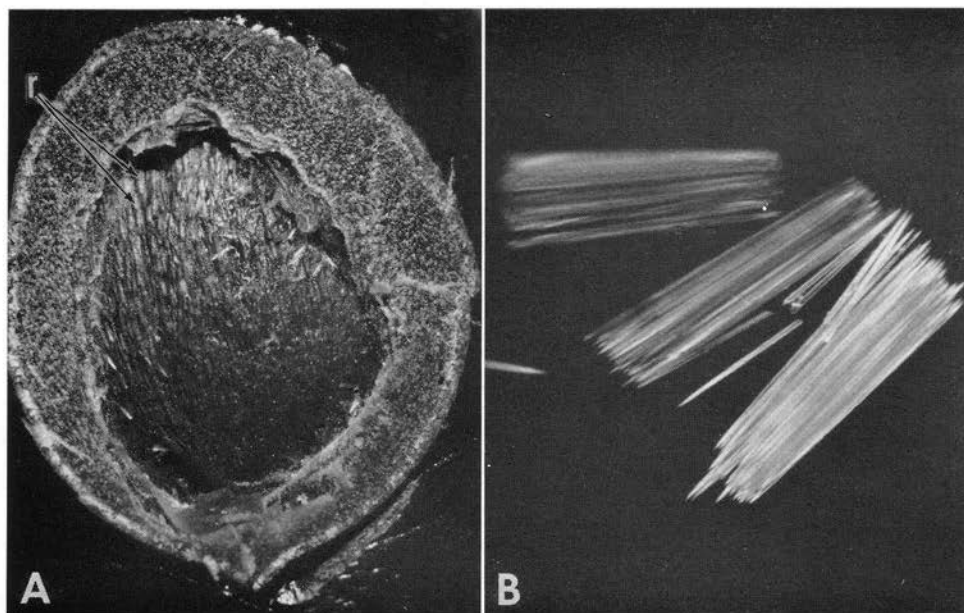
Any floral organ may be specialized for protection. The organs which are so specialized vary in different palms and



18. Floral mechanisms of caryotoid palms. **A**, Staminate flowers of *Arenga undulatifolia* (Moore 6094) have thick, valvate petals (pe) tightly closed in bud. **B**, A transection shows that the petals (pe) are extremely fibrous and that tannin (ta) is present in the connectives of the anthers. **C**, In *Wallichia densiflora* (Moore 9949), pistillate flowers have a tight sheath of petals (pe) around the base of each gynoeceum. **D**, A longisection of a pistillate flower of C shows a distal cap of sclereids (sc) in the exposed upper part of the pistil, and raphides (r) forming a sheath around the locule: pe, petal; ov, ovule.

are related to the degree and kind of protection provided for pollen and ovules by other organs or tissues. Protection by floral organs is a function of their shape, size, texture, and/or cellular

and chemical specialization. At the cellular level, strength and support in plants is provided by a special tissue known as sclerenchyma, composed of two cell types with thick cellulose walls



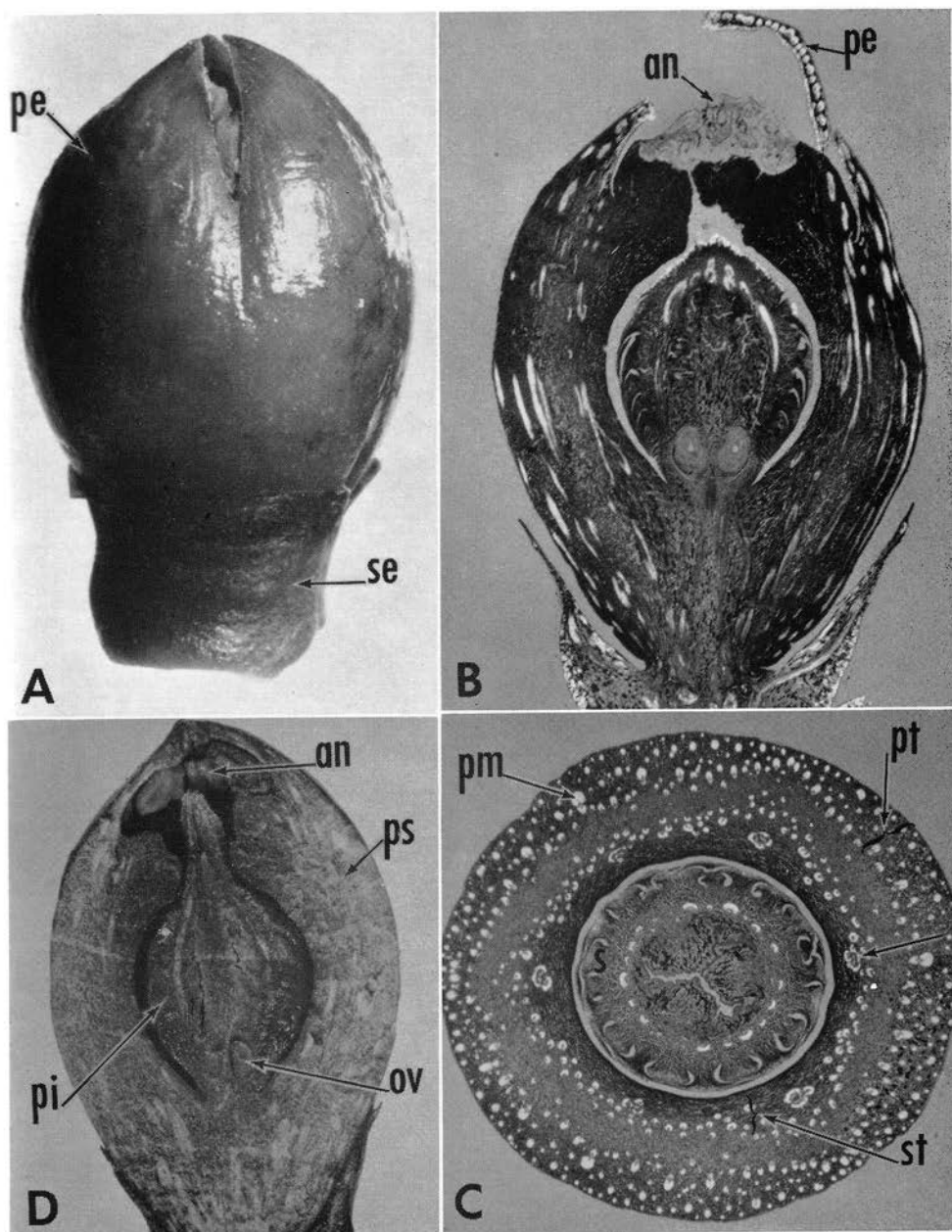
19. Floral mechanisms may also function in fruits. **A**, Removal of the outer layers of the fruit wall in *Arenga engleri* from Fairchild Tropical Garden, Miami, Florida exposes a sheath of raphides (r) on the seed. **B**, A single, rod-shaped bundle of raphides from A, photographed in polarized light, shows many needlelike crystals.

—fibers and sclereids. Fibers are abundant in many palms and commercially important in some. They are long, narrow, thick-walled cells with pointed ends, and groups of them may form sheaths over or around vascular bundles. They may also occur singly or together in various numbers as fibrous bundles. Sclereids also are thick-walled, polyhedral to elongate, sometimes branched cells which may be extremely hard, as in the bony endocarps of cocosoid and other palms. Sclerenchyma has long been recognized as a strengthening tissue in plants and some authors have also pointed out its protective role. Strength in sepals and petals certainly provides protection to organs within, and it seems reasonable to suggest that extremely fibrous tissues do not provide good eating. Many examples, such as the staminate petals of *Phoenix* (Fig. 16B) can be seen where sclerenchyma alternates

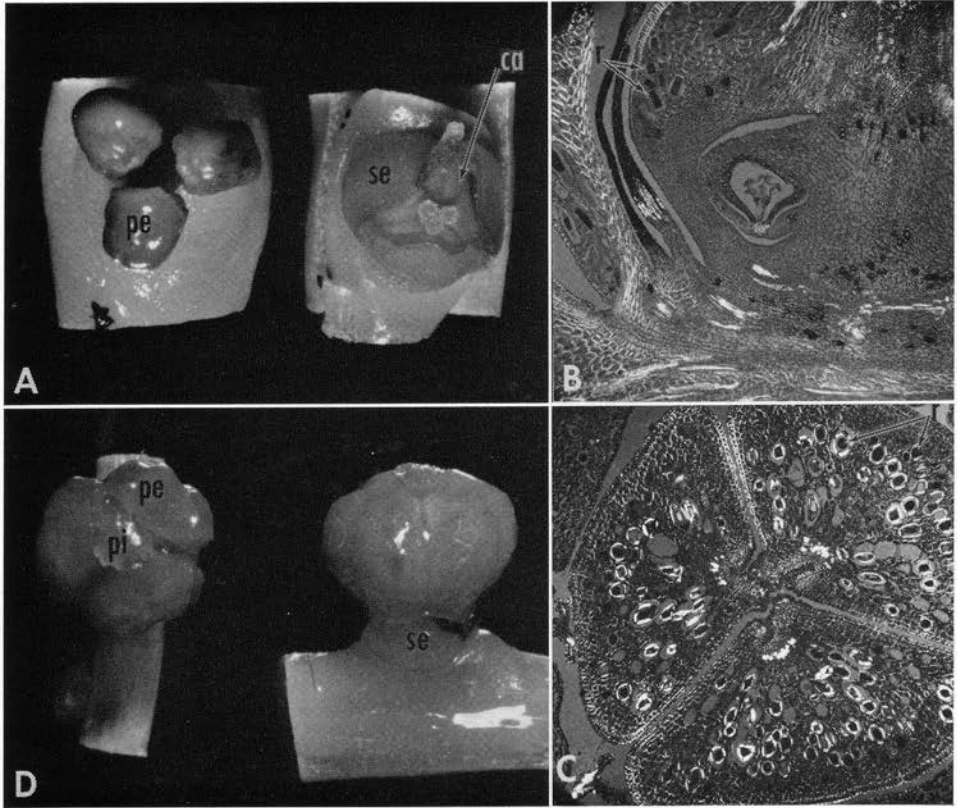
with or reinforces other mechanisms apparently completing a barrier, perhaps against chewing insects.

Chemical Protection

We are just beginning to investigate the complex chemical relationships between plants and other inhabitants of their biospheres. In a recent book on phytochemical phylogeny, McClure (1970, p. 236) has written: "If the secondary compounds are to be understood as they relate to the life of the plant in which they are produced, a bridge needs to be constructed between the patterns of distribution and their possible *in vivo* functions." Two intercellular substances whose distribution indicates that they function in floral protection in palms are crystals of calcium oxalate and tannins. To these should probably be added silica. There seems no question as to the defensive



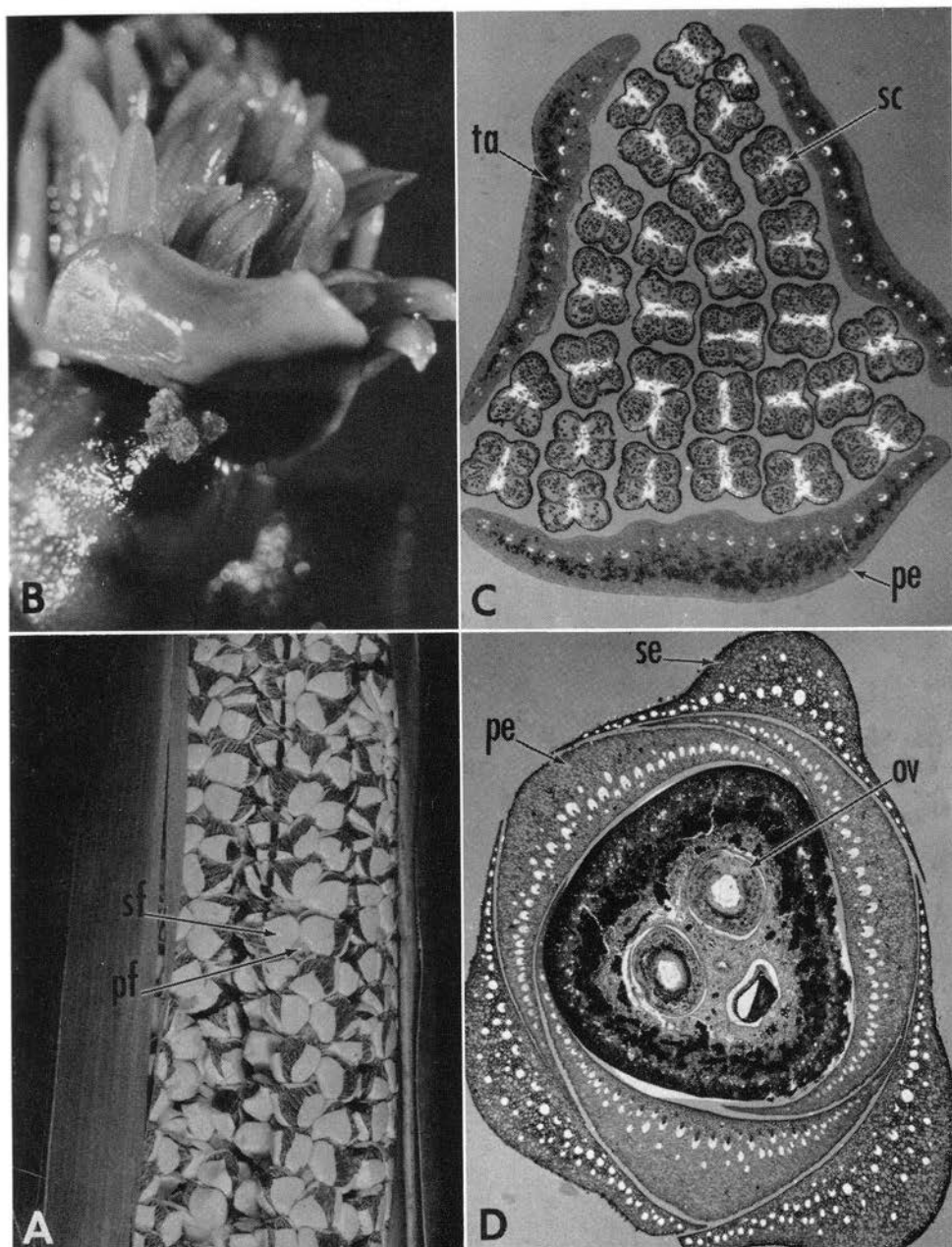
20. Floral mechanisms in *Eremospatha* sp. (Moore & Enti 9893), a lepidocaryoid palm. **A**, Sepals (se) form a low tube around the base of the partly united petals (pe). **B**, In longisection, a thick wall of fused petals and stamens surrounds the gynoeceum: anthers (an) are small and situated in a distal cavity; the pistil shows reflexed scales and bright sclerotic cells and fibers distally. **C**, A transection through the center of the flower shows scales on the pistil and separate vascular systems as bracketed for the stamen tube (st), and for the petal tube (pt); pm, petal midvein; unlabeled arrow indicates one of the six multiple stamen traces. **D**, The pistil (pi) with basal ovule (ov) and the distal anthers (an) are sheathed by the petal-stamen tube (ps).



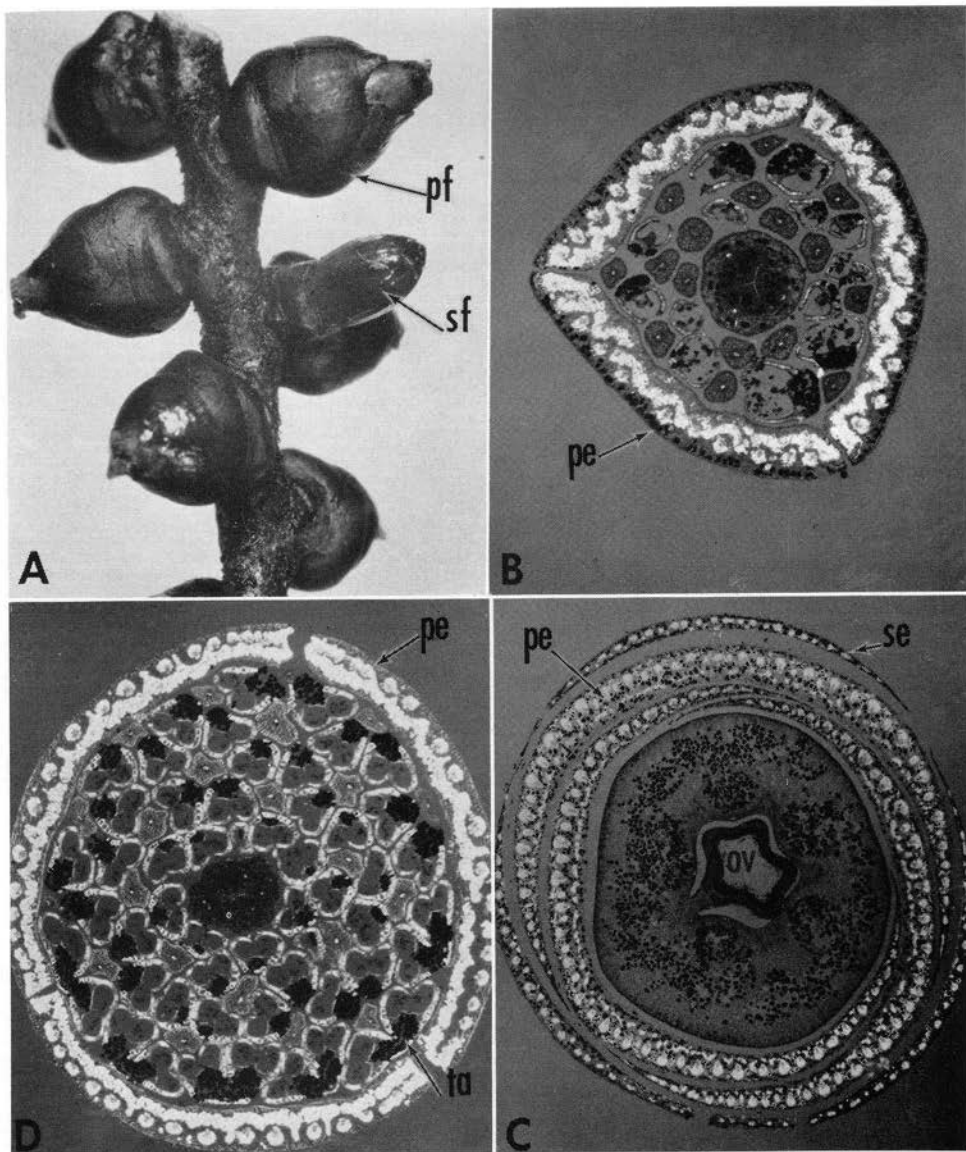
21. Floral mechanisms in *Chamaedorea metallica* (Moore 9373, 9374). **A**, The pistillate flower, left, with hooded petals, and right, with petals removed to reveal the three carpels (ca); se, sepal. **B**, A longitudinal section shows raphides (r) around the locule. **C**, A transection of the styles shows abundant raphides (r). **D**, Staminate flowers are also succulent in appearance, here seen in surface view (left) and side view (right): pe, petal; pi, pistillode; se, sepal.

nature of the needle-shaped raphides of calcium oxalate. The best known example in palms is probably the irritating layer in caryotoid fruits. In *Arenga engleri* Becc., removal of the outer fruit wall (Fig. 19A) reveals a sheath of raphide bundles which covers the seed. Such bundles are also evident surrounding the locules in the flowers of another species at anthesis (Fig. 18D), and, like the scales of lepidocaryoid palms, appear to protect the young ovule as well as the seed. Raphides occur in appropriate locations in sepals, petals, and gynoecea in ceroxylod palms (Uhl, 1969), and surround the locule in the otherwise un-

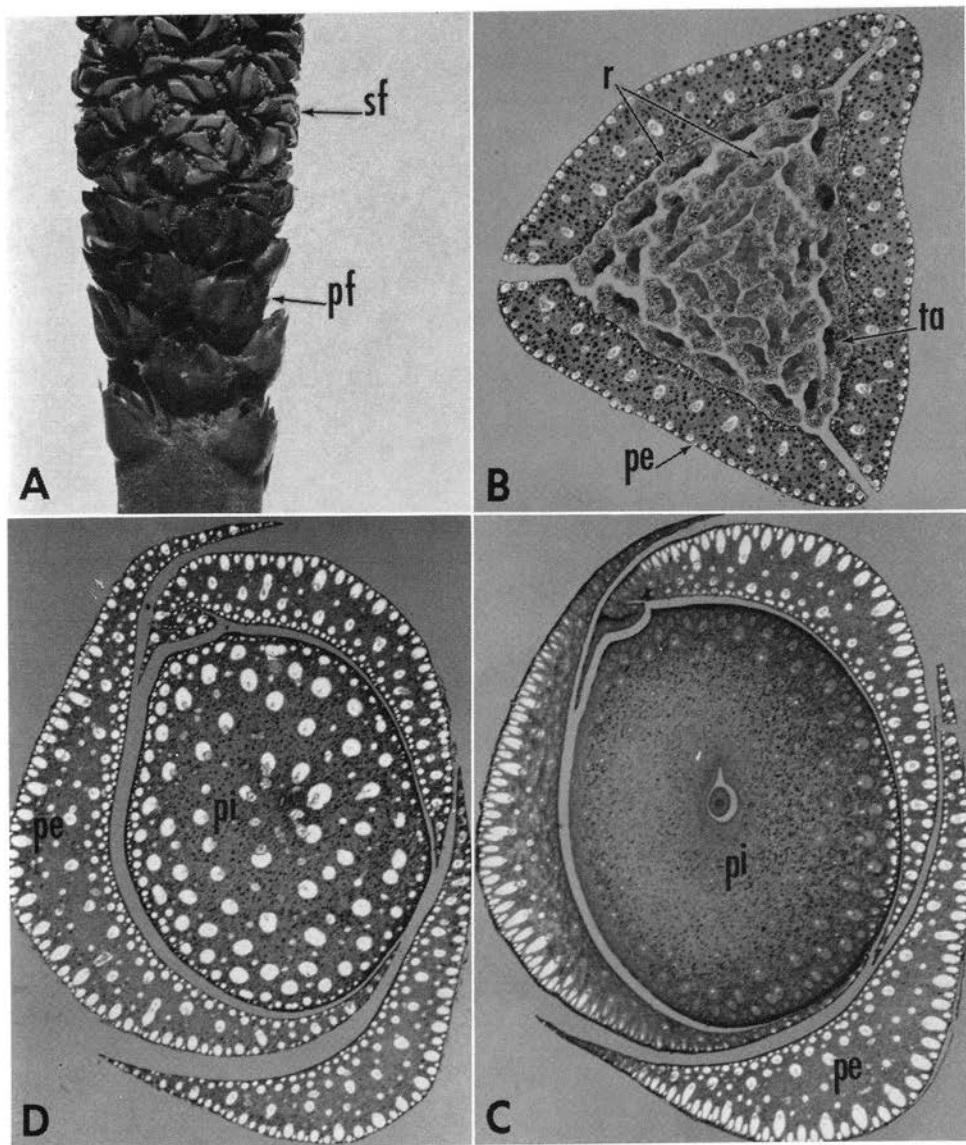
protected flowers in *Zombia*. One of the most striking examples of protection by raphides can be seen in the genus *Chamaedorea* where, in some species, such crystals appear to be the main protective mechanisms. Flowers of *Chamaedorea metallica* H. E. Moore are succulent in appearance (Figs. 21A,D). Sections, however, reveal a large number of raphides in sepals and petals of both staminate and pistillate flowers (Figs. 21B,C). Such crystals are especially numerous around the locules in the pistillate flower (Fig. 21B) and, although not illustrated, are abundant in the lobed pistillode (Fig. 21D) which forms an



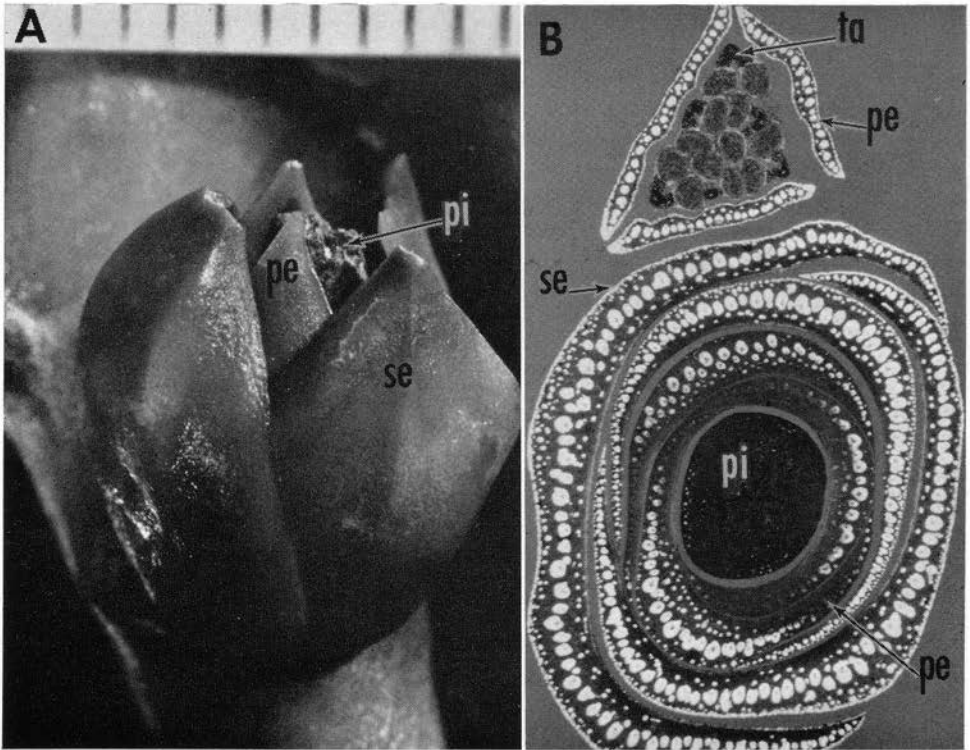
22. Floral mechanisms in *Socratea exorrhiza* (Moore 9950). **A**, An inflorescence with bracts opened to show the flowers which are borne in triads and not closed in bud: pf, pistillate flower; sf, staminate flower. **B**, A pistillate (lower) and a staminate flower, both near anthesis. **C**, Transection of a staminate flower shows the petals (pe) with only a few fibers in bundle sheaths, but with an abaxial layer of tannin in each petal: ta, tannin; sc, sclerotic parenchyma cells in connectives; note tannin in epidermal layers of anthers. **D**, Transection of a pistillate flower reveals more fibers in sepals (se) and in the imbricate petals (pe) and both tannins and raphides (large empty cells) in the pistil: ov, ovule.



23. Floral mechanisms in the *Ptychosperma* alliance. **A**, Part of a rachilla of *Ptychosperma caryotoides* (Moore & Womersley 9279) with one remaining staminate (sf) and several pistillate flowers (pf): staminate flowers in this genus are usually shed before the pistillate flowers are receptive. **B**, A transection of the staminate flower shows abaxial tannin in the petals (pe) and a distinctive "scallop" adaxial band of sclerenchyma; also note tannin in connectives and in the pistillode. **C**, The pistillate flower has tannin interspersed with fibers in sepals (se) and petals (pe) and lightly sclerotic cells (with thin bright walls) between: petals are extremely imbricate; note also large tanniferous cells in the pistil and a ring of tannin around the embryo sac in the ovule (ov). **D**, A transection of a staminate flower of *Veitchia vitiense* var. *parhamiorum* (Moore, Koroiveibau & Parham 9358) has the same pattern of sclerenchyma in the petals (pe): petals, however, lack tannin (ta) which is present in connectives.



24. Floral mechanisms in *Sclerosperma mannii* (Moore & Enti 9883). **A**, Pistillate flowers (pf) are present below the staminate flowers (sf) in the spicate inflorescence. **B**, In transection, fibers and evenly distributed tannin can be seen in the thick, valvate petals of the staminate flowers, and a smooth-appearing tannin (ta) and small dark bundles of raphides (r) are present in the connectives. **C**, In a transection through the ovarian level of the pistillate flower, many fibers can be seen in the thick, imbricate petals (pe): fibers in the pistil (pi) are immature. **D**, At a higher level, the large fibrous bundle sheaths in the pistil (pi) are mature and petals (pe) also have more mature fibers.



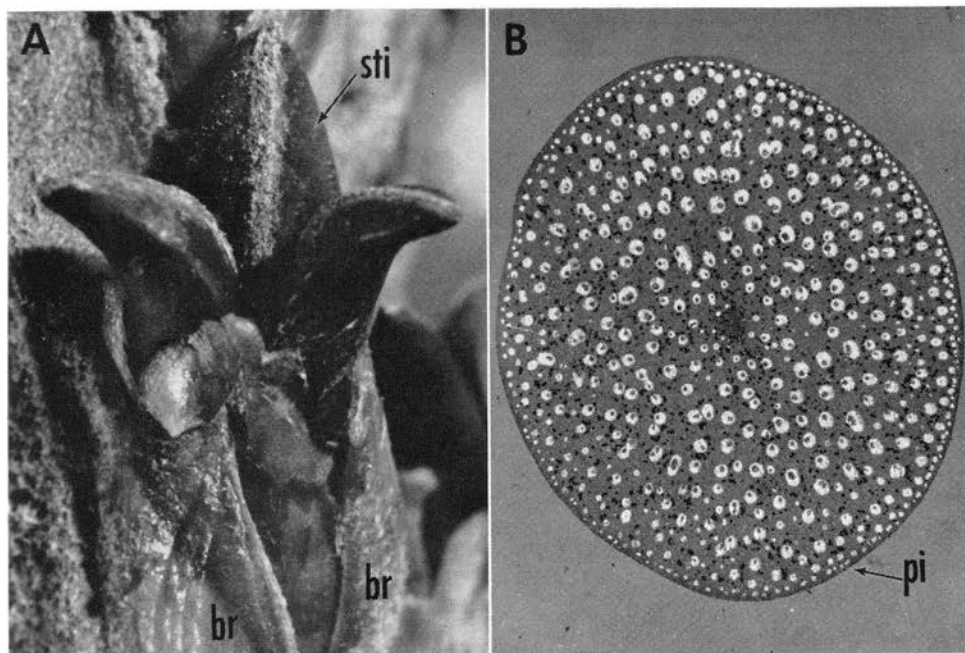
25. Floral mechanisms in cocosoid palms. **A**, Pistillate flower of *Syagrus coronata* (Read 910) with both sepals (se) and petals (pe) thick and imbricate: pi, pistil; scale units equal 1 mm. **B**, In transection, the thin but fibrous, valvate petals (pe) of a staminate flower (upper section) enclose the six anthers with tannin (ta) evident in connectives. The extreme imbrication of both sepals (se) and petals (pe) and the abundant sclerenchyma in both are evident in the pistillate flower (lower section): pi, pistil.

umbrella-like shield over the anthers. Raphides are also present in the anther walls in this species. The possibility of protection of pollen from pollen-eating insects by raphides in anther walls and connectives has been suggested as a factor in plant evolution by van der Pijl (1960). Exactly how protection is provided by raphides is not clear. Puncture by the acicular crystals has been considered mechanical protection and preparation for the entrance of irritating substances (Haberlandt, 1909).

The possible roles of tannins in plants have been discussed by Feeny (1970) who states that there seems little doubt that tannins can defend plants from at-

tack by other organisms. They appear to be broad general protectors against herbivores and pathogens and act in three different ways: as repellents affecting palatability, as growth inhibitors affecting protein availability, and as direct toxic agents.

In palm flowers, intracellular substances which appear to be tannins are present in positions that strongly suggest that tannins have a defensive function. Polyphenols, especially leucoanthocyanins, caffeic acid and flavonols, are reported as widespread in palms and the tannin content in some palms is high enough that they have been tried for tanning leather (Hegnauer, 1963). Chem-



26. Floral mechanisms in cocosoid palms. **A**, The large stigmas (*sti*) of *Elaeis oleifera* (Read 1366) contain fibers and tannin; the perianth is also fibrous and the lower part of the flower is enclosed in bracts (*br*) which are split in the figure. **B**, In transection, the style shows many bundles with fibrous sheaths and smaller, entirely fibrous strands around the periphery.

ical analyses of the tanninlike substances in flowers, however, seem not to have been done and are critically needed. Histochemical tests (Jensen, 1962) give positive results for catechol tannin in fresh material of inflorescences and flowers in *Geonoma acaulis* Mart. and *Reinhardtia simplex* (H. Wendl.) Burret (Uhl, unpublished), and tannin in these tests corresponds in position with that identified in our prepared slides.

For purposes of this paper, we are using "tannin" in a loose sense to refer to intracellular substances, usually granular to globular but occasionally smooth in appearance under the light microscope, which stain bright to dark red (dark bluish-red in some) with safranin (see Uhl, 1972, for references to general techniques followed). Both the chemis-

try and the functions of these substances appear complex. Previous reports (Hegnauer, 1963) and our observations on differences in appearance and staining indicate that tannins in palms are chemically variable. The presence or abundance of tannin may vary during flower or fruit development. In view of the complexity of allelochemical reactions, some of the tanninlike substances in palms may serve as attractants or have other functions. As with other aspects, the biology of these substances must be worked out for individual species. However, as we will show, tannins often appear to complement or substitute for other protective mechanisms. The complete absence of tannins in petals of *Bactris* which are chewed by beetles (Essig, 1971) suggests that the tannins do indeed repel certain insects.

Table 1. Summary of protection by major groups*

Group	Degree	Mechanisms
I Coryphoid	Light	Spines; numerous, relatively thin bracts; some fibers in bundle sheaths but not numerous in perianth; tannin sheaths on carpels; some raphides
II Phoenicoid	Moderate	Large spines at leaf base; single bract on inflorescences; tannin, fibrous sheaths, raphides in perianth; tannin sheaths, distal sclereids in carpels
III Borassoid	Heavy	Several fibrous inflorescence bracts; <i>pits formed from thick fibrous bracts enclosing flowers and/or perianth thick and fibrous</i> ; gynoeceum large with distal sheath of sclereids; trichomes (<i>Hyphaene</i>)
IV Lepidocaryoid	Heavy, diverse	<i>Spines</i> ; bracts and perianth fibrous; <i>filaments and staminodes often thick and fibrous</i> ; <i>gynoecea with distinctive scales</i> ; tannins throughout
V Nypoid	Moderate	Numerous bracts; tannin sheaths abaxially in perianth parts of both sexes; <i>distal parts of carpels large, hard, and closely appressed</i>
VI Caryotoid	Moderate to heavy	Several fibrous bracts; perianth parts thick and extremely fibrous in both sexes; fleshy gynoecea with peripheral sclereid sheaths and <i>raphides around locules</i>
VII Pseudophoenicoid	Light	Two tough bracts; <i>raphides</i> and some tannin in floral organs
VIII Ceroxyloid	Light	Numerous bracts; <i>raphides</i> and some tannin in floral organs
IX Chamaedoreoid	Light	Several thin bracts; <i>raphides</i> especially abundant in all floral organs, small amounts of tannin in some

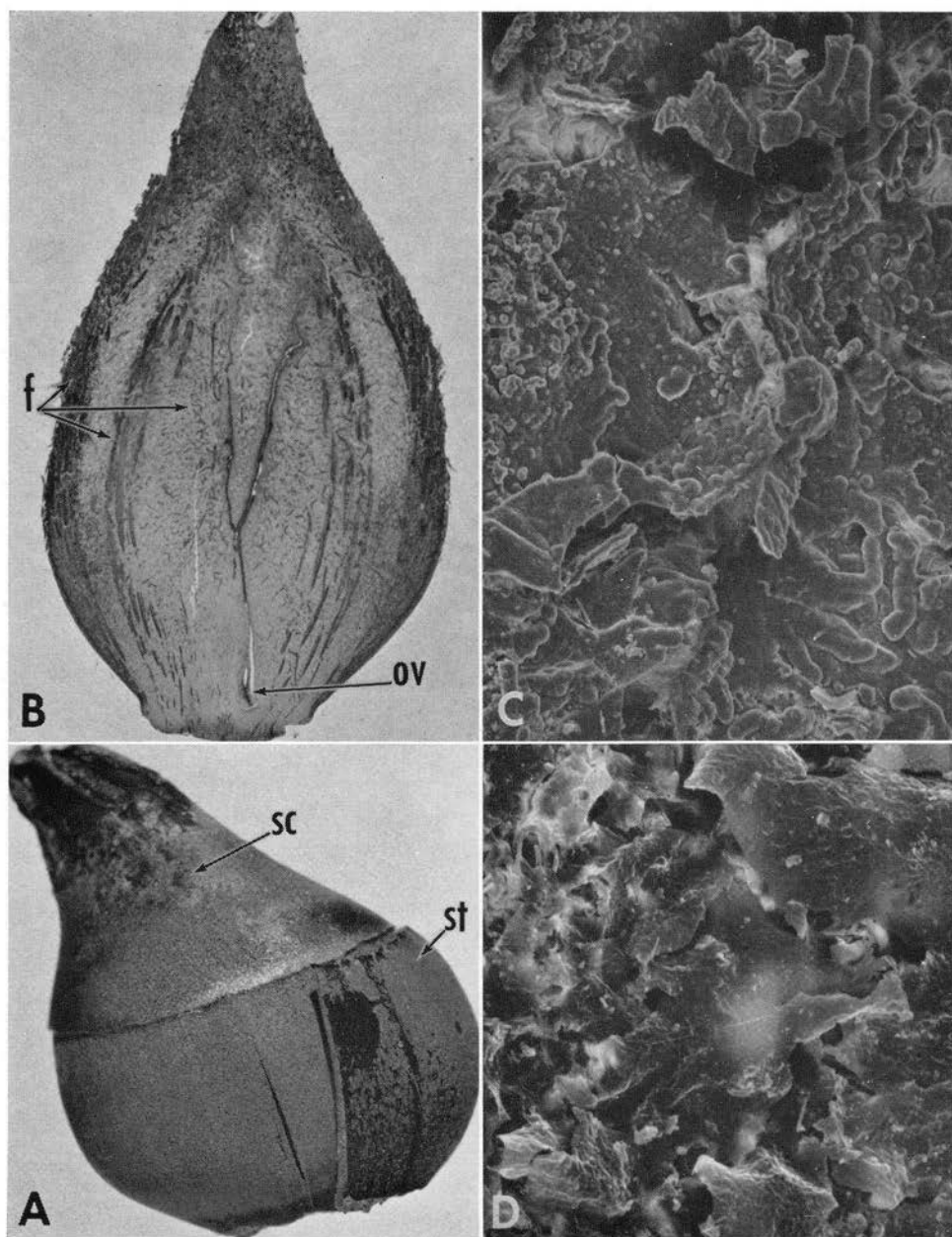
* Mechanisms which predominate in some groups are italicized.

Table 1 Continued

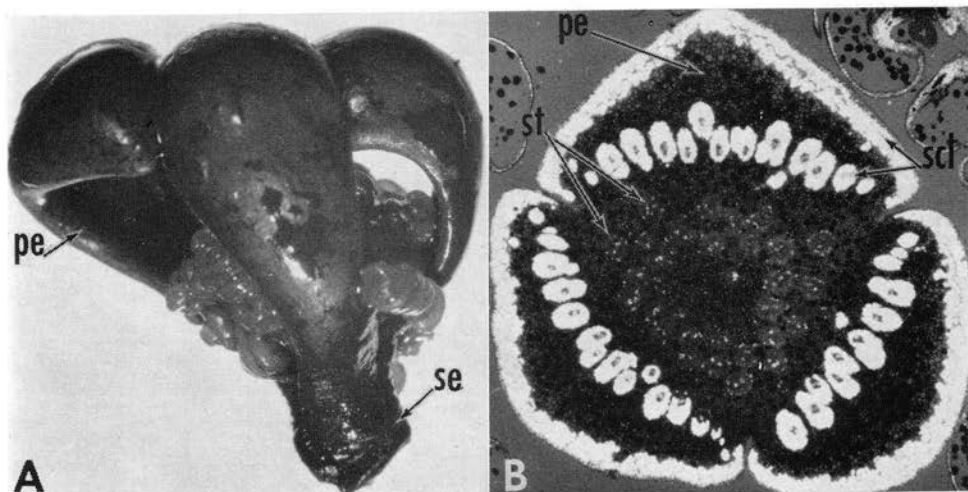
Group	Degree	Mechanisms
X Iriarteoid	Moderate to heavy, diverse	Spines on roots; bracts numerous, sometimes thick; large amounts of tannin and fibers in floral organs; gynoecia with large amounts of tannin, raphides, and a distal sheath of bundles of fiber-sclereids; trichomes (<i>Wettinia</i>)
XI Podococcoid	Light	Pits; trichomes on rachillae; perianth lightly fibrous, a few raphides
XII Arecoid	Moderate to heavy, diverse	Mechanisms varied; spines in one alliance, bracts 1 or 2, not markedly thick; <i>perianth parts extremely fibrous in some; tannins raphides and sclereids in others and in gynoecia</i>
XIII Cocosoid	Heavy, diverse	<i>Spines; hard, woody or fibrous bracts; thick, heavily fibrous perianth; staminodia sometimes thick and fibrous; abundant tannin and raphides in some gynoecia, different systems of fibers in others</i>
XIV Geonomoid	Moderate	One or mostly two fibrous bracts; <i>flowers in pits</i> and floral organs only lightly fibrous, tannin and raphides in some
XV Phytelephantoid	Light to moderate	Staminate flowers lightly protected by single inflorescence bract; pistillate flowers scarcely exerted from leaf sheaths at anthesis; sepals and petals numerous and tanniniferous; gynoecia with specialized fiber-sclereid layer

Silica has been designated as a barrier to feeding on plants (Southwood, 1973). Its distribution in palm flowers is so widespread that we routinely treat all floral material with hydrofluoric acid

before attempting to section. Silica is often abundant in flowers that appear soft, as in the staminate flowers of *Welfia*, which contain large amounts of silica but few fibers. Some data on the



27. Floral mechanisms in cocosoid palms. **A**, The multicarpellate gynoecium of *Orbignya speciosa* (Read 912) is enclosed by a staminodial cup (st) which is extensively vascularized and fibrous. **B**, In longitudinal section, several systems of fibers (f) occur in the large styler region of the gynoecium: ovules (ov) are extremely small. **C**, **D**, Two views of the scales (sc) on the upper surface of the gynoecium in A, with the scanning electron microscope, $\times$ ca. 110.



28. Floral mechanisms in cocosoid palms. A, Petals of the staminate flower of *Orbignya cuatrecasana* (Moore, Parthasarathy & Orjuela 9450) are thick: pe, petal; se, sepal. B, A transection through the lower part of the flower shows the petal bases (pe) which have a wide outer layer of fibers, large fibrous bundle sheaths, and large tannin cells in the ground tissue: scl, sclerenchyma of bundle sheaths and peripheral layer; st, stamen traces.

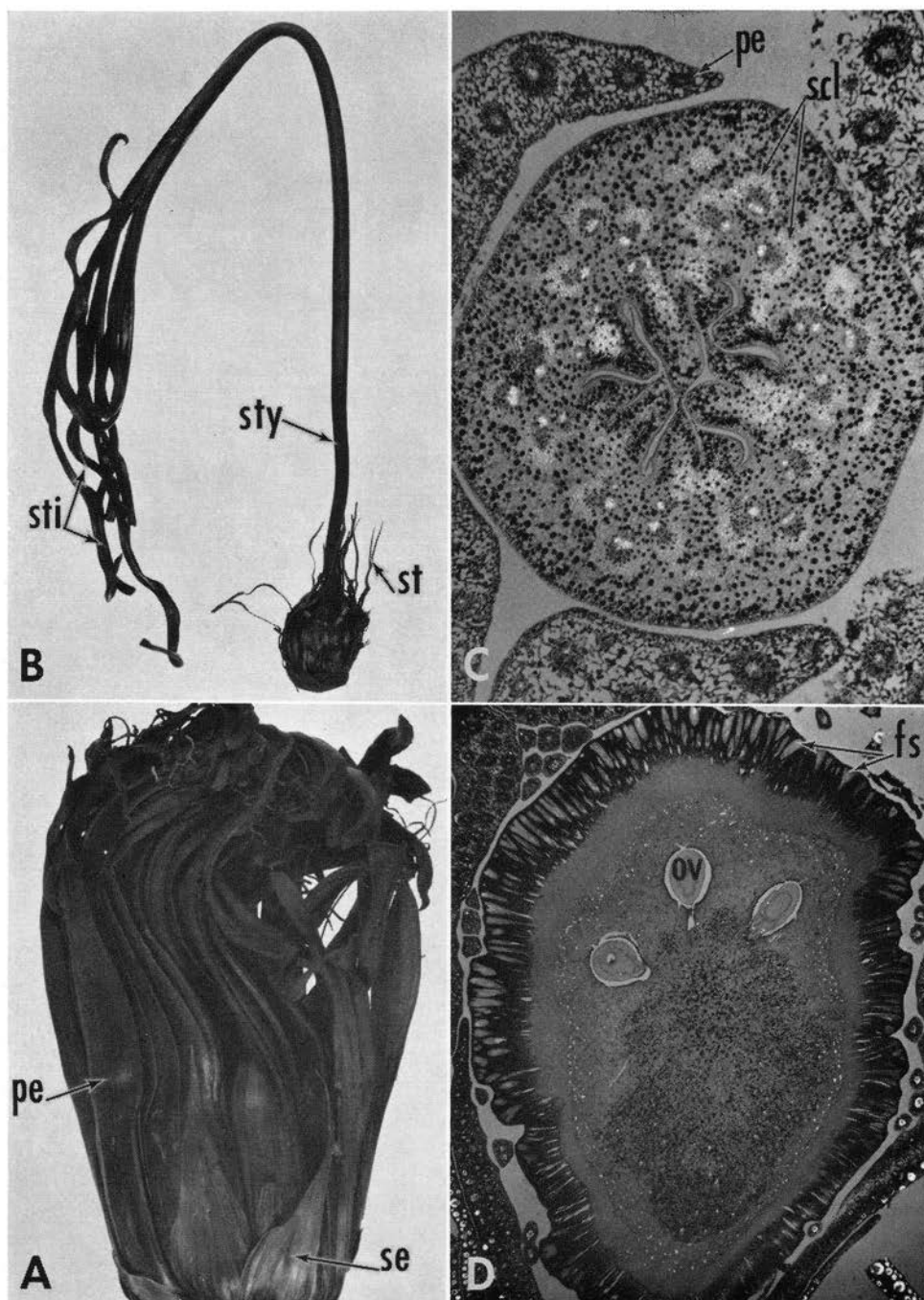
occurrence of silica has been given in studies of fruit development by Murray (1971).

Distribution of Protective Mechanisms

We have assembled a number of figures to illustrate how protective mechanisms are distributed in palm flowers. As previously stated, inflorescences in *Phoenix* are surrounded by unique spines and only a single bract encloses the floral axes (Fig. 2B). Protective devices are also present in the floral organs of both sexes. The connate sepals form a low basal sheath in staminate flowers. Petals are slightly imbricate and moderately thick and fibrous (Figs. 16A,B), with abaxial groups of tanniniferous cells more or less blocking the spaces between fibrous bundle caps and raphides present adaxially. Tanninlike material also occurs in the anthers (Fig. 16B). Staminate flowers thus appear to be well fortified against chewing insects. In pistillate flowers (Fig. 16C), the sepal sheath is relatively

higher and the petals are thicker and more imbricate with large fibrous bundle sheaths. A layer of tanniniferous cells is present peripherally around the locular part of each carpel (Fig. 16D). The immature ovule-containing lower parts of the carpels are thus sheathed in triplicate: by a sepal tube, by thick, fibrous, imbricate petals, and by a carpellary tanniniferous sheath. In addition, the upper parts of the carpels contain sclereids (not illustrated), which provide a hard region that appears to block the opening between the tips of petals through which the stigmas protrude (Fig. 16C).

Phoenix could serve as a model of pollen and ovule protection in many palms. The ovule-bearing region of the palm gynoeceum is enclosed, often by several fibrous or otherwise defensive layers, and the distal opening of the petals, needed to expose a receptive stigmatic surface, is "plugged" by a hard or otherwise defensive upper (styler) part of the carpel or pistil. In



29. Floral mechanisms in phytelephantoid palms. A, Numerous long petals (pe) cover the gynoecium in the pistillate flower of *Phytelphas macrocarpa* (Moore 9951): se, sepal. B, With the perianth removed, the multicarpellate gynoecium has a long compound style (sty) and

staminate flowers, sepals are relatively small compared to the petals just before anthesis. Petals usually are valvate, perhaps an adaptation that permits rapid and complete opening, but are often thick and extremely fibrous and may contain tannins and raphides. Protection of anthers seems also provided by tanniniferous material and raphides in connectives.

In borassoid palms, genera of the *Borassus* alliance have thick, leathery, imbricate sepals and petals in pistillate flowers as shown for *Latania* (Fig. 17A). Several genera of borassoid palms have flowers enclosed in pits. Perianth parts of the flowers borne in pits are thin and have relatively few fibers. The exposed surface of the gynoeceum is hard and smooth with a peripheral layer of sclereids just beneath the surface. The ovule is also shielded by the thick wall of the fleshy gynoeceum (Fig. 17B).

Staminate flowers of *Arenga undulatifolia* Becc., a caryotoid palm, have thick, valvate petals (Figs. 18A,B) which are tightly closed in bud. The numerous fibers in the complete bundle sheaths and in small fibrous bundles can be seen in transections of the petals (Fig. 18B). Tannin in the connectives of the anthers may also be protective. Pistillate flowers in *Wallichia densiflora* (Mart.) Mart. (Figs. 18C,D), also of the caryotoid group, show a tight sheath of basally united, fibrous petals open distally to expose the upper surface of the globular pistil in each flower. The protection of the exposed surface of the pistil is by a distal group of sclereids and by elongate bundles of raphides around the locule, evident in the longi-

tudinal section (Fig. 18D). This section, only 15 microns thick, shows a surprisingly large number of raphides which form a complete layer around the locule and later around the seed as in *Arenga* (Fig. 19A). The irritating nature of these crystals, shown enlarged in Figure 19B, is well known.

A unique kind of ovule protection is exhibited by *Nypa fruticans* where the separate carpels of many flowers are closely appressed, forming a hard head (Fig. 6D). The surface of the head bars access to the ovules far below in the soft base of each carpel. The three carpels of each pistillate flower elongate rapidly, surpassing and obscuring the perianth parts by the time the carpels are receptive (Uhl, 1972). The pistils of many palms much surpass perianth members as the fruit develops, but *Nypa* is unusual in the early timing of carpel enlargement. Abaxial tanniniferous sheaths also occur in perianth members of both staminate and pistillate flowers.

The distinctive scales which cover the pistils (Figs. 14A; 20B) are only one of several protective mechanisms exhibited by flowers of lepidocaryoid palms. In an African genus, *Eremospatha*, a tube of connate, fibrous sepals surrounds the base of the fleshy petals (Fig. 20A) in the perfect flower. The thick wall enclosing the pistil (Figs. 20B,D) is made up of three connate petals united with a tube formed by the filaments of the six stamens. A transection of the upper part of the flower (Fig. 20C) reveals the midveins of other bundles of each petal, a bundle-free intermediate area, and an extensively vascularized stamen tube. Note that each stamen has a cen-

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separate stigmas (sti); staminodes (st) surround the ovarian region. C, Large tannin bodies are present in a section of the style and in petals (pe); sclerenchyma cells (scl) around bundles are thin-walled. D, The ovarian part of the gynoeceum is encased by a thick sheath of horizontally oriented bundles of fiber-sclereids (fs) in a tanniniferous outer layer.

tral, "multiple" bundle, and that other bundles in the androecium are reversed in orientation with respect to petal traces. Scales and bundles at the top of the pistil are mature and somewhat birefringent, forming a hard cap over the delicate ovarian part of the pistil. The anthers are borne in a cavity about the styles (Fig. 20D) and are protected in bud by the fibrous distal parts of the petals (Fig. 20B). Tanniniferous cells are widely distributed in the flower and are especially abundant in the upper parts of the filaments. A heavily vascularized androecium, which may be adnate to the petals and which appears to provide an extra protective layer for the ovary, is characteristic of many lepidocaryoid genera. Other protection is achieved by extreme fibrousness of sepals and petals, and by scales and tannins.

A possible relationship between the opening of bracts and flower structure can be observed in *Socratea exorrhiza* (Mart.) H. Wendl. (Fig. 22). The flower-bearing axes are enclosed in about seven tubular bracts (Figs. 6A,B). Inside the bracts, the flowers are open (Fig. 22A) and immature but fully developed. Petals of staminate flowers have opened slightly in Figure 22B, where both flowers are near anthesis. Staminate petals have very little sclerenchyma, but the abaxial tanniniferous area may discourage chewing insects (Fig. 22C). The bright areas between the anthers are sclerotic parenchyma cells which appear to provide protection and support for the long anthers. There is no tannin in the connectives of this species but the epidermal layers of each anther are tanniniferous. The pistil is sheathed by thicker perianth parts with imbricate petals, and more fibers are present in both sepals and petals in pistillate flowers. Abundant tannins and raphides and distal bundles of fiber-

scleireids (not shown) in the gynoecium also protect the ovules.

In contrast to the staminate petals in *Socratea*, petals of staminate flowers in *Ptychosperma* and the related genus *Veitchia* (Figs. 23B,D) have many fibers and distinctive tanniniferous cells between connectives. Staminate flowers of *Ptychosperma* are known to be in early bud with floral organs only partially developed when bracts open (Essig, 1973). The developing floral organs are protected in turn by each heavily fibrous sepal and petal. Patterns of sclerenchyma are similar in the related genus *Veitchia*, but petals in *Ptychosperma* (Fig. 23B) have tannin peripherally which is absent from those of *Veitchia* (Fig. 23D). Pistillate flowers of *Ptychosperma* (Figs. 23A,C) have thin but fibrous sepals, and thicker, imbricate petals with the fibers in bundle sheaths interspersed with sclerotic parenchyma and large tanniniferous cells. Note the large concentrations of tannin in the walls of the pistil and surrounding the embryo sac in the lobed ovule. It is tempting to guess that the lack of fibers in petals of staminate flowers in *Socratea* (Fig. 22C) reflects the complete development of the flowers before the several bracts open to expose them and that the many fibers in staminate petals of *Ptychosperma* and *Veitchia* protect the developing anthers when the bracts open before the flowers are fully developed.

Fibers and tannins occur in many different patterns in palm flowers. A different combination than that in *Ptychosperma* can be seen in the unusual African genus *Sclerosperma* (Fig. 24). The inflorescence is a single spicate axis with a few pistillate flowers at the base and staminate flowers above (Fig. 24A). This axis remains enclosed in two fibrous bracts until fruits are nearly mature. Pollination may be effected by

insects which crawl into the bracts but no observations have been made. Both staminate and pistillate flowers have extremely fibrous sepals and petals. Petals of staminate flowers (Fig. 24B) show large, rather evenly scattered tanniniferous cells, and tannin and large raphides are present in the connectives. Petals of pistillate flowers (Figs. 24C,D) are thick and imbricate. Bundles in the lower part of the gynoeceum are immature at anthesis (Fig. 24C), but more distally the bundles have large mature fibrous caps (Fig. 24D). Tannin is also scattered in the upper part of the gynoeceum.

Sclerenchyma, in many patterns, characterizes flowers of cocosoid palms. In the pistillate flowers of *Syagrus* (Figs. 25A,B), both sepals and petals are imbricate and have many fibers. The valvate petals of the staminate flower (Fig. 25B, upper) are also fibrous and the connectives of the stamens are tanniniferous. The fleshy stigmas of the oil palm, *Elaeis*, contain both tannins and fibers, and the upper gynoeceum (Fig. 26B) shows numerous bundles with fibrous sheaths and small, completely fibrous strands around the periphery. The gynoeceum of *Orbignya speciosa* is encased by a heavily fibrous staminodial cup (Fig. 27A). The pistil contains several systems of fibrous bundles which provide an extremely tough block above the relatively small ovules (Fig. 27B). Staminate flowers of *Orbignya cuatrecasana* Dug. have hard thick petals (Fig. 28B) that show thick peripheral layers of fibers, large tannin cells in ground tissue, and large fibrous caps on the row of closely aligned bundles. Conceivably, the hard petals of many closely appressed flowers shield the anthers which previously have been protected within a woody, plicate bract, for the petals of individual flowers are not closed (Fig. 28A).

Pistillate flowers of phytelephantoid palms exhibit a different combination of protective structures. Pistillate inflorescences are largely enclosed in leaf sheaths at anthesis and the many long petals of the flowers shield the ovaries. There are some sclerotic parenchyma cells in the long style (Fig. 29B), but large tanniniferous cells appear to provide protection in styles and petals. The gynoeceum also has a peripheral layer containing horizontally aligned bundles of fiber-sclereids and abundant tannin (Fig. 29D).

Discussion

Protection of pollen and ovules in palms has involved selection for and coordination of characters at different structural levels. Protection at the morphological level is by different forms of leaf bases, bracts, emergences such as trichomes and spines, floral organs, and by other mechanisms—pits and other spines—which are formed from modified organs or combinations of organs. Fibers and sclereids in appropriate locations provide cellular protection and intracellular substances, identified as tannins, raphides, and silica, provide chemical defenses. Selection at each level appears to have operated to coordinate these protective aspects within each kind of palm, and an intricate correlation of structure with phenology is also evident.

Some groups of palms are characterized to a degree by the presence of certain of these protective mechanisms (Table 1). One or two mechanisms are strikingly exploited by some groups, e.g., the fibrous carpels of *Nypa*, the raphides, or raphides and tannins in pseudophoenicoid, ceroxylod, and chamaedoreoid palms, and the elaborate pits of geonomoid palms. Several complementary mechanisms may predominate in other groups. For example, in coco-

soid palms thick bracts may be associated with a heavily fibrous perianth and frequently with the presence of tannin, raphides, or fibers in the gynoeceia of larger pistillate flowers. Large flowers tend to have more protective mechanisms.

Size of flowers may, in fact, be one of the factors that has evoked the evolution of protective mechanisms. Other factors may be the often slow development and long exposure of buds on inflorescences such as those of *Ptychosperma*, in which months are required before flowers reach anthesis (Essig, 1973), as well as the need for continuing protection of the ovule during development of fruit and seed. A major factor appears to have been the tremendous number of insects to which palms are hosts—752 insects have been identified on the coconut (*Cocos nucifera* L.), 336 on the oil palm (*Elaeis guineensis* Jacq.), and 136 associated with the date palm (*Phoenix dactylifera* L.) according to Lepesme (1947). About one-third of these insects are beetles which, as an order, are known to feed on pollen and to chew ovules and other floral parts. This insect association may be due in part to the nutrient content of the sap of many palms which appears to be high, witness man's tapping of inflorescences in *Arenga*, *Borassus*, *Caryota*, and *Cocos* for sap from which sugar and alcohol are prepared.

Southwood (1973) has stated that plants and insects are two coevolving, competing, often mutually dependent, biochemical systems. It seems reasonable to infer coevolution with insects as a major factor in the evolution of the many protective mechanisms of palm flowers, just as mammals and birds appear to have figured in the evolution of palm fruits. The work of Essig (1971) on the elegant system of pollination in *Bactris*, for example, now enables us to

understand the lack of protection in the staminate flowers, which serve as food for beetles, and the development of fibers in the pistillate gynoeceium, which must resist feeding. Further extensive and intensive studies of phenology, floral biology, and general animal-palm interrelationships are required before our increasing knowledge of the morphology and anatomy of palms can be interpreted biologically.

Acknowledgments

Acknowledgment is due several persons who have contributed materials or photographs used in this paper. Collectors and collection numbers of voucher specimens, mostly on deposit at the L. H. Bailey Hortorium (BH), are given in the legends for figures. For photography, we are especially indebted to Howard H. Lyon of Cornell University who is responsible for Figures 2A,C, 3B,C,D, 6D, 8, 9, 10A,C,D, 11, 12,B,C, D, 13B, 14, 15A, 16, 17, 18B,C,D, 19–26, 27A,B, 28, 29. Other photographs are by the junior author except 2B, 7B by the late P. H. Allen, 2D by J. Blakeslee, 13C,D, 15B, 27C,D by M. V. Parthasarathy, and 13A by the senior author. We are also grateful for the technical assistance of Mrs. Janice Kaltaler who prepared many of the slides and all of the plates.

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NOTES ON CULTURE

Member Barry R. McElmurry writes:

"On Page 64, Vol. 17 no. 2 of *PRINCIPES*, I read of the high mortality encountered in transplanting seedlings. I recently had 100% success on 14 seedlings of *Chrysalidocarpus lutescens* and *Archontophoenix Alexandrae* using the following method: I immerse the entire plant mass, dirt, plants and all in water so that all is covered. Separate plants gently, under water. Prepare pots and plant palms one at a time, gently, with loose sandy mix, and water immediately and heavily. The seedlings were 2-3" tall with one or two leaves each. Hope this helps someone. At least it's something to try.

Fivestriped Palm Squirrel Nests on Cuban Palm

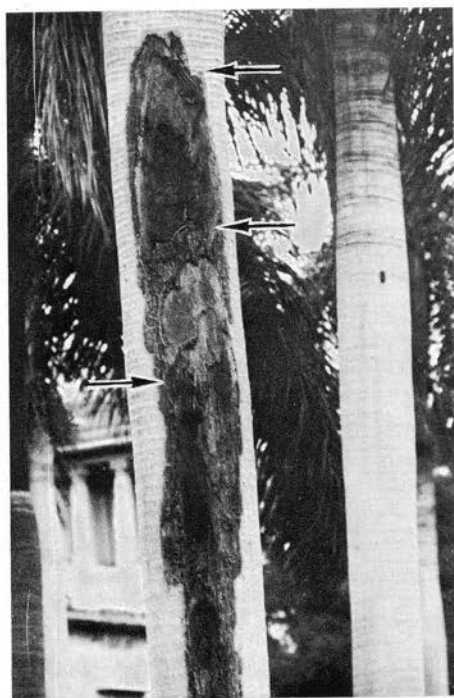
Field observations of the author in Baroda, India, during March and April, 1973, confirmed his observations of the past several years that the fivestriped palm squirrel, *Funambulus pennanti* Wroughton, built her nest in a hollowed trunk of a Cuban palm, *Roystonea regia* (HBK) O. F. Cook, which is cultivated in Indian gardens. The pinnate leaves of the palm and a grass, *Cynodon dactylon* (Linnaeus) Persoon, locally known as daro grass, were utilized in lining the hollow.

The food of this squirrel during the summer includes buds, fruits scattered on the ground, and the bark of *Roy-*

stonea regia. Two young fed on the trunk portion of the palm also, causing considerable damage as can be seen in the photographs accompanying. The palm, if further damaged, becomes dry and dies in a couple of years.

In the compound of the Kirti Mandir or "Temple of Fame" (the Westminster Abbey of the former rulers of Baroda State), the author has seen several such palms with holes in the trunk left alone by squirrels in the past; the animals prefer a fresh trunk in which to build a nest.

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1. Damaged trunk of *Roystonea regia* with arrows pointing to two young and mother squirrel feeding on the bark and trunk; an undamaged palm stands at the right. Photograph courtesy Department of Archeology and Ancient History, M. S. University of Baroda.



2. Arrow points to one young squirrel in the hollow while another young squirrel and the mother rest on the trunk below. Photograph courtesy Department of Archeology and Ancient History, M. S. University of Baroda.

Report of the Lethal Yellowing Symposium at Fairchild Tropical Garden, Miami

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The first international meeting of scientists engaged in research on lethal yellowing disease of coconut (*Cocos nucifera* L.) and related fields took place at Fairchild Tropical Garden on September 20-22, 1973. The research symposium was sponsored by Fairchild Tropical Garden, The Palm Society and the Save-the-Palms Committee, an *ad hoc* group of Coral Gables citizens. The Tourist Development Authority of Miami Beach gave financial support for the meeting. The purpose of the symposium was to bring together 28 researchers from the U.S., Jamaica, England and the United Nations in order to exchange ideas and information regarding this fatal disease which has attacked coconut, and apparently *Veitchia merrillii* (Becc.) H. E. Moore and *Pritchardia pacifica* Seem. & H. Wendl. in Miami (See: Parthasarathy and Fisher, *Principes* 17: 39-45. 1973). The symposium included a tour of the palm collection at Fairchild Tropical Garden, visits to sites of the disease and experiments on diseased palms in Miami, the presentation of technical reports with useful questions and discussions, and perhaps most important, the establishment of an on-going organization to promote international collaborative research on lethal yellowing disease of coconut.

Abstracts of Papers

The coconut palm as an object for phytopathological investigation.

By P. B. Tomlinson (Harvard University, Petersham, MA 01366). The coconut palm, *Cocos nucifera*, is a woody tropical monocotyledon, lacking any mechanism for secondary addition of vascular tissues. It possesses a single apical meristem, does not normally branch vegetatively, and cannot be propagated by vegetative means. There is no dormancy mechanism and leaf production is at a relatively constant rate. The root system is entirely adventitious. Most varieties are facultatively out-crossing. With its massive primary construction, the coconut palm is a particularly difficult organism to work with by orthodox histological and physiological procedures. This, and the fact that it is a tropical plant, means that it has not been investigated in any detail by agronomists. There is considerable dearth of information about its physiology. Our present understanding of the anatomy of the coconut is reviewed in relation to the anatomy of smaller palms which have been investigated in detail and in relation to anatomical symptoms of lethal yellowing. The need for an intimate knowledge of the structure and function of healthy coconut palms is stressed.



The history of lethal yellowing in Florida. By G. H. Gwin (Florida Division of Plant Industry, P.O. Box 338, Miami, FL 33156). Florida's coconut palms, 'Jamaica Tall' (*Cocos nucifera*), and possibly two other palms, (*Veitchia merrillii* and *Pritchardia* sp.) are threatened with extinction by the continued spread of a disease or diseases, believed to be lethal yellowing. This blight was first observed on the mainland of Florida during the fall of 1971 and has extended throughout three counties, Dade, Broward, and Monroe, from a first count of 50 cases to an estimated 15,000 at the present time. The Florida Department of Agriculture and Consumer Services has placed a quarantine on Dade, Broward and portions of Monroe counties. In cooperation with the University of Florida Research Center at Ft. Lauderdale and Pfizer Chemical Company, large scale field experiments are being planned using terramycin and various systemic insecticides in conjunction with removal of diseased palms.

Co-identity of lethal yellowing with Kaïncopé disease of West Africa. By L. Chiarappa (Plant Protection Service, Plant Production and Protection Division, F.A.O, Rome, Italy). Much can be gained by establishing the co-identity of plant diseases of unknown etiology occurring in far away places of the world. The coconut disease known to occur in West Africa under the various names of Kaïncopé (Togo), Cape St. Paul wilt (Ghana) or Awka wilt (Nigeria) presents most if not all of the external symptoms of lethal yellowing. Its mode of spread is also similar if not the same. However, resistance of 'Malayan Dwarf' to the disease in West Africa appears to be different from that in the Caribbean. Also, no mycoplasmalike bodies have been so far detected in diseased African palms. The need for integrating research in the two hemispheres appears quite evident.

Differences in varietal susceptibility of coconut to lethal yellowing disease. By H. C. Harries (Coconut Industry Board, P.O. Box 204, King-

ston-10, Jamaica). In Jamaica, the three commercial coconut varieties show different degrees of susceptibility or resistance to lethal yellowing disease. Some of the varieties introduced from overseas may be grouped with one or other of the local varieties. The 'Jamaica Tall' group is highly susceptible whilst the 'Panama Tall' group is less susceptible. At the moment, the 'Malayan Dwarf' is the sole example in the highly resistant group but it may become possible to select resistant lines from some of the varieties in the 'Panama Tall' group. Other varieties remain to be tested. Due to the difficulties associated with lethal yellowing disease and with coconut breeding, improvement by selection is likely to be a long-term procedure. A better way of producing improved coconut varieties is to make F_1 hybrids, since present evidence suggests that the disease resistance of certain hybrids is satisfactory. Mass controlled pollination techniques developed for this purpose may also be used to produce breeding material for genetic studies and, if a satisfactory way is found for testing lethal yellowing resistance, for the production of new, true-breeding varieties.

Research answers to layman's questions on lethal yellowing disease.

By D. H. Romney (Coconut Industry Board, P.O. Box 204, Kingston-10, Jamaica). (1) Do palms slowly decline in yield and vigour for several years before visible symptoms of lethal yellowing disease occur? There is no decline until a few weeks before visible symptoms. (2) Do cultivation and weed control influence spread of lethal yellowing? The evidence is inconclusive. (3) Does lethal yellowing attack rapidly growing palms before poor palms? Good growing conditions or fertilizer do not encourage attack.

(4) Will coconut palms remain free from lethal yellowing if they are shaded? Shade from above or as a result of dense planting, reduces visible symptoms, but shade also reduces growth and yield. (5) Do coconut seed and young plants carry lethal yellowing? Available evidence indicates that this does not occur. (6) Are coconut palms with visible symptoms a source of infection, and should they therefore be removed? Palms with symptoms are probably infectious, but it is likely that they are a greater source of infection before symptoms are visible. In Jamaica, available funds are spent on replanting and research rather than on disposal of affected palms. (7) Can lethal yellowing be controlled by use of insecticides? Control by insecticides is a possibility, but there are many problems relating to method of application and choice of chemical with reference to efficacy and safety. Identification of a vector and knowledge of its habits would aid in the development of a practical control method. (8) Should 'Malayan Dwarf' be planted under 'Jamaica Tall' affected with lethal yellowing? Underplanting increases the opportunity for a new strain of the disease to attack 'Malayan Dwarf,' but underplanting has been done for many years without this occurring. Farmers cannot wait for all their 'Jamaica Tall' to die. It is hoped that research will lead to a control method which can be applied if 'Malayan Dwarf' should be attacked.

Diversity of procaryotes associated with plant disease.

By R. F. Whitcomb (U.S.D.A., 201 West Bldg., A.R.C.-West, Beltsville, MD 20705). Although several eubacterial inhabitants of xylem were among the first bacteria shown to cause plant disease, definitive etiological proof concerning other procaryotes has not as yet been provided.

Nevertheless, there is good circumstantial evidence that a large number of insect-borne plant diseases are caused by procaryotes other than eubacteria. For example, several noncultivable xylem-inhabiting microorganisms that resemble *Rickettsia* or small gram-negative bacteria have been implicated. A large cluster of diseases (the "yellows" group) is apparently caused by wall-free procaryotes that structurally resemble *Mycoplasma*, *Acholeplasma*, or *Hemobartonella*. *Acholeplasma laidlawii* has appeared in cultures from diseased plants, but its frequent presence as a contaminant of sera and media obscures the meaning of such isolations. The only wall-free procaryote associated with plant disease that has been cultivated and characterized is *Spiroplasma citri*, which differs from other microorganisms in being wall-free but helical and motile. Although existing taxa provide useful models for experimentation, many procaryotes associated with plant disease may have unique physiological properties not possessed by known microorganisms.

Ultrastructural studies on palms affected by the lethal yellowing disease. By M. V. Parthasarathy (Division of Biological Sciences, Section of Genetics, Development and Physiology, Cornell University, Ithaca, NY 14850). Electronmicroscopic studies of coconut, *Pritchardia* and *Veitchia* palms affected by the lethal yellowing disease in Florida, and of coconut palms affected by the same disease in Jamaica have revealed polymorphic, mycoplasmalike organisms (MLO) in the sieve elements of young inflorescences and immature leaves. The presence of MLO in the phloem of all the three species of palms affected by the disease together with the absence of other pathogens in the earliest symptoms of the disease suggest that

MLO may be the causative agents. Structural changes that are frequently seen in or near the necrotic parts of the affected palms include the collapse of phloem cells, plugging of xylem elements with an amorphous substance, presence of electron-dense material between the plasmalemma and cell wall in parenchyma cells, and the occurrence of tubular structures in some nuclei of parenchyma cells. The chloroplasts also undergo structural changes when the leaf of an affected palm turns yellow.

Transport in palms. By M. H. Zimmermann (Harvard University, Peter-sham, MA 01366) and J. A. Milburn (University of Glasgow, U.K.). Long-distance transport occurs through primary tissues which, once formed, must remain functional throughout the entire life span of the palm. Physiologically, on the other hand, it does not seem to differ from transport in other higher plants. Phloem and xylem systems are related but quite separate, normally operating at vastly different pressures (e.g. -10 bars in xylem, +20 bars in sieve tubes) and usually transporting in opposite directions. Water and solutes can be transferred from one to the other however. The two translocation systems could transmit diseases in two main ways: (1) pathogens or poisons can spread rapidly. Xylem-sap velocities range from 1 to 50 meters per hour depending on vessel size and environmental conditions, phloem transport velocities are of the order of 0.5 m/h. (2) The disease may incapacitate the transport systems themselves. Wilting may result from xylem failure when leaves are inadequately supplied by water, but wilting may also be caused by toxins which poison living cells. Phloem failure does not have to become evident immediately unless it occurs in growing organs. Phloem failure in the

stem causes root starvation; growth of the crown eventually suffers from root failure.

Mechanical transmission of the pathogen of lethal yellowing of coconut palms—early success and recent failure. By D. A. Roberts (Plant Pathology Dept., University of Florida, Gainesville, FL 32601). Seven years ago, W. C. Price and A. P. Martinez became the first to transmit mechanically a pathogen from mature lethal yellowing-diseased coconut palms to previously healthy coconut palm seedlings of a common tall variety. Since that time, the pathogen has been transmitted mechanically to 52 of 124 test palms in 13 experiments at Key West, Florida. But the pathogen has never been so transmitted in Jamaica, where assiduous efforts have thus far failed. Diametrically opposed results in two locations could have been due to differences in: (1) freshness and potency of inocula, (2) physiological and genetic conditions of test palms, (3) environment, and (4) species or strains of the causal agent. I believe, regardless of whether the agent of lethal yellowing is a virus, a "viroid," or a mycoplasma-like organism, that scientists will ultimately develop techniques to permit its mechanical transmission wherever it occurs.

Ecology of leafhoppers. By R. F. Whitcomb (U.S.D.A., 201 West Building, A.R.C.-West, Beltsville, MD 20705). Leafhoppers (Homoptera: Cicadellidae) are often dominant components of the communities of sucking insects which utilize plants as a resource base. Division of resources of single plants occurs by selection of xylem, phloem, or parenchyma as feeding sites. Division of resources within a given community of plants is achieved mainly by host selection. The tendency toward specialization is broadly related to leafhopper phy-

logeny. Host spectra of cicadellid species are best envisioned as spaces within the matrix of plant phylogeny. Since the volumes of these spaces vary continuously, distinctions between polyphagy, oligophagy, and monophagy are blurred. The diversity of cicadellid fauna in plant communities is closely related to plant diversity, a correlation that is strengthened when one considers only perennial plants. Many plant communities, particularly those of agricultural interest, are of recent origin, or are periodically stressed. In such communities, the cicadellid biomass is composed chiefly of a few dominant species. These species are more general in their phytophagy and dispersive ability. They are also much more apt to be important as vectors of plant disease.

Lethal yellowing of coconut palms—vector studies and a possible control. By James A. Reinert (University of Florida, Agricultural Research Center, 3205 SW 70 Ave., Ft. Lauderdale, FL 33314). Surveys and records at the State Arthropod Collection in Gainesville, Fla., reveal 117 insects and 17 mites inhabiting coconut palms (*Cocos nucifera*) in Florida. These include 22 species of Homoptera (4 planthoppers, 4 aphids, 3 white flies, 7 scales, and 4 mealybugs), 5 species of Thysanoptera (thrips), and 17 species of Acarina (15 spider mites and 2 eriophid mites) which should be tested as possible vectors of lethal yellowing. *Haplaxius crudus* van Duzee has been used in extensive vectoring tests, but no disease transmission has resulted. Sticky traps were the most successful means of sampling for insects in palms. Applications of systemic insecticides (bark applications, trunk injections, root injections, soil drenches, and bud drenches) are being directed at potential vectors to prevent disease transmission to healthy

trees. Apparent prevention of vectoring has been observed in *Veitchia merrillii* which is declining from lethal yellowing or a similar disease. Only 2 of 21 palms treated with dimethoate and carbofuran by soil drenches and trunk applications have died after 6 months of treatments while 22 of 28 of the untreated check trees have declined. These results are preliminary and further tests are being conducted.

Current attempts to find a vector associated with lethal yellowing disease of coconut. By M. Schuiling and C. G. Johnson (F.A.O. and Overseas Development Administration, Lethal Yellowing Team, respectively, Coconut Industry Board, P.O. Box 204, Kingston-10, Jamaica). In the past, testing leafhoppers as vectors of lethal yellowing disease of coconut (*Cocos nucifera*) did not include deliberate acquisition feeding. Current methods include observed acquisition feeding in the laboratory at approximately 26°C and also out of doors on expanded leaves, spear leaves and flowers from diseased palms; insects are kept on these tissues for a period likely to result in the insects becoming infective, namely for 3–4 weeks before transferring them to test palms. Mortality of all tested species is very high. Only a few insects survive a 4-week feeding period. The leafhoppers currently being tested, mainly as adults collected from the field, all feed on coconut. They are: *Haplaxius crudus* van Duzee, *Antillixius* sp. (Cixiidae), *Omolicna*, probably *O. cubana* Myers and *O. proxima* Fennah (Derbidae), *Colpoptera elevans* Walker (Issidae) and *Psenoflata brevis* van Duzee (Flatidae). The aphid *Cerataphis variabilis* HRL and a scale as yet unidentified, both spear feeders, are also being tested. Twenty-three different experiments have been in progress since Oc-

tober 1972. Most are still within the incubation period of the disease. No transmission has been observed so far.

Some attempts to rear potential leafhopper vectors of lethal yellowing. By S. J. Eden-Green (Overseas Development Administration, Lethal Yellowing Team, Coconut Industry Board, P.O. Box 204, Kingston-10, Jamaica). This work derives from the need both to provide insects for transmission tests and to elucidate the life histories of the species concerned. Of the potential vectors described by Schuiling and Johnson above the only nymphs found on coconut leaves are those of *Colpoptera* (? *elevans*, Walker) and *Psenoflata brevis* van Duzee. Until recently, nymphs of other species could not be recognized in the field. In the laboratory, eggs of *Haplaxius crudus* van Duzee, *Omolicna* (? *cubana*, Myers) and *Colpoptera* can be obtained by caging insects for a few days over moist coir. Eggs of the first are embedded in the substrate and of the two latter deposited exposed on the surface. *Haplaxius* larvae emerge within 12–13 days, and can be reared to maturity on grass roots within 7–8 weeks; although the production of viable breeding colonies of this species requires improved techniques, it is now possible to identify and collect larvae in the field. Nymphs of both *Omolicna* and *Colpoptera* emerge within 15–20 days and both have been reared in the laboratory; but lack of knowledge about the habitats of larvae of *Antillixius* sp. hinders further progress. Rigorous testing of all potential vectors will be achieved only when their life histories are fully understood so that all possible modes of transmission can be investigated.

Results of tetracycline therapy in Jamaica. By P. Hunt (Botany Dept., University of the West Indies, Kingston-7, Jamaica). Preliminary experi-

ments to determine uptake and retention of tetracycline-HCl by detached coconut leaves revealed necrotic flecking of pinnae 4-5 days after cut petioles were immersed for 24 hours in solutions stronger than 500 $\mu\text{g/ml}$. Bioassay of affected leaflets showed a tissue concentration of 80 $\mu\text{g/g}$. Thus, in order to obtain therapeutic concentrations in the tissues in attempts to treat diseased trees, it is desirable to use comparatively large volumes of dilute antibiotic to reduce the risk of toxicity at the introduction site while obtaining therapeutic concentrations in the tissues. Spraying of leaves or soil drenching of trees did not result in uptake. In 12 early stage lethal yellowing-affected trees treated with 1 liter of 2% aqueous tetracycline-HCl by gravity injection via a sloping one-inch-diameter bore-hole, the concentration in leaflet tissue reached a maximum of approximately 12 $\mu\text{g/g}$ 5-7 days after treatment. Six further re-treatments at intervals over a 5-month period maintained the concentration at never less than 3 $\mu\text{g/g}$. All of 12 matching control trees injected similarly with water died within 3-7 months. Of the 12 treated trees, four (those with least leaf yellowing initially) lost all symptoms and now (10 months since last treated) appear quite normal; six showed varying extents of symptom retardation of cessation when compared with their controls; two treated trees (those initially having most leaves yellowed) did not respond. In all instances of retardation or remission of symptoms, leaf yellowing proceeded at the same rate as in untreated trees for at least 60 days and was not fully arrested until 85 days after first treatment. Similarly, nutfall was not arrested for 60 days. These findings differ from those of McCoy in Florida who, using much lower quantities of antibiotic, often achieved much more rapid, but less prolonged, remis-

sion. Nevertheless the positive responses to tetracyclines in Florida and Jamaica support the concept of a similar or identical mycoplasma-like organism as the causal agent of lethal yellowing in both countries.

Antibiotic treatment of lethal yellowing. By R. E. McCoy (University of Florida, Agricultural Research Center, 3205 SW 70 Ave., Ft. Lauderdale, Fl. 33314). A series of three antibiotic therapy tests on coconut and one series on *Veitchia merrillii* and *Pritchardia thurstonii* F. Muell. & Drude were carried out in Miami, Florida beginning in May 1972. In series I on coconut, 29 palms in various stages of disease development were selected and administered .05-20 g oxytetracycline-HCl or tetracycline-HCl through either gravity flow or pressurized trunk injection. All symptom development in eleven of these palms stopped for 4-7 months following treatment. Of 18 palms continuing to develop symptoms, 8 showed definite signs of remission in the form of fruit set and retention and production of healthy new inflorescences within the succeeding 3 months. Six of the 10 remaining palms were showing yellowing symptoms at time of treatment and 4 had received 0.5 g or less of actual antibiotic. Trees in which symptom expression has resumed after a remission period of 4-7 months have responded to re-treatment. Two trees originally expressing symptoms in June 1972 have been kept in remission through September 1973. Series II (pressurized trunk injection) on coconut was performed on 51 trees showing primary (pre-yellowing) symptoms of lethal yellowing. Oxytetracycline-HCl, 2 g/tree, produced 10 remissions in 10 treatments. Tetracycline-HCl, 2 g/tree, produced 4 remissions in 6 treatments. Penicillin-G, streptomycin, and griseo-

fulvin trunk injections, and oxytetracycline-HCl soil injections had no effect on disease development as compared to untreated palms. Series III on coconut established that doses of oxytetracycline-HCl as low as 100 mg/tree could be effective in producing remission of lethal yellowing in trees in early stages of disease development. Diseased *Veitchia* palms treated with oxytetracycline-HCl did not respond to treatment, whereas diseased *Pritchardia* palms began to produce healthy new leaves and inflorescences within 3 months of treatment. Conclusions from these tests are that 1 to 3 g doses of tetracycline antibiotics can produce disease remission in coconut and *Pritchardia* palms, that this remission is temporary but renewable, that early treatment gives best results, and that the causal agent is most probably a mycoplasma-like organism.

Some preliminary results of possible transmission of lethal yellowing from diseased *Veitchia* via dodder were informally presented by H. C. Burnett (Florida Division of Plant Industry, Drawer A, F.V. Sta., Winter Haven, Fl. 33880). Several dicotyledons have shown decline and apparent yellowing symptoms after union with diseased palm leaves via dodder plants. The dicotyledons still must be examined with the electronmicroscope for verification of pathogen transfer.

Summary

Strong evidence was presented that indicated a mycoplasma as the pathogen. Mycoplasma-like bodies have been found in diseased coconuts from Jamaica and Miami and in diseased *Veitchia* and *Pritchardia* palms from Miami. Antibiotic sensitivity of Jamaican and Miami diseased coconuts (penicillin insensitive, tetracycline sensitive) also supports a

mycoplasma cause. However, the evidence is not conclusive. The agent of the disease has not been isolated and transmitted, the vector (presumably an insect) is unknown, and the antibiotic sensitivity of *Veitchia* and *Pritchardia* palms and West African diseased coconuts must be worked on.

It is still too early to know if tetracycline (terramycin) therapy will give a permanent cure. The only known way to prevent the disease is to plant with resistant coconut varieties (e.g., 'Malayan Dwarf'). There has been no work on resistance in *Veitchia* or *Pritchardia*.

The participants established the "International Council on Lethal Yellowing Disease of Coconut" that will be responsible for international collaborative programs on lethal yellowing research. Its objectives are: to improve exchange of information, to promote collaborative efforts on similar problems, to identify and integrate priority research areas, to attract additional expertise, to procure financial support for specific projects, to organize future meetings. The elected steering committee members are: Chairman, Prof. P. B. Tomlinson (Harvard University), Vice-chairman, Dr. R. F. Whitcomb (U.S.D.A.) and Prof. L. H. Purdy (University of Florida), Secretary, Dr. L. Chiarappa (F.A.O.). Researchers interested in contributing to work on this disease are encouraged to write to Dr. Tomlinson or Dr. Chiarappa (see Abstracts for addresses). The following are recommended priority areas in need of research: 1) West African diseased palms should be: examined under the electronmicroscope to locate mycoplasma-like bodies, tested for antibiotic sensitivity, and surveyed entomologically to locate vectors. 2) Resistance of 'Malayan Dwarf' coconut, *Veitchia* and *Pritchardia* should be tested under West African conditions.

3) A full record of disease occurrence should be maintained in existing valuable palm collections as a means for identifying additional sources of resistance. 4) A second symposium of

researchers will be planned for 1975, possibly meeting in Jamaica.

The publication of this report was supported by a grant from the Tourist Development Authority of Miami Beach.

LETTERS

The undersigned is writing a horticultural handbook on subtropical palms to be published in about two years by the Huntington Library, whose "Palms and Cycads" by William Hertrich is now out of print. The new work will be extensive, consisting of about 450 pages, and will deal in alphabetical order with some 150 species, giving for each the synonymy, a concise description, the geographic range with exact localities, and notes about history, variation, hardiness, and culture. An appendix will list additional species which are, or might be, frost-tender but cool-tolerant, with references to pertinent literature. Separate chapters will discuss such subjects as palm classification above the generic level, landscaping, hybridizing, soils, fertilizing, diseases, pest-control and public collections; concluding will be a glossary and a bibliography. Aside from well-known palms, others that should be widely grown, such as *Ceroxylon* and *Brahea*, will be thoroughly treated. As far as possible, each species will be illustrated.

At present I am summarizing the literature, but if the book is to be truly useful it should also include information from Palm Society members about their cultural experiences, especially as to hardiness. I would like to hear from any members who have such information not already appearing in print; I may not be able to answer or carry on extended correspondence, but the information will be gratefully received and make the book more useful to palm enthu-

siasts. Good quality photos are also needed, particularly of species not illustrated in the literature.

I am especially interested now in hearing from those who have grown any of the following species where they have been subjected to temperatures below 35°F.: *Acrocomia aculeata*, *A. belizensis*, *A. crispa*, *A. fusiformis*, *A. hospes*, *A. mexicana*, *Arenga microcarpa*, *A. obtusifolia*, *A. wightii*, *Attalea guaranitica*, *Barbosa pseudococos*, *Borassodendron machadonis*, *Borassus flabellifer*, *Calamus muelleri*, *Carpentaria acuminata*, *Caryota mitis*, *Chrysalidocarpus cabadae*, *C. lutescens*, *C. madagascariensis*, *Clinostigma savoryanum*, *Coccothrinax alta*, *C. argentata*, *Copernicia* spp., *Euterpe edulis*, *Haitiella ekmanii*, *Hyphaene crinita*, *Kentiopsis olivaeformis*, *Laccospadix australasica*, *Licuala spinosa*, *Livistona alfredii*, *L. benthamii*, *L. eastonii*, *L. holtzei*, *L. humilis*, *L. inermis*, *L. japonica*, *L. jenkinsiana*, *L. loriphylla*, *L. muelleri*, *L. rigida*, *L. saribus*, *L. speciosa*, *Neodypsis baronii*, *Normanbya normanbya*, *Orbignya cohune*, *O. speciosa*, *Phoenix abyssinica*, *P. acaulis*, *P. farinifera*, *P. pusilla*, *Prestoa montana*, *Pritchardia* spp., *Ptychosperma elegans*, *P. macarthurii*, *Ravenea hildebrandtii*, *Rhyticocos amara*, *Sabal allenii*, *S. bermudana*, *S. jamaicensis*, *S. mauritiiformis*, *S. morrisiana*, *S. questeliana*, *S. uresana*, *S. yapa*, *Satakentia liukiensis*, *Syagrus* spp.

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Palmologue

Letters and Excerpts

Although bearing on the palms, an occasional letter reaches me that seems not quite suitable for publication in this journal, and accordingly I refrain from using it. Each has elicited a polite reply, but happily enough there have been only a negligible number of such letters so far. For example, a recent letter from a non-member Miamian expounds at some length the notion that The Palm Society should campaign with great vigor for the beautification of Florida highways with palms, this to be brought about by lobbying for it in Tallahassee, the state capital. The letter is cogent and states the case so plausibly that it just might be effective, but for us it contains a fatal defect, to wit, that the Society is a tax-exempt organization barred from trying to influence legislation. If the code provisions were violated, the Internal Revenue Service would cut the Society's jugular vein in half by ending its tax-exempt status and, by the same token, ending the tax-deductibility of contributions from members. Wherefore I had to inform my

correspondent that, even though we might like to see the state roadsides adorned with countless palms at enormous public expense, we are hardly in a position to agitate for it.

In another vein, a letter floats in from someone who has contemplated joining the Society, but has been tipped off that its activities are all social, and this sad fact has caused him to hesitate. My reply stated that he had been misinformed, although the regulations contain no prohibition against meetings of members even if some of them rub elbows from time to time in a palmy sort of way.

Why does a non-member write in any case, and where does he get my name and address? Heaven knows, but I don't. For a guess, he might pick it all up in one of the libraries that subscribe to this journal. But none of these off-beat letters appear below. They are all from solid members of the club. Yet this is not meant to imply that non-members are barred from these columns. They are not all that exclusive.

—Dent Smith

From Mr. M. Siksik, Tel-Aviv, Israel, August, 1973.

I enclose a few words about the palms being grown ornamentally in Tel-Aviv today, and also some photographs. My English is not so good, so please correct it if you want to print it in PRINCIPES. . . . I hope to learn and write more about palms.

Ornamentally, in Tel-Aviv today, we can see mostly *Phoenix canariensis*, *P. dactylifera*, *Washingtonia robusta* and

W. filifera along boulevards and roads, and near apartment houses.

Actually species of *Phoenix* are today the most widespread palms planted near houses in Tel-Aviv and obtained from two sources. Young plants grown from seed come from nurseries, but the mature palms are obtained by transplanting uncultivated trees. We also see in Tel-Aviv additional genera and species such as *Sabal palmetto*, *Trachycarpus fortunei*, *Chamaerops humilis* and *Livistona australis*. On sale in the



1. *Phoenix* and *Washingtonia* line the entrance to the Mique-Israel School of Agriculture.

market are potted plants of *Howeia forsteriana*, *H. belmoreana*, *Chamaedorea elegans*, *Phoenix roebelenii* and several of the species mentioned above.

The palms on both sides of the entrance to Mique-Israel School of Agriculture afford a view more beautiful than may be seen any place near Tel-Aviv. In the School's botanic garden there are a number of venerable palms that I have determined to be the following: *Arecastrum romanzoffianum*, *Butia capitata*, *Chamaerops humilis*, *Phoenix canariensis*, *P. sylvestris*, *Sabal palmetto*, *S. umbraculifera* and *Trachycarpus fortunei*.

In spite of the good climate in Israel we cannot see a great choice of palm species. I am very much interested in enlarging their number, especially in the central and southern parts of the country, for there the conditions for their cultivation are better. How can I



3. These young *Phoenix canariensis* at Tel-Aviv University will someday make a handsome entrance.

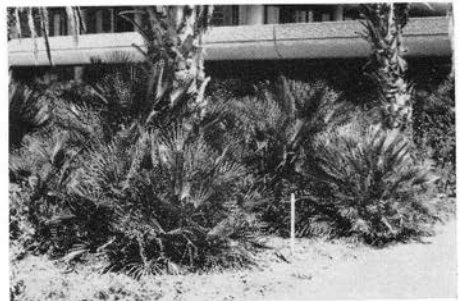
receive some palm seed to experiment with here? I thank you in advance for your help.

Mr. Siksik has since been advised of the Seed Bank services. But perhaps to extend the plantings of palms new to Israel, one or more readers can supply larger quantities of certain seed. Wherever *arecastrums* are thriving, a fair number of other palms, not mentioned in the foregoing letter, should succeed.

From the Scriptures we know there were palms in Jerusalem, whence the Christians have Palm Sunday. These palms of antiquity were unquestionably the date palms. It seems extremely unlikely that any other palms were cultivated in what is now Israel. Other palms were suited to that climate then as now, but there is no record of any others. If Solomon in all his glory had a collection of live palms, it is a secret.



2. *Arecastrum romanzoffianum* grows well in the botanical garden at Mique-Israel.



4. *Chamaerops humilis* flourish below taller palms at Tel-Aviv University.



5. *Washingtonia filifera* beside an apartment house at Tel-Aviv.

**From Prof. Harold E. Moore, Jr.,
Ithaca, N.Y.,
September 11, 1973.**

You asked about reprinting some of "The Major Groups of Palms and Their Distribution" in *PRINCIPES*. Originally, as you know, I prepared the paper with *PRINCIPES* in mind. In fact I have already cited it as "PRINCIPES 17 (in press)" in my account of palms in the tropical forests of Africa and South America that appeared in January of this year. Unfortunately, when I reviewed the suggestions of the several persons to whom I sent preliminary manuscript and acted upon them, the manuscript became much too long for *PRINCIPES* and we decided to publish it as a fascicle of *Gentes Herbarum* instead and to reprint it with separate pagination for broader distribution. We expect that this reprint will be available in mid-September and I hope that it will provide some information of use to members of The Palm Society. As I examine the galleys, however, I find it difficult to pull out pieces that would seem appropriate for separate publication in *PRINCIPES* with the possible exception of Table 3. This might prove useful as a filler item sometime in 1974 since it is a summary table. Time and the availability of more original manuscript will tell.

The work referred to consists mainly of the two considerations expressed in its title, of which the first deals with the fifteen major groups and their composition, with several tables, numerous diagnostic plates (drawings of floral parts by Marion Sheehan), photographic plates of many palms or their parts; and the second deals with the natural distribution of those fifteen major groups and the several alliances, made quite effective by a series of maps showing their occurrence throughout the world; for tables alone, as the author has noted, "fail to present distribution in so graphic a form as maps."

Some sections of the work may seem rather too technical for the generality of gardeners and growers, but by no means does this apply to it as a whole. Much of it, on the contrary, contains no difficulties of any kind for the non-botanist. All that relates to the distribution of palms is readily comprehensible by anyone interested, and it surely has direct practical implications for palm fanciers. Table 3, referred to in the foregoing letter excerpt, is a pointed instance that merits more than a fleeting glance.

As tables go, the one just alluded to is something of a marvel by reason of containing more essential information than usually found compressed into so small a space, and is of great value to anyone having more than the mildest, or even vaguest, interest in the palm family. It tabulates the "Distribution of genera, endemic genera, and species of palms by major geographic regions." Perhaps one would like to know how many palm genera and species are North American or South American, or the total number in either Western or Eastern Hemisphere. The answers are right there in the table. Or perhaps one would like to know, with some assurance of being within hailing distance, the total number of palm genera and species

on the planet. And there they are too, in good black type, easy to spot without a magnifying glass: genera, 212; species, 2,779. Granted there will be some minor ups or downs, but this is the calculation based on present knowledge. Quite apart from the table, I award three cheers plus some loud huzzahs for the maps of palm distribution. Pragmatic hints and clues for the gardener are inherent in them, and certainly he should be able to draw useful intimations if not conclusions about what to expect of his exotics.

Copies of the work may be obtained over the counter at the Fairchild Tropical Garden, or by mail from the L. H. Bailey Hortorium. It's a really first-rate contribution, even though the author calls it, in the lingo of all scientists, a "paper." Yes, it's 115 pp. of paper, crammed with clear perception of facts about palms.

**From Mrs. Robert N. Smith, Jr.,
Harlingen, Texas, August, 1973.**

The Valley had a short freeze, but there were two mornings of heavy frost, one morning of ice on the ground, and one morning of sleet, all in January, 1973. I was in Mexico at the time, and the pass between San Luis Potosí and Victoria was closed because of snow, so our bus had to detour and return via Reynosa. The lowest temperature recorded during the freeze was 25°. It stayed cool for long periods and didn't warm up fast at it usually does. The last cold spell this year came the first and second weeks in March.

Of our four bottle palms (*Mascarena lagenicaulis*), which were very large but



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6. *Roystonea regia* at the home of Mrs. Robert N. Smith, Jr., in Harlingen, Texas. One of 21 recovering from the freeze damage of January, 1973, and all grown from seed sown in 1966.



7. Some of the other royal palms on Mrs. Smith's grounds in various stages of recovery from the January injury.

always looked bad in the winter months, three were killed and one survived. Two spindle palms (*Mascarena Verschaffeltii*) were also lost. Other palms killed by the freeze were: *Cocos nucifera*, 1; *Chrysalidocarpus lutescens*, 3, and *Caryota mitis*, 2, from both of which species new shoots are rising from the roots; *Caryota urens*, 1; *Lantania lontaroides*, 6; *L. loddigesii*, 1; *Ptychosperma elegans*, 3; *Elaeis guineensis*, 1.

The hardier palms, all of which survived undamaged, are the following: *Phoenix reclinata*, 13; *P. canariensis*, 1; *P. roebelenii*, 31; *Arecastrum roman-zoffianum*, 11; *Washingtonia filifera*, 1; *W. robusta*, 36; *Butia capitata*, 2; *Butia yatay*, 1; *Livistona chinensis*, 4; *Trachycarpus fortunei*, 5; *T. takil*, 2; *Sabal texana*, 5; *Rhapis excelsa*, 3; *Erythea armata*, 4; *Acoelorrhapha wrightii*, 2.

Also surviving are the following palms uncommon in South Texas yards: *Arenga pinnata*, 1; *A. engleri*, 4; *Neodypsis decaryi*, 1; *Bismarckia nobilis*, 1; *Coccothrinax argentata*, 3; *Thrinax parviflora*, 1; *Archontophoenix* sp., 2; *Livistona mariae*, 2; *Howeia belmoreana*, 1; *H. forsteriana*, 1; *Arikuryroba schizophylla*, 3; *Chamaedorea erumpens*, 4; *C. seifrizii*, 1; *C. brachypoda*, 2; *C.*

graminifolia, 3; *Erythea armata*, 4; *Roystonea regia*, 21.

Those last, the 21 royal palms, were grown from seed we collected in Mexico in April, 1966. They are tremendous. Gradually they are losing the fronds that were damaged last January.

Rhapis excelsa will take the coldest weather. It is the only thing that did not freeze in my yard during the big freeze of 1951, when the Valley lost all its citrus crop.

An omission from the list of survivors: *Rhapis humilis*, very hardy, very beautiful. Not many to be seen here.

Mrs. Smith is the widow of the late Dr. Robert N. Smith, Jr., who gave a collection of palm fossils to The Palm Society and will be remembered by many individual members in far places who received from him gifts of other petrefactions of palm. She has always been as keenly interested in the palms as he was, as evidenced by the excerpts from her letter about the effects of the January freeze.

Harlingen, in the lower Rio Grande Valley of Texas, is but a scant few miles from Brownsville and in the approximate latitude of Miami. Outbreaks of severe cold are infrequent, but when Arctic air comes in on the wings of a norther it's time to take any tender plants to bed with you. Fortunately the lowest temperature ever recorded in Brownsville has never been repeated or even approached, officially 12° F. in February, 1899. In contrast, a high temperature of 94° occurred in February, 1912.

The royal palms grown from seed brought back by Dr. and Mrs. Smith from Mexico were already of impressive size when I saw them in 1968. Mrs. Smith observes in her letter that the arecastrums grow more beautifully where she lives than in Florida. Indisputably so, for they and many other

palms are more luxuriant where the soil is heavy instead of sandy.

**From Mr. H. A. Paden,
Fort Worth, Texas,
August, 1973.**

From other Society members I have learned of the existence of crosses between *Washingtonia robusta* and *W. filifera*, and was excited about the possible characteristics that might occur in such a plant hybrid if it could be bred and produced. The hardiness of the *W. filifera* and the beautiful emerald-green color of the *W. robusta* would be very desirable qualities to have inbred in such a palm if possible, although the reverse could result just as easily.

For those of us in the north-central Texas area the *W. robusta* lives a very tentative existence if planted here, due to its tenderness as a species. The *W. filifera*, by contrast, often does quite well and it is a shame that we can't enjoy the delights of the *W. robusta* as much as we would wish to. Thus a cross-bred plant combining the most desirable characteristics of each species would be a wonderful tree to plant.

Do you or any readers have information relative to such cross-bred palms? I would greatly appreciate such news.

L. H. Bailey, who while living was the foremost authority in the United States on the palms, monographed the genus *Washingtonia* (*Gentes Herbarum*, 1936), in which this statement appears: "Whether these two species hybridize when brought together under cultivation is not known. It appears that no cytological studies in the genus have been published."

Suspected hybrids may not have been authenticated, but it seems plausible that they may exist and also that controlled experiments with cross pollination might be successful. Quite possibly others may have more precise informa-

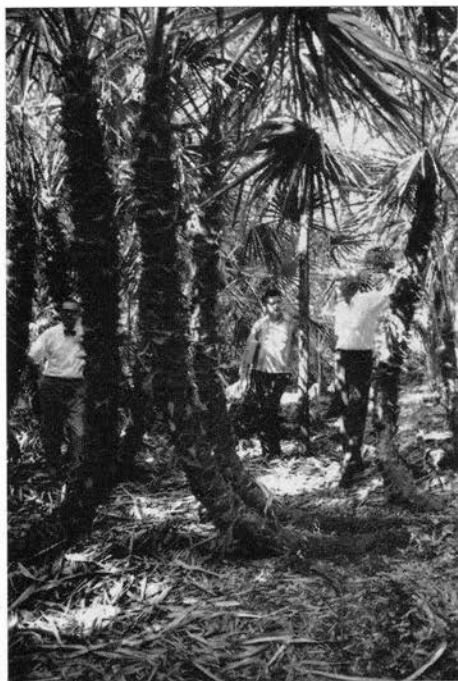
tion and will communicate it in these pages.

**From Mr. David Barry, Jr.,
Los Angeles, Calif., July, 1973.**

You have seen wallpaper with palm leaves as the motif? Now comes ceiling paper. Artists with Mitchell Designs spent a day recently at our nursery to capture the beauty of the intricate design of the leaves of our fishtail palms for a ceiling paper. It would be like looking up at the sky through a leaf. Inspiring!

One more item: Michael Taylor, the leading interior decorator in San Francisco, has bought \$4,000 of *Caryota urens*, mountain type, within the last two years, for use in interior plantings mostly on the Bay Area. Some have been planted in Beverly Hills by Mr. Taylor. Inside. All in high-ceiling rooms. And many have been photographed and shown in publications. It is the doubly-pinnate leaf that is apparently the appeal, as it is a pattern not often found in foliage.

With the "mountain fishtails" going indoors, the ceilings of those high-ceiling rooms had better be plenty high, for these palms are irrepressible, stupendous growers. Luckily, palms seldom make such rapid headway indoors as they do outdoors. About ten years ago Mr. Barry introduced to American horticulture this more cold-tolerant deviant of *Caryota urens* from the Himalayan foothills of northern India and Sikkim, and due to his enterprise I now have four flourishing examples of it, two of which are forcing their way up through the overhanging crowns of forty-foot oaks and are about to overtop them. One of these prodigious caryotas was grown from seed imported by Mr. Barry and sent to me in 1962. See his article, "The Semi-Hardy Mountain *Caryota*," *PRINCIPES* 12: 3-9, 1968.



8. Among the wild saw-palmettos (*Serenoa repens*) beside the newly opened footpath at Florida Institute of Technology, Melbourne; left to right, Dr. Jerome P. Keuper, Mr. Ken Foster, and Mr. James Joyner.

**From Dr. Jerome P. Keuper,
Melbourne, Fla., July, 1973.**

I am enclosing a photo of the *Serenoa repens* which you took on your recent visit to F.I.T. There are many hundreds of these magnificent specimens growing in the northeast section of the campus clustered in a half dozen or more definable areas. We had, of course, always known of their existence in that part of the campus, but we were not fully aware of their unusual size until recently when we completed a bridge across the creek and extended the Dent Smith Trail through that area. The new trail in this part of the campus winds around for about a half mile, although the *Serenoa repens* are to be seen only in selected spots. All who have seen them marvel at their density and height.

Me too, for before seeing them I had not suspected their presence there in such numbers. Permission to extend "my" trail was not even asked of me (tsk, tsk), but modesty kept me calm enough to be mollified upon finding all



9. BEFORE the destruction of the wild saw-palmettos on an ocean dune at Daytona Beach, where Kenneth C. Foster, had gone to photograph them.



10. And AFTER. Less than two years later, Mr. Foster returns to the identical spot where the serenoas, and the dune to boot, have since made way for construction of the new Daytona Hilton.

those saw palmettos spared intact instead of bulldozed into oblivion, which seems to be increasingly their fate in Florida. This is graphically reinforced by Figs. 9 and 10, constituting a before-and-after record of the kind of Progress in store for the wild serenoas.

From Mr. Otto Martens, Goleta, Calif., June, 1973.

While recently viewing the 1972 Mexico convention slides I came upon the Palacio Nacional, Guatemala. It was on the morning you had left for San Luis. The multi-headed *Phoenix roebelenii* flabbergasted me again and possibly will many of our members, although Hal Moore wrote me that there had been a brief description in an earlier issue of PRINCIPES.

What's so special about *Phoenix roe-*

belenii? It's what follows, making them the outstanding palms of Guatemala, in spite of all those beautiful species we found on our hunts in the jungles of Tikal, around Lake Atitlán, in patios and open places here and there:

There are two perfect specimens of *Phoenix roebelenii* in Guatemala City adorning the front landscape of the Palacio Nacional, 12' to 15' tall, each with a graceful slender trunk and well-shaped head. But it is on the west side where we get the surprise. There are three, in a row on raised flowerbeds, that are true phenomena. We have heard of and seen in California and Florida branching tops of this species, but the Guatemala specimens must be unique in the world.

Specimen No. 1 has a single trunk 5' high, then divides into two with four additional subbranches. From these latter four arise in majestic fan shape 14 more branches with healthy full crowns. Total height about 12 to 14 feet.

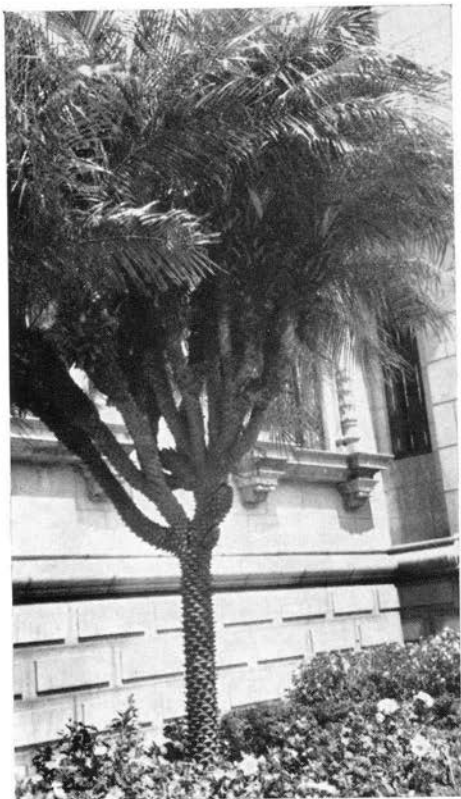
Specimen No. 2 beats its two companions in number of individual branches by far. First branching occurs from a 2½' main trunk again into a double trunk. One of these two main arms, after a length of 3', carries a fan of fifteen individual stems, the second one divides into two side branches of 4' length with eight fully developed branches and heads on one, and a fan of twenty—yes, exactly twenty—on the other, for a fantastic total of forty-three fully developed, individual heads. Phenomenal indeed!

Specimen No. 3 is more modest, but has 14 individual crowns growing in the same manner. These majestic crowns are carried apparently without difficulty and in perfect balance as the palm lightly sways in the breeze.

All three specimens are in excellent healthy condition, with dark green glossy and graceful foliage, typical of



11. Three many-headed trees of *Phoenix roebelenii* adorn the Palacio Nacional in Guatemala City.



12. Specimen number 1 has a single trunk five feet high with a total of 14 branches.



14. Specimen number 3 carries 14 crowns.

true *Phoenix roebelenii*. They fascinated me no end.

A photograph of one of the pigmy dates described above, together with a paragraph of comment ascribed to Morgan Evans, appeared in *PRINCIPES* 10: 5, 1966. It was advanced that the hand of a skilled craftsman was responsible for its strange development. Mr. Martens in his letter notes but three of those remarkable palms, but the 1966 paragraph mentions "perhaps a dozen," leading one to wonder if any had died or were transplanted to another location.



13. Specimen number 2 has a total of 43 individual heads.

NEWS OF THE SOCIETY

South Florida Meetings

On June 16, 1973, the South Florida members attended a meeting held to coincide with the Miami visit of President Ken Foster. For several reasons the meeting, held at the home of Ted and Teddie Buhler, must go down as one of the most outstanding in a long time. The good food brought by the individual members, the good fellowship and the accommodating weather all added their share.

An unprecedented number of members, some of whom came from very far away, attended and rendered the occasion a special success. In addition to President Foster, present were Vice-President Dr. U. A. Young of Tampa and Board Member Billings McArthur from Winter Park accompanied by their wives, Ben and Jane, and Dr. and Mrs. Stewart Mathews from Indian-town, also of Florida. Dr. Barry Tomlinson from Harvard was in Miami giving a special course at Fairchild Tropical Garden and with him came Larry Klotz, a student of Dr. H. E. Moore, Jr. at Ithaca, N. Y. Anthony Lambe, who presently calls Portugal his home but who is spending the summer in Miami, was another visitor from afar. And, unexpectedly but fortunately, Dr. John Dransfield, stationed at the Botanical Garden in Bogor, Indonesia, was able to be in Miami after taking part in the palm symposium at Ithaca on June 14. The highlight of the evening was Dr. Dransfield's talk on Indonesian palms, delivered under the imposing coconuts and still more imposing jetliners overflying the Buhlers' bayfront garden. The numerous and excellent slides presented impressive views of Indonesia's remaining virgin landscape and several natural palm treasures, particularly some exquisite pinangas. These had until re-

cently been virtually unknown and some are still unnamed. The Society looks forward to receiving seeds of these palms which will add to the already considerable list of exotics sent to the Seed Bank from Bogor.

* * *

On July 14, 1973, the South Florida members again had a meeting, this time for the privilege of hearing Dr. H. E. Moore, Jr., who was in Miami to give a lecture in a series entitled "Topics in Tropical Botany" sponsored by Florida International and Florida Atlantic Universities and held at the Fairchild Tropical Garden.

Dr. Moore showed slides of his wide-ranging trip last fall which included the Fiji Islands, New Caledonia, the Mascarene and Seychelles Islands, and Madagascar. We were somewhat amazed at the variety of terrain in Fiji and New Caledonia and at the extent of damage done by mining of nickel in New Caledonia. Dr. Moore's slides plainly showed how man is rapidly eliminating the last vestiges of virgin forests on Mauritius. Sometimes a few palms are allowed to remain but they may not survive and some scarce species are almost extinct. Outstanding slides showed a solitary *Hyophorbe amaricaulis* in silhouette, a grove of tall and very old *Dictyosperma album*, none of which seemed to have the very straight trunks we associate with these palms, and views of the Vallee de Mai on Praslin Island with *Lodoicea maldivica* growing not high on the hills nor actually in the bottom of the valley but only on the lower slopes. Fortunately, this area is now a reserve and these magnificent, rare, and very old trees will be preserved.

The meeting closed with a cool drink of punch and cookies offered by hostess Mrs. Ruth Shatz on her pleasant patio.

T. B. BUHLER



1. Ken Foster (left) and Otto Martens discuss *Desmoncus demeraranus* (center) during the palm party. Ken collected the seed of this climbing palm during the 1970 Biennial Meeting post-convention trip. Photo by Peter Nazarian.

California Meetings

Thanks to the tremendous enthusiasm of the members of the Western Chapter, the meeting on August 5, 1973, was a success as usual. By 1 P.M. about 60-70 members were admiring Arnold and Arline Newman's most interesting home and garden in the rugged hills of Hollywood, north of Los Angeles, California. Not only can deer, foxes, coyotes and other wildlife occasionally be seen, but the Newmans have five 2 to 4½ ft. alligators of their own and even some tortoises. They have a geodesic dome inside which are numerous reptiles and amphibians as well as exotic plants. Several species of palms as well as other tropical plants are to be seen in the gardens.

A delicious catered meal was enjoyed and the costs thereof were defrayed

partly by assessment on those present and partly from the proceeds of the plant auction held after the meeting. Being a casual group they elected Dr. Leroy Phelps to be the new Western Chapter Chairman in his absence while his wife was elected to be Secretary.

* * *

On September 8, 1973 a group consisting of 94 members and their families assembled at President Ken Foster's home in Yorba Linda, California, to honor Otto and Gertrude Martens who are moving from Goleta, California to Virginia Beach, Virginia. Those attending the meeting were greeted by a 23' banner which streaked across the upper portion of Ken's two story Spanish-style home. The banner read "Good Luck Otto—The Western Chapter will miss you!." Each member was given a



2. Assembled Western Chapter members enjoyed a catered dinner out-of-doors in ideal weather. Photo by Peter Nazarian.

special name tag proclaiming "Good Luck Otto."

For many years Otto has been a very prominent member of the Western Chapter. He is a past president of The Palm Society and is presently on the Board of Directors. He will be greatly missed by all the California members as will his devotion to, enthusiasm for, and knowledge of the palm family.

The group met at 4:00 P.M. and spent the first hour and a half looking at Ken's large collection of palms. The latest count showed 437 different species, many housed in the tropical palm house. A *Licuala* table and a "spiny palm" table had been set up under a canopy of trees where members could get a close look at some of the rarities. A variegated *Rhapis* received considerable attention: it had been a gift from Toshihiko Satake of Japan some years ago.

At 5:30 a delicious catered dinner was served out-of-doors. After the meal Ken introduced Dr. Leroy N. Phelps, newly elected Chairman of the Western

Chapter. Then Mrs. Lucita Wait, a very special guest from Miami, Florida, and an old friend of the Martens, spoke about the expanding activities of the Seed Bank. Lucita and her friend and member Mrs. Ruth Shatz delayed a trip



3. Otto holds up an 8 × 10 colored photo of himself taken by Ken Foster in southern Mexico last year during the trip following the Biennial Meeting of The Palm Society. Mrs. Martens looks on from the left. Photo by Peter Nazarian.

to California so they could arrive for the palm party, after which they were planning to spend a month sight-seeing in northern California.

The honored guest, Otto Martens, was presented a beautiful plaque from the Western Chapter. Included in the engraving was a facsimile of the royal palm, the official Palm Society emblem. Then Ken presented Otto with a framed 8 x 10 photo showing Otto looking up at an old specimen of *Astrocaryum mex-*

icanum in a lush jungle canyon. The picture had been taken last summer during the trip to southern Mexico after the Biennial Meeting.

Otto was called upon to express his feelings, which he did very eloquently, thanking the assembled majority of the members of the Western Chapter for the honors shown him. A reception line then formed and each member had the opportunity to wish Otto and Gertrude a fond farewell.

CLASSIFIED SECTION

FOR SALE: *Hyphaene Schattan* (at least 100), *Hyphaene thebaica*, *Ptychosperma hospitum*, *Scheelea Leandroana*. Many others also in 4 gal. pots. No shipping. Jack Koebernik, U.S. #1, Cudjoe Key, Florida. 305-745-3885.

NOTES ON CULTURE

I have been experimenting with different soil mixes for about three years, and have come across one that seems to have merit for potted palms. It is a peat/lite mix, and is loose, friable, 80 percent sterile, and has an abundance of good organic material.

Potted palms, which must be grown indoors during most of the year here in Portland, Oregon, thrive in this mixture. They grow steadily, put down nice thick good white roots, and the leaves take on a pretty shade of green. The mix also makes a fairly good mixture for starting seeds. The only drawback is that fertilizer must be applied often, but as with palms, this helps them even more.

To make $\frac{3}{4}$ of a cubic yard of this mix, the following ingredients should be used:

- (All measures in 1 gal. cans)
- 6 perlite
- 3 vermiculite
- 6 Mica-peat (peat moss w/vermiculite & fertilizers)

or

- 6 peat moss
- 3 barkdust
- 3 composted steer manure

To this add:

- 2 tbsp. 4-2-2 transplanter
- 4 tbsp. superphosphate
- 2 cups dolomite
- 3 tbsp. bone meal
- 1 tbsp. Ammonium Sulfate

Wet the mix before using.

This peat mix also works very well for all other types of plants. It is light in weight, making it good for shipping, and fairly inexpensive as soils go, costing about \$1.00 per $\frac{3}{4}$ cubic yard batch.

With my potted palms, I also fertilize once every other week with 20-20-20 soluble fertilizer at the rate of one tablespoonful per gallon. Between fertilizings, I water the plants with clear water to remove any salts that may build up.

KIMBALL WALLIS,
6410 SE 32 Ave.,
Portland, Oregon 97202

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