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Cover Picture

Rhapidophyllum hystrix in damp lowland flood plain forest on Tuckabum Creek, about eight miles north of Butler on Alabama highway 17, Choctaw County, Alabama. Photograph courtesy Hugh H. Iltis and University of Wisconsin Plant Geography Field Trip, 10 April 1966.

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The Needle Palm: Rhapidophyllum hystrix

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Rhapidophyllum is a monotypic palm genus endemic to the southeastern United States. Its single species, *R. hystrix* (Fig. 1), is commonly referred to as the needle palm. Other names which have been used are blue palmetto (Elliott, 1817), creeping palmetto (Small, 1923), vegetable porcupine (Small, 1923), dwarf saw palmetto (Moore, 1963), and spine palm (Mitchell, 1963).

In the United States, the needle palm is cultivated to a limited extent both within and outside its natural range. It is very cold hardy, having been successfully grown out of doors as far north as Virginia and Tennessee (Popenoe, 1973).

Outside the United States, *R. hystrix* has been successfully grown in the Black Sea region of the Soviet Union (Saakov, 1963) and on the French Riviera (Barry, 1961).

Although *Rhapidophyllum* has great potential as an ornamental because of its attractiveness, ability to withstand freezing temperatures, and ease of maintenance, it is rare in the nursery trade. Only recently has it begun to to be used in public and private landscaping. Most plants found in the nursery trade and in cultivation have been taken from the wild. This is probably due, at least in part, to the fact that seeds are slow to germinate and the plant is very slow growing. It takes from four to six years from the time seed is planted until a marketable plant is produced, thus not making it economically feasible for nurseries to grow it from seed.

Rhapidophyllum is on the rare and endangered plant species list for the United States as a threatened species which is commercially exploited. During the late 1800's and early 1900's, this palm was commercially exploited by foliage shippers. Whole crowns were cut off and shipped north for use as decoration in homes. This has been called to our attention by Harper (1906) who lamented the exploitation of this palm in the vicinity of Evergreen, Alabama. Later, Harper (1928) related that the species has been exterminated in the Evergreen area. Today the exploitation continues, but is through the nursery trade.

This paper is for a large part the result of the senior author's personal observations of both wild and cultivated specimens over a five-year period. Field observations were made throughout much of the range of the species in Florida with the more critical and detailed observations made on a population near Oviedo, Seminole County, Florida.

Taxonomic History

Rhapidophyllum is a monotypic genus of coryphoid palms in the *Trithrinax* unit of the *Trithrinax alliance* (Moore, 1973). This unit also includes the gen-

1. *Rhapidophyllum hystrix* near Oviedo, Seminole County, Florida.

era *Trachycarpus* and *Chamaerops* in addition to *Trithrinax* and *Rhapidophyllum.*

Small (1923) presented a fairly complete and accurate taxonomic history of *Rhapidophyllum* so only a few points need to be touched on here in summation and for clarification.

In 1814, Frederick Pursh described the species from material collected near Savannah, Georgia by John Fraser several years earlier, and placed it in the genus *Chamaerops.* In 1818, Thomas Nuttall, apparently having seen only sterile material, transferred it to the genus *Sabal* because of its superficial resemblance to *S. adansonii* (= *S. minor*). Finally, in 1876, Wendland and Drude found that the species could not be satisfactorily accommodated in either *Chamaerops* or *Sabal* and accordingly created the monotypic genus *Rhapidophyllum.*

Small (1923) states that the species has been placed in two other genera in addition to those previously discussed, *Corypha* and *Rhapis,* although he does not elaborate.

Dahlgren (1936), and later Glassman (1972), give *Rhapis arundinacea* Ait. (Hort. Kew. ed. 1, 3: 474. 1789) and *Rhapis caroliniana* Hort. ex Kunth (Enun. Pl. 3: 246. 1841) as synonyms of *Rhapidophyllum hystrix.* From Aiton's protologue of *Rhapis arundinacea,* it is immediately obvious that the plant described is not *Rhapidophyllum hystrix.*

William Wood (*in* Rees, Cycl. 7, n. 3. 1807) transferred Aiton's species to *Chamaerops* with no additional clues to its identity.

Finally, Moore (1975), after having examined the type specimen of *Rhapis arundinacea* in the British Museum (Natural History), revealed Aiton's species to be based on an aberrant, juvenile specimen of *Sabal minor.*

Also, *Rhapis caroliniana*, the second *Rhapis* species placed in synonymy under *Rhapidophyllum hystrix* by Dahlgren and Glassman, can also be excluded. The name *Rhapis caroliniana* is not found under the discussion of *Rhapis* which appears on pages 251–252 of Kunth (1841). However, on page 246 under the treatment *Sabal adansonii* (= *S. minor*), the name *Sabal carolinianum* Hort. is proposed in synonymy. If this is the source of *Rhapis caroliniana* Hort. ex Kunth, which appears to be the case, this name must be removed from the synonymy of *Rhapidophyllum hystrix* and added to that of *Sabal minor.*

No validly published name in *Corypha* can be accredited to *R. hystrix. Corypha hystrix* Desf. (Tabl. 1. 19. 1804) is a *nomen nudum* and in addition undoubtedly not synonymous with *Rhapidophyllum hystrix* since it is reported as a native of South America. Also, *Chamaerops hystrix* (spelled "*histrix*" by Steudel) Desf. ex Steud. (Nom. Bot. ed. 1. 183. 1840. based on *Corypha hystrix* Desf.) is also a *nomen nudum* and is accordingly removed from consideration here.

Martius (1838) provides an excellent description and illustration of the needle palm under *Chamaerops hystrix.* In addition to *Sabal hystrix, Rhapis arundinacea*, and *Chamaerops arundinacea*, Martius also lists *Corypha repens* Bartr. in synonymy. The last is now well known as *Serenoa repens* (Bartr.) Small.

Of final note, the crediting of *Chamaerops hystrix* to Fraser instead of to Pursh by some authors is an error in citation.

In summation, the following nomenclature is to be applied to the needle palm:

Rhapidophyllum hystrix (Pursh) H. Wendl. & Drude, Bot. Zeit. 34: 803. 1876.

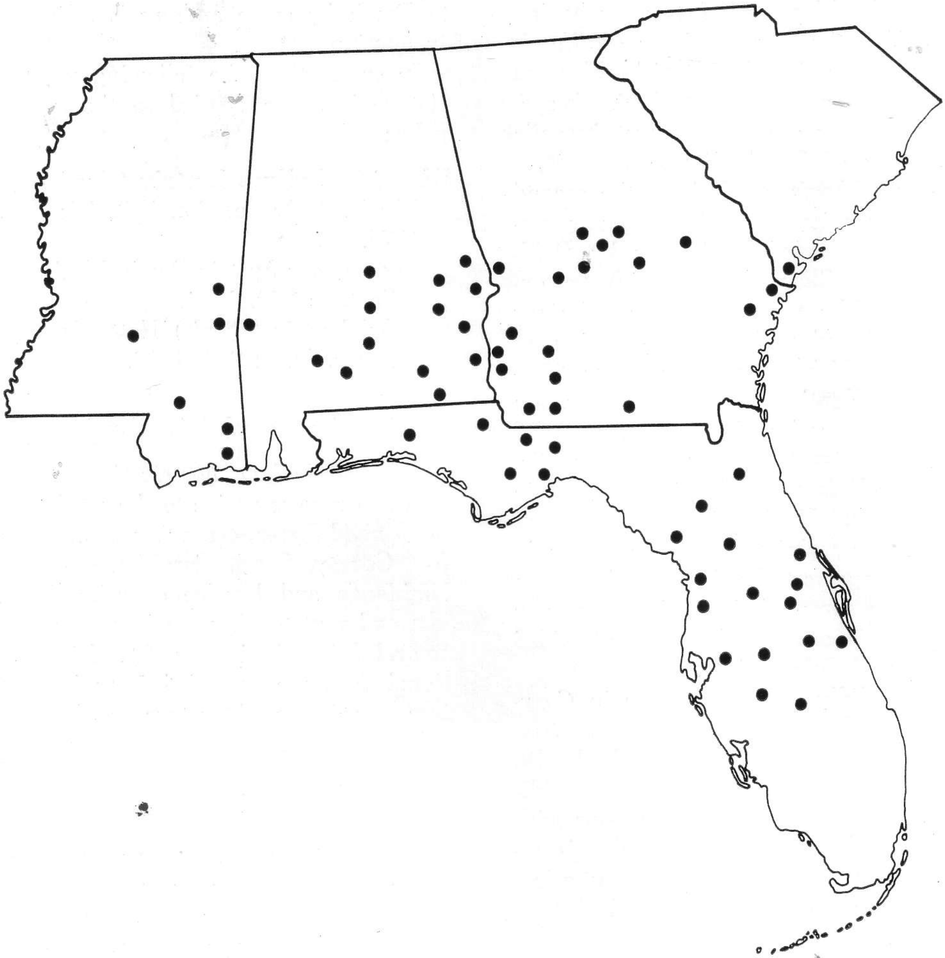
Chamaerops hystrix Pursh, Fl. Amer. Sept. 1: 240. 1814.

Sabal hystrix (Pursh) Nutt., Gen. N. Amer. Pl. 1: 230. 1818.

Habitat and Distribution

Rhapidophyllum hystrix is an uncommon species native to the southeastern United States, occurring from Beaufort County, South Carolina, south to Highlands and Hardee counties, Florida, and west to Simpson County, south central Mississippi (Fig. 2). Distributional data are compiled from herbarium specimens, literature, and sight records (pers. comm.). Questionable records in the literature which could not be verified with specimens are excluded.

Throughout its range, *Rhapidophyllum* is found primarily in low, moist to wet sites with rich, humus, calcareous clay, or sandy soils in woods, swamps, and hammocks (Fig. 3). Less commonly, it occurs in limestone sinks, grottos, and shaded pinelands. Although rarely found in full sun and well-drained sites in the wild, the species will thrive in such locations in cultivation if sufficient soil moisture is present. Specimens occasionally found in the wild on well-drained sites are generally smaller and in poorer condition as compared to those found in wetter soils. There does not appear to be a specific correlation of soil type with the presence of *Rhapidophyllum.* However, in the north central part of its range it is generally associated with



2. Distribution of *Rhapidophyllum hystrix.*

limestone soils. In central Florida, where the limestone bedrock is overlain with sandy soils, *Rhapidophyllum* often occurs in seepage areas along the edges of the various uplands constituting the central Florida ridge area.

Rhapidophyllum apparently has a fairly high degree of salt tolerance, at least for periods of short duration. To cite a specific example: a cultivated specimen in the medial strip of US 90 near Biloxi, Mississippi, which undoubtedly was submerged in salt water by Hurricane Camille in 1969 was a large and beautiful clump in 1973. It apparently was not severely affected.

Rhapidophyllum can be considered locally common or even abundant in some areas within its range, but its distribution is irregular. It was observed to be the dominant understory species in several Florida hardwood swamps, although it is rarely found where it would be highly competitive with other species.

The species does not appear to be

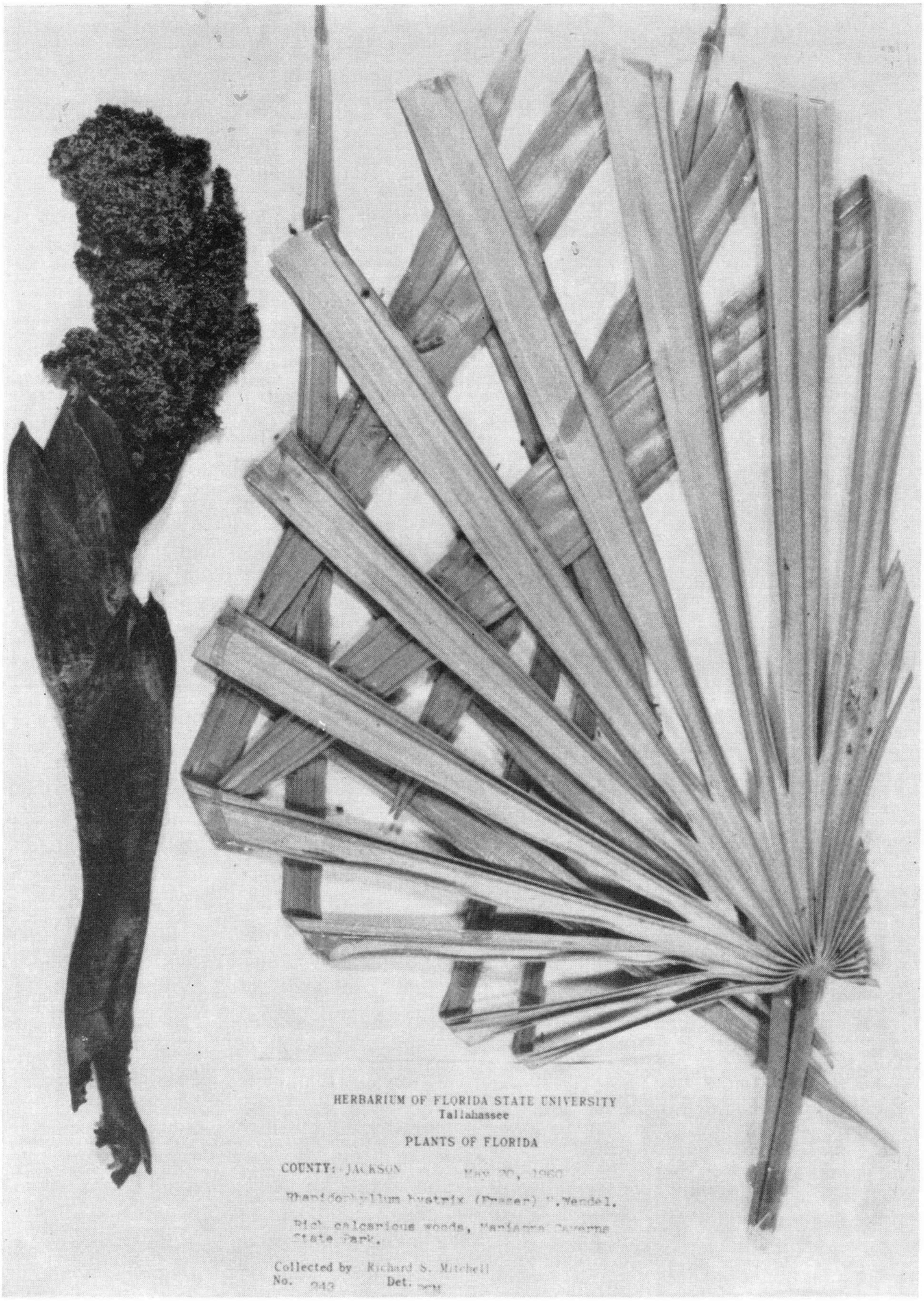
3. *Rhapidophyllum* colony near Oviedo, Seminole County, Florida.

occupying all the available suitable habitat. Many areas that appear environmentally identical from visual observations to those occupied by *Rhapidophyllum* do not support the species, even though the occupied and unoccupied areas are often found quite near one another. Also, what appears to be a uniform habitat is frequently poorly utilized by the species. Some possible reasons for this irregular distribution will be discussed later in this paper.

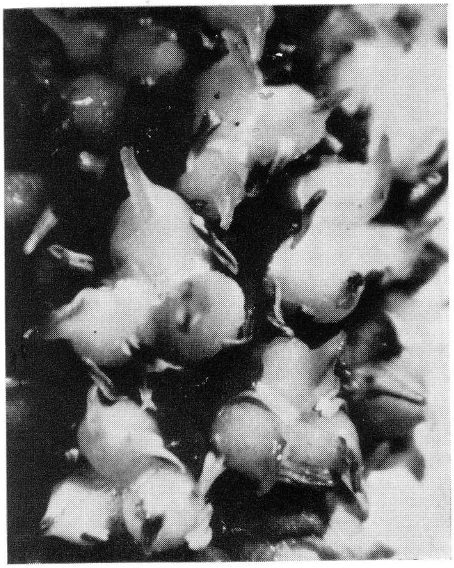
Reproductive Biology

Flowering generally occurs from March to August with flowering having been observed in both cultivated and wild plants as early as February and as late as November. Flowering in the wild is irregular and infrequent. Individual plants generally do not bloom annually. The reason for this irregularity is not known, but may be due in part to less than optimum environmental conditions. For example, flowering in central Florida populations in 1970, a wet year, was good, but since 1970 the seasons have been considerably drier and as a result flowering less frequent and more irregular. However, cultivated specimens which appear to receive sufficient moisture will also flower irregularly. Although the availability of moisture may play a role in initiating the process, flowering appears to be physiologically more complex.

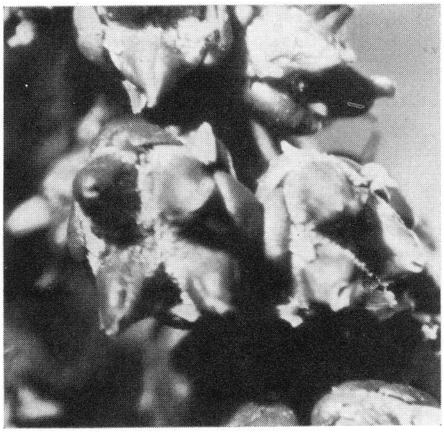
Rhapidophyllum is usually dioecious, less commonly polygamodioecious or rarely monoecious. In most populations staminate or predominately staminate inflorescences are more fre-



4. Specimen showing staminate inflorescence.



5. Close-up of pistillate flowers.



6. An unusual 4-carpellate flower (left) and a typical 3-carpellate flower (right).

quently observed than pistillate. The staminate inflorescences (Fig. 4) are the more conspicuous of the two with most or all of the inflorescence being forced clear of the bracts. The pistillate inflorescences are less noticeable, being much more constricted and not well projected from the bracts with half or more usually remaining permanently enclosed. A close-up view of the pistillate flowers is seen in Figure 5.

Flower color has been reported as being yellow, orange, or purple. We have observed all three colors in the field with purple predominant. Staminate flowers appear yellowish from a distance because of the predominantly cream-colored anthers. The calyx, corolla, and rachis vary from a dirty cream-color to pale pink to deep purple or brownish-purple. The corolla of the pistillate flowers ranges from brownish-purple to deep purple before pollination. The gynoecium in *Rhapidophyllum* is apocarpus and usually tricarpellate. However, the carpel number is sometimes reduced to one or two by abortion or rarely increased to four (Fig. 6). This latter condition is highly unusual in palms and merits further investigation. The young carpels are yellow to yellowish-green, turning yellow or yellowish-cream at anthesis. The rachis of the pistillate inflorescence is purple. After pollination, or in age, the corolla turns a whitish or yellowish color, eventually becoming brown. The four to six bracts are cream or dirty white in color, occasionally purple-tinged. Two major color variations of pistillate flowers were observed in the Seminole County, Florida populations. Two plants were seen which had a clear citrus-orange corolla and a whitish calyx. The rachis of the inflorescence was purple. A third plant was observed with an orangish-purple corolla and a purplish-white calyx. The rachis of this inflorescence was also purple. These flowers were fresh, having emerged from the bracts only a short time before observation. Although these color variations are striking, it is improbable that they have any taxonomic significance.

During the day, the staminate flowers emit a distinct musky odor. The pistillate flowers give off little or no odor during the day. However, they emit a weak version of that produced by the staminate flowers during the evening hours. It has not been determined if a fragrance is produced by either the pistillate or staminate flowers at night. The exact time relationship of the pollinator visitation needs further investigation.

Rhapidophyllum is self-compatible since isolated, cultivated plants will occasionally set abundant fruit. As the fruit matures, the white-hirsute condition, which is very evident when young, becomes more diffuse, but is persistent. The surface of the mature fruit varies from brown to reddish- or purplish-brown to red. The flesh is orangish and somewhat mealy in consistency. The fruits mature from December to February. The pistillate inflorescences remain crowded in the bracts and sheath fibers during fruit maturation. As a result, the fruits on the lower and inner parts of the stalks usually become greatly distorted (squarish or pyriform) while those on the upper part possess the more characteristic ovoid or globose shape. The fruits average 1.5–2.0 cm in diameter. Fruit clusters weighing up to 845 grams have been found. Most fruits possess a small spine near the apex of the endocarp. This spine varies from practically nonexistent to 2 mm in length. The endocarp frequently has a marking resembling that of pressed cork board. However, some endocarps, are smooth.

Inflorescences well projecting from the subtending bracts and resembling the staminate, but with scattered fruits, are sometimes encountered. This is indicative of the polygamodioecious condition. Plants have also been observed that produce abundant fruit which is smaller than normal and hollow or with shriveled, inviable seeds. These fruits are usually produced on well-projected inflorescences which resemble staminate inflorescences. The reason for this condition is unknown.

Rhapidophyllum seeds are extremely well protected by spines surrounding the trunk. They appear to be largely unattractive to animals since they are rarely disturbed. The pistillate inflorescence is so short that most fruits are caught in the cluster of petioles and needles surrounding and below it. Most of the fruits remain in the crown until they either decay or sprout. Manley (1967) found the ripe fruits of needle palm chewed on by what he thought to be mice. *Rhapidophyllum* seeds in the Seminole County, Florida populations have been found scattered around the bases of the parent plant. Most of the flesh had been removed and the seed bore marks produced by the teeth of a small mammal. The fresh mature fruit apparently has few properties to attract animals. It is bland in taste, being only slightly sweetish. Little or no odor was detected. However, overripe fruit emits a strong, overly sweet, pungent odor. Manley (1967) describes it as being like rotten cheese. It may be the odor of the overripe fruits that attracts animals. This odor is apparently produced after the fruits have been subjected to freezing temperatures.

The immature, half-formed fruits seem to be preferred by some animals over the mature fruits. Several times the remains of immature seeds were observed scattered around and near a fruiting palm. It appears that whatever feeds on the fruit, possibly squirrels, mice, or wood rats, prefers the endosperm before it becomes hard. It is also noted that the flesh of the green fruit is very astringent in taste, similar to that of a green persimmon.

In addition, many fruits are parasitized by small cereal beetles which make small burrows into the hard endosperm making an opening through the endocarp of the fruits which have the exocarp and mesocarp removed. These openings permit the easy entry of fungi and other decomposing organisms which further damage the seed so that it eventually becomes inviable. As a conservative estimate, about 20% are parasitized by these beetles.

Seed germination takes from about six months to about two years. The first divided leaves appear about three years after germination. Small, weak spines are evident at this time. Seedlings were found to be uncommon in the wild on the ground; however, many were found in the crowns of the parent plants where they germinated among the spines and thick dark brown fiber surrounding the trunk. The chances of these seedlings surviving is low because of the lack of available nutrients and water. The fiber and spines produce a favorable environment for few plants other than some fern species.

Only one *Rhapidophyllum* population was found in Florida (Stallion Hammock, Hillsborough County) where a pronounced increase in population by seedlings could be detected. The seedlings were well established on the ground and outnumbered the adult plants. The other populations examined usually did not have enough seedlings to replace even a small percentage of the existing population of palms.

One offset to poor production of viable seed in *Rhapidophyllum* is that it is relatively long-lived, allowing it to produce seed over a long period of time.

Another factor in the maintenance of populations is that the species reproduces by suckering. Although this does not increase its range at a rapid rate, it does increase its numbers within the population.

Offshoots produced by suckering plants tend to grow away from each other. In time the connection between the parent plant and the offshoot is severed by the rotting away of the stem tissue, resulting in the establishment of two individual plants.

Many *Rhapidophyllum* specimens have a slanted or decumbent trunk with three-fourths or more of it covered with a thick coat of spines and fiber. The remainder of the trunk is naked with rings of previous leaf bases quite evident. Palms with upright trunks or those in dense clumps generally have spines and fiber almost to the ground. In large plants a sizable cloak of leaf bases and fiber is retained on the trunk. The trunk may appear to be 0.5 m or more in diameter although it actually may be only 8–10 cm. The spines are the result of the partial breakdown of the leaf sheath tissue so that only the rigid sclerotic tissue persists (Tomlinson, 1962). The spines range in length from 2–4 dm. The retention of the leaf base fiber prevents the loss of the spines. It may be speculated that the spines probably evolved to protect the rather succulent flowers from herbivores rather than the growing tip of the palm. Seedlings four or five years old produce only weak spines and if spines were needed for the protection of the growing tip, they would develop early in the life history of the plant. There may have been strong predation pressure causing the palm to develop the spines and constricted inflorescences. A second reason for the leaf base and fiber retention is for the protection of the roots. It seems that the reclining trunk of most *Rhapidophyllum* in the wild is not the result of a natural tendency to lean or crawl, as it is in some species of palms, such as *Sabal etonia*, but because of unstable anchoring. Seedling *Rhapidophyllum* show no tendency to lean as do seedlings of *Serenoa* and

Sabal. As the needle palm grows, the end of the trunk rots off, taking with it any roots which would give support. In time, the weight of the palm or other forces causes the palm to tip or fall over. *Rhapidophyllum* has the ability to produce roots anywhere along the trunk, no matter what age the plant or the diameter of the trunk. A large palm examined from the Seminole County populations showed numerous roots about three-fourths the way up on all sides of the trunk 8 cm in diameter. The roots were growing among the old leaf bases and fiber, damp and well protected. The cloak of fibers therefore acts not only as an initial protection for the young roots, but as a damp medium for the roots to pass through from the trunk to the soil should the palm fall over. It also is conceivable that the young roots function as absorption organs, imbibing water from the spongy trunk mantle. On one occasion a specimen was observed with about a foot of trunk covered to ground with fiber and spines. Upon examination, it was found that only one root reached into the soil. The rest of the functional roots were found intermeshed in leaf bases and fiber.

Roots from the canopy and understory trees often invade the fibrous mantle of *Rhapidophyllum.* These roots may eventually provide support for the poorly anchored palms.

Rhapidophyllum also has the potential to produce suckers anywhere along the trunk regardless of the size or age of the plant. Suckers may be found on different plants from the base of the trunk to within several inches of the growing apex. Still, many palms fail to form suckers. Fisher and Tomlinson (1973), in their studies of the branching suckering of *Serenoa repens,* found that this species produced an axillary bud which could either produce inflorescences or suckers. Of the buds produced, about 50% abort and of the remainder, 80% produce inflorescences and only about 20% produce suckers. Also suckering may be inhibited by a strong, healthy apex. Until there is damage to the apex or sufficient distance created by addition of the trunk between the apex and the vegetative bud, suckering will be inhibited. This inhibition may also be effective in *Rhapidophyllum* and would account for the absence or sparse suckering in old, large, single-stemmed plants with a large crown. However, there may also be other explanations such as environmental restrictions. A single-stemmed plant taken from the wild will often sucker profusely, probably due to transplant shock. It is also of interest that seedlings, to the best of the authors' knowledge, always produce suckers.

The ability of the plants in cultivation to grow taller is probably due to better growing conditions and more light. Drier conditions and probably better air circulation keep the trunk and roots from rotting. The creeping habit which *Rhapidophyllum* in the wild exhibits has rarely been seen in cultivated plantings.

Rhapidophyllum is not vigorous or aggressive and it is doubtful whether it could successfully compete with heliophilic plants. However, its slow growth probably allows it to occupy habitats with low light intensity. As suggested in a study of *Iguanura geonomiformis* (Kiew, 1972), the success of undergrowth palms in occupying a dark habitat is due to their slow growth because not much light is required to maintain them. *Rhapidophyllum,* like several other species of palms, apparently is occupying a habitat where it does not have to compete with faster-growing plants for light, moisture, and nutrients. Bannister (1970) noted, in the case of

Prestoea montana (reported as *Euterpe globosa*) in Puerto Rico, that it is most likely that seedlings of this, and perhaps other forest species as well, may be able to exist in a state of semidormancy until some environmental factor becomes more favorable, at which time rapid growth can resume. A similar response may also occur in *Rhapidophyllum*. In the case of *Rhapidophyllum*, as perhaps in other forest palm species as well, light is suspected to be the limiting factor. *Rhapidophyllum*, when transplanted from a dark to a well-lit site, will usually grow much more rapidly.

Popenoe (1973) reported that the species has withstood temperatures down to 12 degrees below zero without being damaged. The minimum temperature that *Rhapidophyllum* can withstand without being killed has not been determined. It certainly is one of the more hardy palms.

In April, 1975, a survey of the insects on the flowers of *Rhapidophyllum* was made. Flowering at that time was poor and a high proportion of staminate inflorescences was produced as compared to pistillate.

Inflorescences were collected with the staminate and pistillate placed in separate containers of alcohol for preservation. These were later examined and the insect visitors noted. A weevil, identified by Rose Ella Warner as probably a new species of *Notolomus* (Curculionidae) near *N. basalis*, comprised more than 90% of the insects found on both types of inflorescences. Presently only two described species of *Notolomus* are known from North America: *N. bicolor* and *N. basalis*. Based on data from the entomological collections at the United States National Museum, *N. bicolor* has been collected on the inflorescences of *Chamaerops* sp. and *Sabal palmetto*. *Notolomus basalis*, on the other hand, has been collected on the inflorescences of such diverse species as *Albizzia* sp. (Fabaceae), *Asimina parviflora* (Annonaceae), *Cassia tora* (Fabaceae), *Castanea mollissima* (Fagaceae), *Carica papaya* (Caricaceae), *Gossypium hirsutum* (Malvaceae), *Hibiscus* sp. (Malvaceae), *Nerium oleander* (Apocynaceae), *Passiflora* sp. (Passifloraceae), and *Pluchea foetida* (Asteraceae). The larva has also been known to bore into the stem of sugar cane (*Saccharum officinarum*—Poaceae). *Notolomus* has also been observed on the inflorescences of *Serenoa repens* and *Forestiera segregata* (Oleaceae). Based on the known preference of the two described species of this genus, it is probable that *N. bicolor* is the species found on *Serenoa* while *N. basalis* is found on *Forestiera*.

This undescribed *Notolomus* species, found in great abundance on the inflorescences of *Rhapidophyllum*, is the prime candidate for pollinator. Adult beetles taken from the staminate inflorescences were found to be heavily covered with pollen. *Notolomus* sp. nov. is ideally suited as a pollinator since it is small, active, and a strong flyer. When the inflorescence is disturbed, the beetles will respond by quickly dropping from the inflorescence into the fiber or spines surrounding it, by crawling deeper into the inflorescence, or by flying away. Since the compacted pistillate inflorescence does not emerge far from the bracts a small and active pollinator would be necessary for *Rhapidophyllum*.

As previously stated, staminate flowers, and to a lesser extent, the pistillate flowers, emit a musky odor that serves as the attractant for the beetles which then feed on the pollen and various flower parts. The large numbers of beetles present (estimated to be about a hundred per inflorescence), their small size, pollen load, and mobility make this insect an effective pollinator. It is postulated that the beetle is first attracted to the area by the strong odor produced by the staminate flowers, which usually outnumber the pistillate in a given area. The beetle will then go from inflorescence to inflorescence seeking food.

Pollination by curculionid beetles is not rare in palms. Essig (1971) provides evidence that in Costa Rica, two species of *Bactris* are pollinated by *Phyllotrox megalops* and possibly *Grasidium longimanus* along with two species of the nitidulid beetle genus, *Mystrops*. Essig (1973) also suggested that the curculionid beetle *Nodocnemus* sp. pollinates *Hydriastele microspadix* in Papua New Guinea. This latter genus of beetles and related genera are believed to occur almost exclusively in palm flowers and are pantropical in distribution (Essig, 1973).

Schmid (1970) observed curculionids (*Celestes* sp. and *Phytotribus* sp.) on *Asterogyne martiana* in Costa Rica, but concluded that they were not effective pollinators for a number of valid reasons. Similarly Brown (1976) noted *Notolomus basalis* on *Sabal palmetto*, but concluded that this palm was pollinated by bees, primarily *Apis mellifera*, rather than by this curculionid.

Various other organisms were found in the inflorescences of *Rhapidophyllum*, but are discounted because they either were not found in sufficient numbers or were not physically able to satisfy the requirements for pollination of this species. Among these were neuropteran larvae, immature hemipterans, isopods, arachnids, lepidopteran larvae, chilopods, various coleopteran larvae, an amphipod, and a snail. The amphipod, which was very abundant on both the inflorescences and in the leaf litter on the forest floor in one population of *Rhapidophyllum*, has been identified by Edward Bousfield as *Talitroides topitotum* (Talitridae), an increasingly common pantropical and pansubtropical species. These organisms probably account for some of the damage to the flowers, resulting in lower fruit set.

The needle palm appears to be a senescent species. Flowering is irregular, fruit set poor, seed parasitism high. Its distribution is irregular and suggests a disintegrating range. Available habitat is also diminishing, due primarily to human activity. There appears to be no effective long-range dispersal mechanism for the establishment of new populations in now existing suitable habitats. Reproduction is apparently primarily by vegetative means, which results only in the maintenance rather than expansion of existing populations. Expansion of populations apparently only takes place locally. *Rhapidophyllum hystrix* is best interpreted as a slowly vanishing relict species.

Acknowledgments

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Palms as Energy Sources: A Solicitation

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Following the oil crisis in 1973, and Hodge's excellent review of palms as oil sources in 1975, a look at palms as energy sources may be in order. Palms rank relatively high among tropical trees for converting solar energy into potential energy in the form of sugars and oils. Palms are prevalent in some of the developing tropical and subtropical nations that are hard hit by soaring costs of energy. Palm oils and alcohols might contribute to making these countries self-sufficient in terms of energy (1).

Files in the Plant Taxonomy Laboratory of the USDA at Beltsville, Maryland, have yield data only on the following palms:

1. *Areca catechu* L. Betel palms average 840 kg of prepared nuts per hectare but yields may be twice this high.
2. *Arenga pinnata* (Wurmb) Merr. A sugar palm yields about 2.8 liters of toddy per day for a period of about two months, the sugar content ranging from 5 to 8%. Sugar yields are about 20 MT (metric tons: 1 MT = 1,000 kg or 2,200 pounds) per hectare. Upon felling, each tree might yield about 70 kg of sago starch.
3. *Bactris gasipaes* HBK. One peach palm may bear 13 full fruit clusters, each weighing up to 100 kg. It has been suggested that monthly returns are higher from peach palm than from corn (3.4 MT dry peach palm fruit/ha).
4. *Borassus flabellifer* L. One palmyra tree may yield 150 liters of sap per year, the fresh sap producing 3% alcohol spontaneously. Some trees with many inflorescences may yield 20 liters per day.
5. *Caryota urens* L. A single fishtail palm may yield over 600 liters of toddy per year (13.6% sucrose), sometimes yielding 27 liters per day.
6. *Ceroxylon alpinum* Bonpl. ex DC. A single wax palm may yield 6–11 kg of wax per year, and 360 kg of fruit.
7. *Cocos nucifera* L. Coconut yields range from 2,500 to 7,500 nuts per hectare, with copra yields up to 5 MT per hectare. Hodge (4) reports oil yields of ca. 900–1,350 kg per hectare. Coconut oil can be cracked at around 190°C to form nearly 50% motor and diesel fuel. Coconut trees can be tapped to yield 250 liters of toddy (12–17.5% sucrose) which natural fermentation takes to 2.7–5.8% ethanol.
8. *Elaeis guineensis* Jacq. The African oil palm is reported to have an annual mean productivity (total biomass per year) of 37 MT of dry matter per hectare. Good hybrid palms yield more than 2 MT of oil per hectare; Hodge (4) cites yields of nearly 3 MT (2,790 kg/ha), more than three times higher than oil yields from coconut. He suggests that this is the most efficient oil-making plant species.
9. *Jubaea chilensis* (Mol.) Baill. A full-sized Chile coco may yield more than 340 liters of toddy per year.
10. *Metroxylon sagu* Rottb. A sago

Table 1. Ecological amplitudes of some palm trees (2, 3)

	Life zone[1]		Ann. precip. (dm)	Ann. temp. (°C)	Warm wet months	pH
African oil palm (*Elaeis guineensis*)	Sdw	Tdw	7–40	21–27	5–12	4.3–8.0
American oil palm (*Elaeis oleifera*)	Sdm	Tdm	7–15	21–27	5–11	6.8–7.3
Betel nut (*Areca catechu*)	Sdw	Tvw	7–42	15–27	6–12	5.3–6.8
Chile coco (*Jubaea chilensis*)	Wdm		3–10	13	0–3	8.2
Coconut (*Cocos nucifera*)	Sdw	Tvw	7–42	19–29	4–12	4.3–8.3
Cohune palm (*Orbignya cohune*)	Sdm	Td	7–40	25–27	5–11	6.8–7.8
Date palm (*Phoenix dactylifera*)	Wtd	Txm	2–40	13–27	0–11	5.1–8.3
Fishtail palm (*Caryota urens*)	Sdm	Tvw	7–42	19–27	5–12	5.7–8.0
Palmyra (*Borassus flabellifer*)	Sdm	Tvw	7–42	19–29	5–12	7.3–8.0
Peach palm (*Bactris gasipaes*)	Sdw	Tmw	7–40	19–25	5–12	5.8–8.0
Rattan (*Calamus rotang*)	Sm	Tw	17–42	19–27	9–12	—
Sugar palm (*Arenga pinnata*)	Sd	Tm	7–40	19–27	8–12	5.8–8.0
Wax palm (*Ceroxylon alpinum*)	Cw	Tw	11	9–19	6	4.5

[1] C = cool temperate, W = warm temperate, S = subtropical, T = tropical, x = desert, t = thorn, v = very dry, d = dry, m = moist, w = wet, r = rain forest life zone (5).

palm may yield 100 to 550 kg of sago starch: some stands of *Metroxylon* yield 8 tons of crude starch (35–40% water) per hectare.

11. *Nypa fruticans* Wurmb. Once five years old, a nypa palm may be tapped for 50 years. One hectare yields 30,000 liters of toddy, translating to 3 MT of sugar or 4,000 liters of alcohol (in terms of energy equalling 1,000 liters of gasoline) per hectare.

12. *Orbignya speciosa* (Mart.) Barb. Rodr. Each babassu may produce 40 kg of oil per year.

13. *Phoenix dactylifera* L. A single date palm may yield 180–280 liters of toddy and 40–80 kg of dates, or 7–10 MT of dried dates per hectare.

14. *Syagrus coronata* (Mart.) Becc. A single ouricury palm yields only about 1 kg of fruit per year.

One purpose of this paper is to solicit from readers any information they may have that might help me evaluate these and others palms as potential energy sources. Many palm yields are sustainable yields that can be repeated year after year. Shade-tolerant money crops, e.g., coffee, cocoa, pepper, vanilla, etc., can be intercropped in the shade of the energy crop.

Four liters of ethyl alcohol is energetically equivalent to one liter of gasoline. If the price of gasoline continues to climb, ethanol will be economically competitive with gasoline. Perhaps even palm oils would compete. In early 1976, the Chemical Marketing Reporter listed prices for bulk oil as follows (assuming 8 pounds to the gallon): coconut oil $1.30 per gallon (8 lbs), palm oil $1.34, palm kernel oil $1.42 as compared with corn $2.24; cottonseed $1.88; linseed $2.56, oiticica $2.16, peanut $2.80, and soybean $1.65. I understand that gasoline costs nearly $2.00 per gallon in parts of Europe. Palm oil at $1.30 per gallon would clearly be competitive with gasoline at $2.00 per gallon. But palm oil, at $50.00 a barrel doesn't compete with gasoline at $15.00 per barrel. If gasoline prices were to go up as much in the next ten years as they did in the last ten years, and palm oil remained unchanged, palm oil would be cheaper. And palm oil is a renewable resource.

Hodge (4) notes that Paraguay exported 7,400 MT of oil of *Acrocomia totai* in 1971, while Brazil exported ca. 14,000 MT of *Astocaryum* kernels in 1949, 44,000 MT of *Orbignya* kernels in 1945. Such figures are dwarfed by Malaysia's palm oil production. During the first nine months of 1975, peninsular Malaysia exported nearly 600,000 MT or more than four million barrels of oil per year. Indonesia is building a new palm oil processing plant ($11.3 million) in northern Sumatra expected to process 125,000 MT of palm bunches which should yield more than 150,000 barrels of palm oil per year (Foreign Agriculture, January 26, 1976).

Determining which species of palms will yield the most energy depends very much on the ecological parameters of an area. Ecological amplitudes of certain palms are tabulated in Table 1. Palms listed are from a recently published Crop Diversification Matrix (2, 3). Life Zones are recorded using the Holdridge system (5). Annual precipitation and mean annual temperature are tabulated, followed by the range of warm wet months (consecutive frost free months, each with at least 0.6 dm rainfall) and pH.

If Table 1 were expanded to cover the palm flora of many more stations, accompanied by ecological data, one might deduce the climatic parameters of a remote area by its palm flora. If Table 1 represented the real world rather than my small sample, one could deduce from a palm flora containing the Chile coco and wax palm that the area was Warm Temperate Dry to Moist Forest Life Zone, with about 10 dm annual precipitation and mean annual temperature near 19°C. With enough data one might integrate the curves for the palms in a remote flora and get a statistically reliable estimate of the climate of that remote area. Palms, being photogrammetrically distinctive, might then be used to determine the climate of an area, and its crop potential, via remote sensing. The purpose of this preliminary report is to solicit data from palm-growing areas. Readers interested in participating in a palm survey are requested to write me. Palm lists from botanical gardens accompanied by ecological data pertinent to that station are solicited. If enough interest is generated and data accumulated, we can better estimate potential energy yields in various ecosystems of developing and developed nations.

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Palm-Collecting Adventures in Asia

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Palm Society members have an extraordinary bond; namely, as Dent Smith, the society's founder, might put it—a pervading fondness for the most princely of the monocotyledons. Fortunately, for the palm seeker, this membership is worldwide, embracing some 40 nations in and around the tropical belt, and other localities, like Alaska, far removed from it. Palm Society members are very helpful people, wherever they are. Phyllis Sneed and I know this so well, after having gone "on our own" on a palm trek into Asia. Our trip was a very rewarding experience, thanks to the members who made it so. We shall introduce them as we go along. We thank them all, here at the outset, for their kindness and many courtesies that made our travels possible and fruitful as well.

Before we depart we should say that we are not explorers. We really don't believe we ever will discover a new genus, or species, for that matter, but it's a thrilling experience to see palms growing in their habitat and to try to photograph and collect them. Actually there were many times on our trip, in jungles and elsewhere, when we felt like explorers. But one must not be deluded. Our Editor, Dr. H. E. Moore, Jr., in his many travels that have contributed so much to the knowledge of palms, had been there long before we arrived. There were others before him, but Dr. Moore's footsteps are implanted wherever palms are found. We are proud to have retraced some of his paths in Asia about 12 years later.

I. Montego Bay to Bangkok and Malaysia

We left Montego Bay 23 August 1975 and overnighted in San Mateo, near the San Francisco airport. Glancing out our hotel window the next morning we were astonished to see a towering *Phoenix canariensis*, all by itself with no other vegetation near it. And it was fruiting! So, Asia notwithstanding, we collected some good viable palm seeds in California. To make way for construction or other changes, the *Phoenix* recently had been transplanted at a cost estimated at $10,000. One would have to conclude that the good people of San Mateo care about palms.

Our China Airline flight left on schedule and we went on to Bangkok via Honolulu and Tokyo, overnighting in Taipei, thence to Hong Kong, then over the South China Sea and Gulf of Siam, skirting Viet Nam and Cambodia, which the airline deemed to be inhospitable territory.

In Bangkok, we enjoyed the splendid old Oriental Hotel located on the busy river front where one can watch the endless river traffic. The hotel grounds are well landscaped with *Cyrtostachys*, *Areca catechu* and other palms.

No time was lost getting in touch with Cmdr. Watana Sumawong, one of The Palm Society's most ardent and helpful members, with whom we had corresponded and exchanged plants for several years. Our visit coincided with the eve of his departure on a trip to Florida, so we certainly appreciated his taking the time to introduce us first to

1. Cmdr. Watana Sumawong and Phyllis in a section of his nurseries in Bangkok.

Mrs. Sumawong, and then to his very extensive collection of palms, cycads, and many other plants in the nurseries at his attractive home (Fig. 1).

As noted earlier in *Principes* 17: 30–32, most of his plants are in containers—ceramic pots of all sizes on up to huge ornate jars. Watana even has *Lodoicea maldivica* growing in large, barrel-like wooden containers. We understand that later he hopes to establish a botanical garden at another location. Certainly he has assembled the ingredients for a very fine one. The Sumawongs hosted us for an evening of superb Thai cuisine, with entertainment by the traditional, rapturous Thai dancers, and in other ways made our visit to Bangkok memorable.

We had time to take the river and floating market trips, see the splendid temples and palaces, and spend an evening with Mr. Ura Snidvongs, also a devoted member of The Palm Society. We not only talked about palms with Ura but proceeded after dinner to look at some in a nearby city park. It was too dark for pictures but we were delighted that he would take us to see the palms in the glow of Bangkok's lamp lights.

On 30 August we left for Malaysia, with Penang, an island state in the Malacca Straits, off the northwestern coast, our first destination. Penang has been called Palm Island, and today its state flag is centered with an *Areca catechu* (betel nut). Our main interest there was Waterfall Gardens, the island's principal botanic attraction. Although we had the name of someone to contact at the gardens, there was no prior warning that we had arrived on a holiday and all officialdom would be off duty! We couldn't get inside the nurseries, which looked as promising

2. Phyllis is dwarfed by towering cluster of *Oncosperma fasciculatum*, Waterfall Gardens, Penang.

3. A magnificent *Licuala* sp. may be seen in Waterfall Gardens.

as the gardens themselves, or obtain any available catalog of plants, or official permission to collect seeds. Not many seeds were available anyway, unless they were more plentiful behind the locked nursery gates.

The garden has impressive clusters of *Oncosperma fasciculatum* (Fig. 2) and *Cyrtostachys renda.* Several species of *Pinanga* and *Calamus* are along paths in a forested area adjoining the open spaces of the garden. Our favorite palm there was a beautiful, large-leafed *Licuala* sp. (Fig. 3). There was one female *Lodoicea maldivica* bearing abortive fruits which attracted the garden's large population of monkeys. Having heard that Waterfall's palm collection contained a specimen of *Johannesteijsmannia,* we searched in vain for it. Later we learned that indeed one had been there years ago but disappeared during the Japanese occupation in World War II. We have yet to see this unusual palm in any botanical garden. But we saw it in the wild farther along in Malaysia. More about that later.

Leaving Waterfall Gardens, we proceeded to explore the island. We rode the funicular railway up Penang Hill for spectacular vistas dotted with palms and went on to the Snake Temple, where the author firmly refused to pose with a viper around his neck. Then, along the road we spotted a stand of dead coconut palms and wondered if the lethal yellowing disease had spread to this part of the world. Although loss of palms for any reason is deplorable, we were relieved to learn that these trees had been killed deliberately to make way for an airport runway. After viewing the landscaping at several new resort hotels on the north coast, we raced the oncoming darkness back to the E & O Hotel in Georgetown.

The flight south to Malaysia's capital Kuala Lumpur, took only 35 minutes. Soon we were being greeted by Mr. Eric Taylor, a Britisher, who is a landscape architect with projects in Southeast Asia, formerly based in Singapore, now in Kuala Lumpur. Though he would eschew any accolades, Eric is a devoted Palm Society member who has gone much out of his way to assist traveling members. He helped make arrangements and guided us on most of our palm quest in Malaysia.

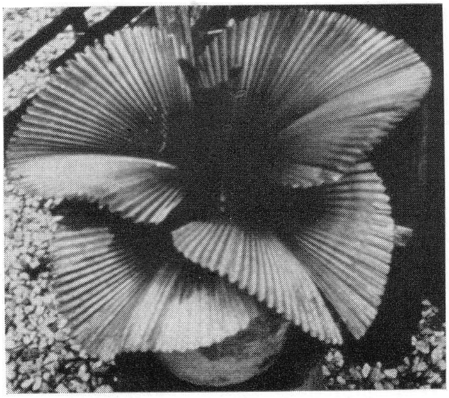
We had time that afternoon for Templer Park, 14 miles north of Kuala Lumpur, which we reached in a rented car with Eric at the wheel. This park gives the visitor a sample of the Malaysian jungles. Along the paths we saw *Eugeissona*, *Orania*, and what appeared to be *Metroxylon* species. Rain hurried us along, as well as darkness, postponing a visit to the Batu Caves, some seven miles from Kuala Lumpur, which is perhaps the only place having relatively easy access to *Maxburretia rupicola.* We returned later and saw this rare small palm but didn't get a good photograph or collect any seeds (for more on this see Principes 15:3–9).

Early next morning, the three of us headed for Genting Highlands, about an hour's drive from Kuala Lumpur. These mist-shrouded highlands are covered with precipitous jungles loaded with palms. The highest elevation is 5,600 ft. We snaked our way upward constantly on the lookout for roadside openings where we could edge into the bush without the help of an entourage of machete swingers. These forests are heavily laced with *Pinanga*, *Licuala*, *Nenga*, and the formidable rattans (*Calamus* and *Daemonorops*). We gleaned some seeds from these incursions but not in sufficient quantities for the Seed Bank. Some of the species from whence seed came were unfamiliar to us. Later in the day we found a dense stand of *Pinanga polymorpha* and collected seeds in quantity, although it was uncertain whether some of the fruits were ready for harvest. We also encountered species of wickedly clawed *Korthalsia*, a "fishtail-leaf" rattan, and collected a few of the round, scaly fruits.

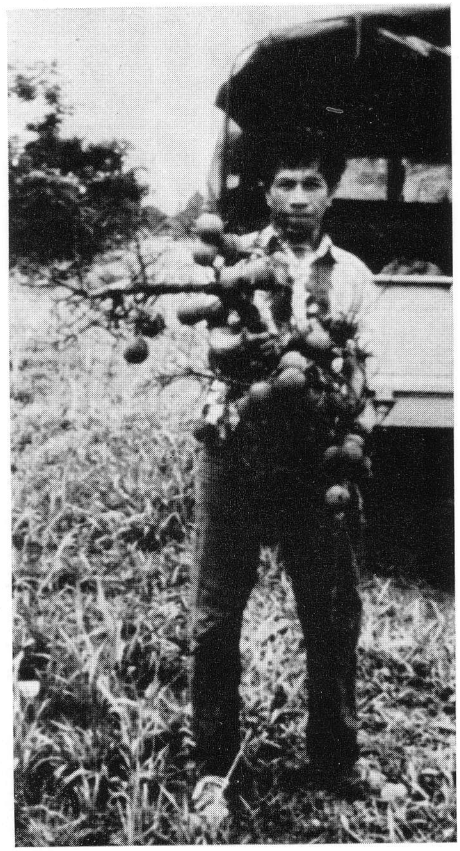
The following day Eric drove us to the Fraser Hill area farther north of Kuala Lumpur, more rugged and somewhat less accessible than Genting Highlands. Ascent to the area is by one-way road, closed during certain hours to upgoers while open to downcomers. We repeated procedures of the day before, stopping at accessible places which Eric Taylor had visited previously, and probing for seeds with some success. *Livistona speciosa*, *Oncosperma*, *Arenga*, and the giant mountain rattan were conspicuous. But it takes more time than we had to explore the trails and see the palms that abound all over the area. It is beautiful country, prominently studded with the huge, solitary caryotas that tower in the misty vistas.

Back to Kuala Lumpur after dark, Phyllis cleaned the seed gleanings of the day, bagging and labeling them to go with earlier collections. We each reduced our traveling paraphernalia to what would go into a small carry-on bag, and we were ready for the next leg of our adventures.

Early in planning the trip we wanted to visit the Kuching area of Sarawak, but could not time it, or arrange it, before leaving Jamaica—so we decided to "play it by ear." The receptive "ear" that made it possible belonged to Mr. Paul Chai, Forest Botanist with the



4. *Licuala orbicularis*, Semengoh Arboretum, Sarawak.



5. Jugah Kuti and fruit of *Pholidocarpus* near Kuching.

Forest Department in Kuching, and a member of The Palm Society. We had phoned him from Kuala Lumpur upon arrival, and his response was heartwarming. Our itinerary was juggled thereupon to make room for Kuching.

Leaving Kuala Lumpur airport early 4 September, we were happy to be accompanied by Eric Taylor, who speaks Malay and Indonesian. The hour-and-a-half flight above cultivated forests of *Elaeis guineensis* and the tin mines of West Malaysia, then across the South China Sea was fascinating. Sarawak and Sabah are the Borneo states of East Malaysia, Kuching being the capital of Sarawak. Low cloud floats partially obscured our approach to Kuching beside the snaking Sarawak River.

Going directly to the Forest Department, we found Paul Chai expecting us. Although his duties prevented him from going along, he had programmed us to palm hunt within our time restrictions, and scheduled a land rover and guides, who also accompanied us for the next two days. That afternoon we went out of Kuching a few miles to the Forest Department's Semengoh Arboretum.

We spent much of the afternoon collecting *Pinanga* species and admiring the plants. Trails made viewing quite accessible and except for a few leeches we enjoyed it thoroughly. In addition to the arboretum's forest reserve, there is an adjoining nursery where we found a most beguiling palm, the diminutive *Licuala orbicularis* (Fig. 4). This delightful little palm, we were told, is native elsewhere in the area and rare in cultivation. No seeds of it were available at the arboretum and we departed with a gnawing yen to get them eventually. On our return to Kuching we saw *Pholidocarpus* in fruit in a swampy area off the road, and Jugah Kuti climbed an adjacent tree to bring down

6. Down the Sarawak River to Bako National Park. Photograph by Eric Taylor.

a large stalk of seeds (Fig. 5). Unfortunately they were immature.

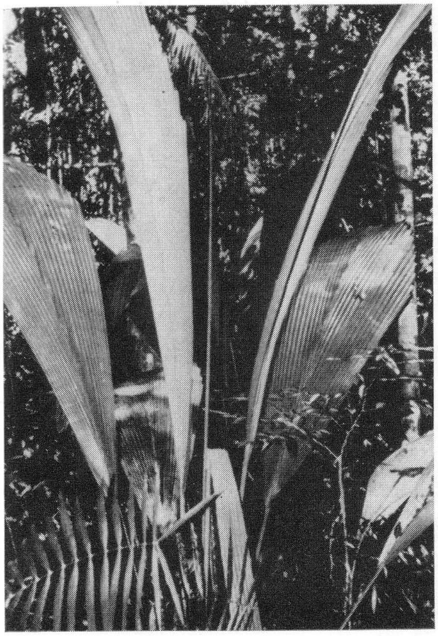
Paul Chai joined us that evening for conversation (palm-oriented) and introduced us to a splendid Chinese restaurant where we indulged in genuine bird's nest soup. From its Niah Caves, considerably east of Kuching, Sarawak is a principal source of edible bird's nests, made from the saliva of their architects —millions of small swifts that live in the caves.

Before dinner we had shopped for provisions to take on our overnight trek next day to Bako National Park. Bako, consisting of some 10 square miles of primary forest, is on a peninsula at the mouth of the Sarawak River. It is reached by speed boat downstream from Kuching in one and one-half hours.

Dr. Moore, our editor, visited Malaysia and Bako late 1963 to early 1964, and his account of it in *Principes* 9: 103–117 was an inspiration to us. He detailed the palms there and we believe that our visit found the area little changed from what he described (refer also to *A Guide to Bako National Park*, reprint of the *Malaysian Nature Journal*, Vol. 24, Nos. 3 & 4, Aug. 1971).

We were picked up early and deliv-

7. Disembarking at Bako.



8. *Johannesteijsmannia altifrons* in Bako National Park.

9. *Eugeissona insignis* along trail in Bako.

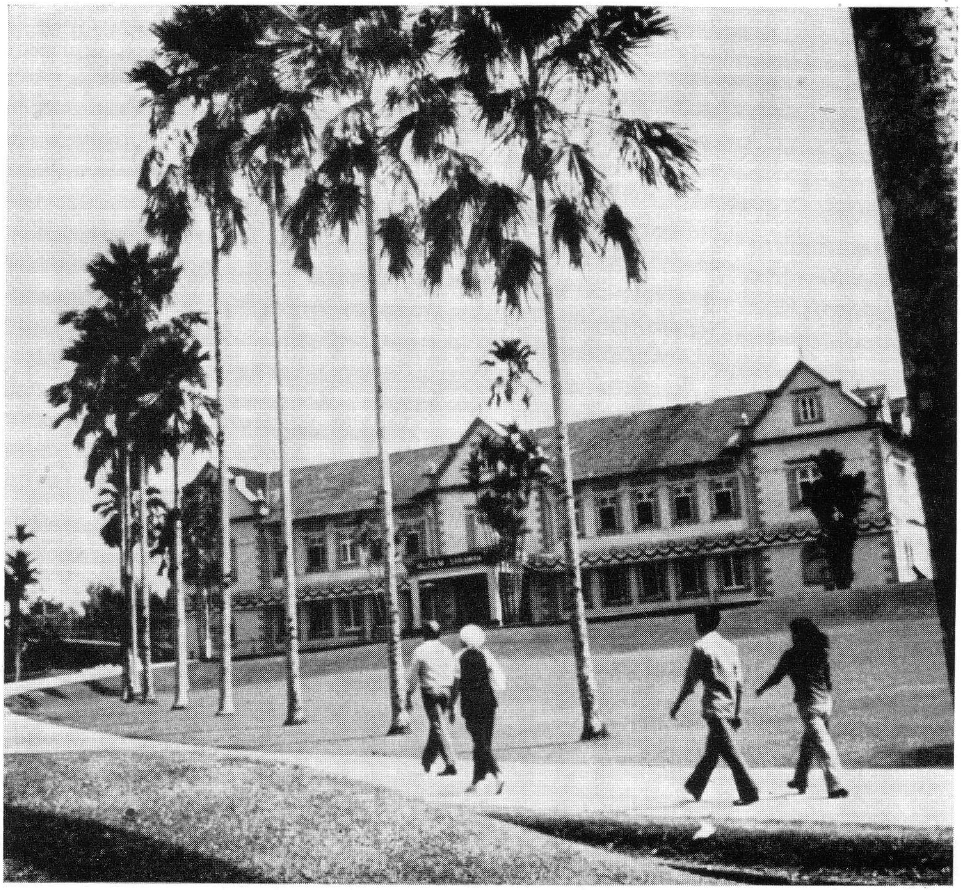
ered at the river dock, where our party assembled. Joining Phyllis, Eric Taylor, and me were our Iban (Dyak) assistants of the day before—James Mamit and Jugah Kuti—a cook, Jagong Suka, together with Peter Martin, a student volunteer worker from Britain. After a bit of delay due to necessary switching of boats, our longboat pulled up and the boatman completed the party.

The river traffic and fishing villages were interesting with the scenery improving as we advanced, but mainly we relaxed and enjoyed the ride (Fig. 6). We saw *Nypa fruticans* along the tide-flushed river banks, and stopped once, not far from the Park, while James Mamit bargained for a fisherman's catch. The ray wound up in the stew pot that evening.

Rounding a rugged cliff, the boat pulled up in a shallow bay where we disembarked our gear and waded to shore over the mud flats (Fig. 7). The overnight cottage was quite adequate, having three sleeping rooms with multiple cots, kitchen with gas fridge, dining area, and lavatory facility.

Quickly getting things in order, with Jagong Suka staying behind to thwart the kera and proboscis monkeys from raiding our provisions, the trails beckoned and we set out shortly after noon. The forest abuts the cottage clearing and we were in the jungle almost immediately. *Pinanga*, *Licuala*, and the omnifarious rattans are all along the trails, except for a plateau area of sandstone, which though palmless was studded with interesting *Nepenthes* (the pitcher plant). The licualas were especially handsome, but our most exciting moments on the trail came past midafternoon, about halfway around, when we advanced into a large stand of *Johannesteijsmannia altifrons*.

They ranged through the forest, up-



10. Livistonas enhance approach to the Sarawak Museum in Kuching.

hill and down, on both sides of the trail but weren't easy to photograph either individually or in depth (see Fig. 8). The entire party began searching for seeds, which meant probing the forest debris that collects around the base of this trunkless species of palm that fruits near the ground. Our efforts were in vain as we didn't find a single viable seed. Disappointing though it was, we thrilled at the sight of this beautiful and unusual palm and resolved to try again for seeds later on our itinerary.

Bako has *Eugeissona insignis* in several areas along the trails (Fig. 9). Though the fruits are large and heavy for mailing we collected some for the Seed Bank, together with a quantity of *Pinanga crassipes*, the latter having beautifully mottled leaves that are characteristic even of the smallest seedlings.

A much welcome rest stop, atop the cliff area we had seen from the boat coming in, found the author wringing wet with perspiration, due more to exertion than the equatorial climate, and still some distance from that fridge back at camp. James and Jugah smilingly assured us that the climbing was over; that it was all "down hill" back to camp. It was down all right, straight down a series of ladders and gouged out steps that kept the trail connected from the top of rock outcrops down through ravines, across streams, and so on. But it was a beautiful passage, weary legs notwithstanding.

The Bako trails were a highlight of our trip; the relaxation back at camp, dinner that evening, torrential rains that night, the shoreline exploration next morning, and return to Kuching by early afternoon were anticlimactic. We visited the Sarawak Museum where the grounds are beautifully landscaped with palms, such as the livistonas along the walk in Fig. 10. The museum is impressive with exotic items including an Iban longhouse with genuine skulls furnishing a cogent bit of realism. It is well worth a visit. We returned next morning to search the grounds and adjoining areas for seeds, collecting several species, including a quantity of *Cyrtostachys*, after which we canvassed Kuching's very clean and tidy market area and downtown shopping stalls. These were all within easy walking distance from our Hotel Borneo.

Back in Kuala Lumpur we packaged an accumulation of seeds for mailing and had them ready when Eric Taylor arrived next morning to guide us on another foray into a swamp forest to view a natural stand of *Cyrtostachys*, which seemed to thrive in a peatlike debris. We passed a few individual specimens of *Actinorhytis* along the way, and stopped frequently to explore promising byroads. Also, we mailed the packaged seeds, although for one of the larger containers a crisis arose. The postoffice substation had exhausted its supply of large denomination stamps and before the carton got into the mailsack it looked like a Christmas package as it was completely enwrapped with colorful, small-denomination stamps.

Another day we drove to historic Malacca, 100 miles from Kuala Lumpur, on the straits, with an unbroken history back into the fourteenth century. This is the place where one can acquire a malacca cane, the sire of which is a palm. But history is neither our forte nor purpose, and up to this writing we can walk without a cane. That evening we bid temporary adieu to Eric Taylor; temporary, because Eric was to rejoin us later on our itinerary. Our last day we explored downtown Kuala Lumpur, cabbing through lovely Lake Gardens with its beautiful ornamental palms, visiting the National Museum adjoining it, and walking through the interesting parts of the city back to our hotel.

We didn't get to Cameron Highlands in the north, with its rugged trails and alluring palm-collecting potential. Nor did we have time, or stamina, even to consider venturing into Taman Negara, which is West Malaysia's great (1,700 sq. mile) natural forest reserve. For what we missed there, see *Principes* 13: 83–98. We planned to double back later on out of Singapore into the southern state of Johore where, in certain traditional areas, *Johannesteijsmannia* is easily accessible and abundant.

Early 11th September we departed Kuala Lumpur with heartfelt gratitude to The Palm Society members and all our many new friends in Malaysia who had helped us so much. Also, it should be noted that T. C. Whitmore's *Palms of Malaysia* (Oxford University Press, London, 1973), which details the location of palms throughout Malaysia, was a most useful reference. Our next destination was Indonesia, starting in Medan, the capital of Sumatra, which will be another story.

Promising Structural Fiber Palms of the Colombian Amazon[1]

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We have . . . two natural groups of fibers—the commercial species with their substitutes, . . . and the vast group of the so-called native fibers. . . . These so-called native fibers are all interesting . . . and through our knowledge of some of them, or when a species finds its way to the outside world, a new commercial fiber now and then is brought to light. They are legion when taken collectively, and therefore in enumerating the many species found in the countries of the globe it is very easy to secure a list that can only be stated in four figures.

Charles Richard Dodge (2, p. 23)

A country like Colombia, with such a wealth of ecological sites and altitudinal localities, a broad spectrum of economic conditions and, above all, an unbelievably rich and varied flora, is blessed with the possibility of giving the tropical world useful products from a great variety of species. The rich flora of this country and its still viable indigenous knowledge of the properties and uses of the ambient vegetation have not yet fully been scientifically explored or exploited.

Colombia possesses some 50,000 species of plants in its richly varied ecological and geographical zones, yet little of its national wealth is based upon the exploitation of a plant of Colombian origin. In my many years of research on the flora of Colombia, I have felt for a long time that Colombian industrialists, like their counterparts elsewhere, have indicated a preference for the exploitation of introduced foreign plants—yes, even a prejudice against the study of the potentialities of native plants of promise. It should never be overlooked that there is great danger in allowing a national economy to be too heavily dependent on a monoculture, such as coffee in Colombia.

While great strides can and will be made in the production for local use and for exportation of fibers from *Furcraea*, *Agave*, and related genera, the time has come, I believe, to consider some of the lesser known but promising sources of other structural fibers.

Much of my botanical work has consisted in a search of the Plant Kingdom to the use and betterment of mankind. The palms have always interested me as one of the economically most important plant families but one that still offers many opportunities for new cultivated species.

Some of the promising fiber plants used by the natives of the Colombian Amazon may well deserve to be domesticated. They are exploited by man in aboriginal societies from purely wild stock and with primitive methods. The first step involved in modern domestication of a plant lies in the amassing of a living collection of as many wild strains as possible from wild populations—strains showing differing morphological or physiological characteristics that might prove to be valuable in programs of breeding or selection. This procedure has proven its worth

[1] Delivered at the Primer Simposio del Fique, el Sisál y Otras Fibras Duras in Medellin, Colombia, March 12–14, 1975.

in many modern plant improvement programs—rice, maize, wheat, potatoes, rubber, quinine, tung oil, to mention only a few.

A meticulous study and evaluation of the economic potentialities of the structural fibers in some of the species that I shall mention as promising should be carried out to decide which are most deserving of serious research. When the choice is made, it will be necessary to start building up living collections of wild strains, to engage in a physical study of the fibers, and to initiate an agronomic and ethnobotanical evaluation of the characteristics of the various strains.

As we consider the domestication of a new crop plant, the great importance of the multipurpose plant must nowadays be borne in mind. It will be much sounder economically to develop a plant that, in addition to fibers, may yield another useful product, such as a wax, an oil, food for humans or animals, or some medicinally valuable constituent. Even primitive societies have recognized the wisdom of this approach. We may cite a number of examples among our most ancient cultigens: *Cannabis*, the source of marijuana, with its five uses; *Linum usitatissimum* or linen, the source of flax fiber and linseed oil; the several species of *Agave* which, in Mexican cultures, yield not only sisal or ixtle but have a number of other locally important uses.

There are sundry plants that are promising sources of economically valuable structural fibers. They belong to several families. The most promising as potential new domesticates for specific ecological zones such as the humid tropics, however, belong to the palm family.

There are some 300 native species of palms known from the Republic of Colombia (3). At least seven species should demand our attention. They are: *Astrocaryum jauari*, *A. murumuru*, *A. tucuma*, *A. vulgare*, *Mauritia flexuosa*, *M. minor*, and *Oenocarpus bacaba*.

Astrocaryum

Botanists have recognized about 40 species of *Astrocaryum* G. F. W. Mey., native to tropical areas up to an altitude of 2,000 feet from Mexico to Brazil. Those species with trunks are usually tall and thickly beset with very long black spines. Wallace wrote in 1853 that they "have a rather repulsive aspect, from almost every part—stem, leaves, fruitstalk and spathe, being armed with acute spines in some cases a foot long." Several species yield fiber and oil.

Astrocaryum jauari Mart.

Known in *lingua geral* in the Amazon region as *javarí*, this common tree grows along the flood banks of alluvial rivers, mainly in the western half of the Amazon Valley. In some localities that are under water more than half a year, it is extraordinarily abundant, occurring often for miles in dense stands, to the exclusion of any other plant.

Exploitation of this species as a major source of fiber, even locally by the Amazon native, has been hindered by the fierce spines protecting all parts of the plant and by its forbiddingly unfavorable natural habitat. It is, nonetheless, the source of a very strong, beautiful, white structural fiber which has found local use in the Río Negro of Brazil.

There is no agronomical reason to presume that *Astrocaryum jauari* might not—like *Hevea brasiliensis*—prosper better in a much drier habitat than that to which in nature it seems best adapted. Furthermore, the rapid growth of the plant and the quality of its fiber

1. *Astrocaryum murumuru* on the Río Putumayo, Amazonas, Colombia.

would seem to indicate the wisdom of a search for strains less fiercely armed with spines. Indians have informed me of "sports" with unarmed stems, and I have found in the Amazon several cultivated strains of the *pupunha* or *chontaduro* palm, *Bactris gasipaes* HBK. [*Guillielma gasipaes* (HBK.) L. H. Bailey], the trunks of which are devoid of spines. What we must do in our search for new economic plants is to examine nature—to see what nature itself has accomplished that we may bend to economic advantage.

Astrocaryum murumuru Mart.

A small tree that may attain a height of 12–18 feet, the *murumurú* palm grows along almost permanently flooded bog-banks of alluvial rivers and swamps. It is especially abundant in the eastern Amazon, but there may be a variety endemic in the westernmost part of the Amazon that prefers drier habitats (Fig. 1). The trunk, petiole, and sheathing bases are provided with strong spines, sometimes up to eight inches in length. The ovoid yellow fruit has a thin hard pulp around the endocarp. The fruit may be eaten by cattle, even though the stony endocarp enclosing the seed passes through the intestines of cows undigested. Swine are able to crush the endocarp and eat the seed.

The leaves are the source of a very strong white fiber. There is, however, little local production because of the fierce spines on the plant and the inhospitable habitat where it usually grows in nature.

In addition to its valuable structural fiber, *Astrocaryum murumuru* is economically interesting because of the oil content of its seed. The endocarp contains a seed with 44% of an edible white fat which is admirably suited for the making of oleomargarine. Its melting point is exceptionally high: 33–36° C; and its point of solidification is 32°. Its iodine index is 11–12.4 and its index of saponification is 241.6 (5).

As with *Astrocaryum jauari*, the *murumurú* palm deserves study to ascertain whether or not it might grow better on drier land than that of its native habitat and whether or not, in nature, one might find unarmed strains.

Astrocaryum tucuma Mart.

The fiber palm known as *tucúm* or *tucuma* in Brazil and *chambira* in Colombia and parts of Peru is native to the western part of the Amazon Valley, where it is one of the most useful of the native trees. Attaining a height of up to 50 feet, *Astrocaryum tucuma* has a stout trunk a foot in diameter covered with long strong black spines and growing singly in rather well-drained forests far above the level of high water.

Fiber from this species has long been recognized as one of the finest and strongest. Its strength has been compared with that of flax. The fiber is so fine that it has been called "vegetable wool." It has been produced in the Amazon by native labor from wild trees for a variety of purposes: the manufacture of cordage and rope, strings for bows, fish nets, carrying bags, hammocks, and other artifacts requiring great strength, durability, and resistance to decay.

The yellowish-white fiber is extracted from the leaves by maceration in water. An interesting description of the preparation by Siona Indians of the Colombian Amazon of chambira fiber states that both men and women gather the immature leaves. "The woman prepares the fiber from the palm heart, which consists of 20 to 40 blades about two to three feet long. The blade, three quarters of an inch wide at the base, tapers to a point at the other end. Starting at the base of the blade, the Siona woman strips off the inner surface, which is the usable fiber and discards the rest. The fiber is cooked in a metal kettle hung over a wood fire, until about one-third of the water has boiled away. Then the woman carries the kettle with its contents outside. With a stick, she removes the hot fibers from the kettle and hangs them over a line. She leaves them there to dry in the sun for a day or two, at which time they are ready to be twisted into string" (8).

2. The crown of *Astrocaryum vulgare*, source of chambira fiber, on Río Apaporis, Vaupés, Colombia.

The Brazilian natives likewise employ the round yellow-green fruit in preparing a nutritious drink known as *vinho de tucuma.*

In Brazil, 50 tons of tucúm fiber were produced in 1958 (4). Its commercial production is on the increase, although all production still comes wholly from wild trees.

This species of *Astrocaryum* is perhaps one of the Amazonian palms of economic importance most deserving of serious attention as a potential domes-

3. The spinous leaf of *Astrocaryum vulgare*, Vaupés, Colombia. Photo by J. Zarucchi.

ticate. A principal disadvantage to commercialization in plantation form might be its spiny nature, but a search for spineless mutants and a program of selection undoubtedly could overcome this problem.

The fiber from *Astrocaryum tucuma* should not be confused with that produced in the eastern Amazon and coastal regions of Brazil from *Bactris setosa* Mart., also called *tucúm* and produced for the making of bags, cobbler's thread, twine and ropes, and fishing nets for use in sea water, to which it is extremely resistant (2).

Astrocaryum vulgare Mart.

A lofty tree attaining a height of 50–60 feet, *Astrocaryum vulgare* (Fig. 2) is commonly known in Brazil as *tucuma bravo*, *tucuma piranga*, or *cumare*. In Colombia, the most usual native name for the tree and its fiber is likewise *cumare*. The stout trunks, often up to 10 inches in diameter and heavily covered, especially in the higher parts, with rings of strong black spines, grow in clumps, not singly as in the closely related species *Astrocaryum tucuma*. The petioles and midribs of the leaves are similarly armed (Fig. 3). This species is native to the western part of the Amazon Valley, common especially in the Río Negro basin of Brazil and in the Amazonian parts of Colombia. Like *Astrocaryum tucuma*, it prefers high, drained forests away from flood banks of the rivers. It is such an important economic tree that often, where it does not occur wild, the natives cultivate a few individuals in their yuca fields near houses.

The undeveloped leaves are the source of an exceptionally strong fiber, prized locally for purposes similar to those for which the fiber of *Astrocaryum tucuma* is employed: cordage, lines, nets, hammocks, etc. This fiber will produce a small cord hardly 2 mm in thickness that will sustain a weight of three kilograms and, at the end of six hours, will have extended from 800 mm to only 809 mm—or 1.011% (2)!

The tender immature leaf blades (Fig. 4), occurring in tight bundles, are shaken apart and the epidermis of each one is carefully removed by stripping. This ribbon epidermis is hung up to dry, then each ribbon is rolled between the hand and thigh into a string (Fig. 5). The fiber is strong, durable and of a creamy-white color. In some tribes, the mature leaves may be boiled in water and the fibers then stripped free.

As with *Astrocaryum tucuma*, this species very definitely merits serious industrial consideration. Investigation of native knowledge of the palm is, however, strongly suggested.

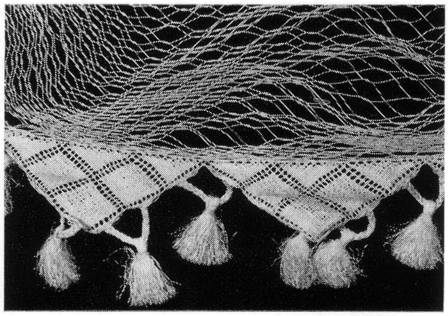
Both of these species might be adaptable to plantation practice in areas of the country covered with humid tropical forests, where little else can at pres-

4. Bundles of young pinnae of *Astrocaryum vulgare* ready for extraction of fibers, Río Apaporis, Vaupés, Colombia.

ent be cultivated and where hand labor is available. There is a very real possibility that simple machinery could be developed for the extraction of cumare fiber. There exists, naturally, the same hope that the wise application of agronomical procedures might develop strains with fewer or no spines—for these are a major disadvantage present in all species of *Astrocaryum*.

A potentially valuable secondary product from *Astrocaryum vulgare* could be the oils provided by the fruits, which ripen from February to June. The yellow-green pulp yields from 33% to 47% of its weight of an orange-colored oil or fat of the consistency of Vaseline and with properties very analogous to those of the oil of the African *Elaeis guineensis* Jacq.: it has an initial melting point of 27° C and melts totally at 35°; its iodine index is 46.4 and its index of

5. An Indian woman twisting chambira fiber of *Astrocaryum vulgare* into twine, Río Apaporis, Vaupés, Colombia.



6. Portion of a native hammock made in the Vaupés of Colombia. The fiber of the lower edge is of *Mauritia flexuosa*; that of the main part of the hammock is of *Astrocaryum vulgare*. Photo by M. J. Balick.

saponification is 220.2. The seed oil, solid at ordinary temperatures, has a slightly higher initial melting point (30° C), a higher saponification index (240–245), and much lower iodine index (12–14). These two oils are admirably suited for use in the soap industries (5).

In 1919, Correa stated that no fiber from any species of *Astrocaryum* could compete with *sisal*, *henequen* or *abacá* in the world market (1). Conditions have drastically altered in the past half century; needs have changed; secondary products from palm sources may have acquired new importance; and the obligation to find industrially valuable products for hinterland areas most certainly has developed. All of these considerations suggest a new critical technical look at *Astrocaryum* and its potentialities.

Euterpe

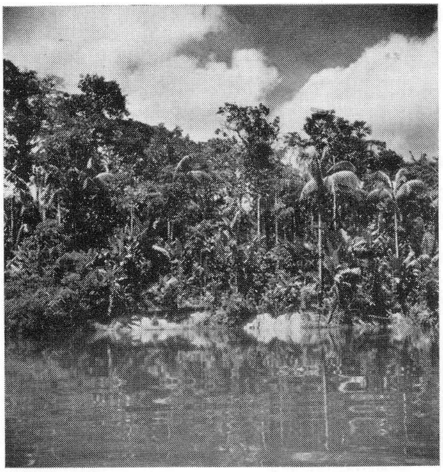
Approximately 30 species of *Euterpe* Mart., native to tropical America from Belize to South America and the West Indies, are recognized. They are usually extremely delicate and elegant palms with terminal leaves in a plumose arrangement. They occur all the way from swampy habitats to well-drained altitudes of some 4,000 feet. Many species occur in incredible abundance in nature.

Euterpe oleracea Mart.

This graceful tree up to 60 feet tall (Fig. 7) is known throughout the Amazon basin as *assaí*. In Colombia, the name applied to this or other species of the genus is *manaca*. At least 17 species are listed for the flora of Colombia, although many of the 17 are often included in the genus *Prestoea*.

Although I have never seen fiber extracted from any species of *Euterpe*, there are references to several species as the source of structural fibers useful for ropes and coarse textiles. Here is one point at which our botanical re-

7. A clump of *Euterpe oleracea* on the outskirts of Mitú, Vaupés, Colombia. Photo by J. Zarucchi.



8. *Euterpe precatoria* along banks of the Río Caquetá, Amazonas, Colombia.

search cannot, at the moment, help industry, and where industry should give heed to the vague reports that may be indicative of important economic characteristics of a group of plants.

This species, and the closely related *Euterpe precatoria* Mart. (Fig. 8), are the source of fruits from which are made a very popular drink and ice cream in many parts of Brazil and Peru.

Mauritia

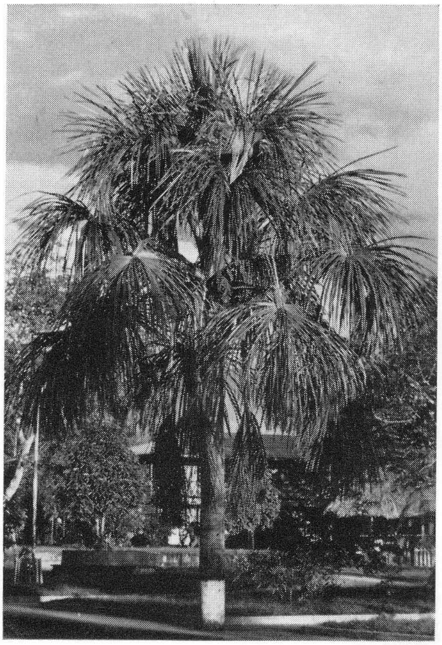
A genus native chiefly to the Amazon and Orinoco areas, to the Chocó, and to Trinidad, *Mauritia* L. f. prefers permanently swampy regions or localities at least periodically flooded. Nine or ten species are recognized. This genus may be potentially one of our most promising economic plants for domestication and deserves study.

Mauritia flexuosa L. f.

This species—or its very close relative *M. vinifera* Mart., which is often considered to be the same as *M. flexuosa*—is native from British Guiana to Colombia and Peru (Fig. 9). Described by Wallace (7) as one of the "most noble and majestic of the American palms," it is known in Venezuela and Colombia as *moriche*, as *aguaje* in Peru, and, in Brazil, as *buriti* or *miriti*. It attains a height of 80 feet, with a stout unarmed trunk measuring up to two feet in diameter. *Mauritia minor* Burret, often considered as a separate species, is undoubtedly used for identical purposes.

This may prove to be one of the most important tropical economic plants ever to be domesticated in South America, once serious attempts are made to domesticate it. It is a multipurpose economic plant.

We are here interested in it as a fiber source. Since it apparently has never been cultivated, even by primitive peoples, we have no idea of the extent to which cultivation may alter the plant



9. *Mauritia flexuosa* growing in the center of the town of Mitú, Vaupés, Colombia. Photo by J. Zarucchi.

and render it more important as a potential domesticate, especially for ecological sites not usable for other cultigens.

Occurring widely in the Amazon and Orinoco valleys, the *moriche* holds a very important place in the life of native peoples in tropical South America. The sap is the source of a wine; another beverage is prepared from the leaves; a kind of sago starch is made from the inner pithlike parts of the stem; the fruits have an edible pulp from which also a fermented chicha is made; and the immature leaves yield a fiber.

The strong structural fiber is prepared from the epidermis, stripped from very young leaf blades and dried. It is threadlike and white. The fiber extracted from young leaf spikes appears to be much stronger than that taken from older material. Widely regarded as one of the best fibers for cordage, hammocks, and fishing nets, it has been rated even more durable than the fiber provided by *Astrocaryum vulgare*. *Mauritia* fiber has been classed as the most useful native fiber produced in British Guiana.

Because of interest in this fiber plant as a possible candidate for domestication, it will perhaps be valuable to mention some of its other economic potentialities. The quality and quantity of a sagolike starch from the stem of *Mauritia flexuosa* puts this palm in the same category with *Metroxylon sagu* Rottb. of the Old World. The Warao and other Indians of the Orinoco prepare great quantities of this starch from wild stands of *Mauritia flexuosa.* The production of starch from the *moriche* palm is, perhaps, a locally exploitable industry.

In addition to its importance as a source of starch, *Mauritia flexuosa* yields interesting oils. The pulp of the fruit comprises approximately 10% of an edible oil, valuable because of its high concentration of reddish carotenoids. The fruit kernel has up to 48% of an oil of a light yellow color with an iodine index of 25 and a saponification index of 246 (5). Little has been done, even in Brazil, about the industrialization of this oil, but it could, together with fiber production, become the basis for cultivation of extensive plantations of *Mauritia flexuosa* and its relatives. It most certainly demands the attention of modern science and industry as a neglected economic plant (6).

The interesting genus *Mauritiella*, a segregate of *Mauritia*, may well supply the same fibrous elements as does *Mauritia*, but I have never encountered its use. It is very similar to *Mauritia* but is of a slenderer and more graceful habit. Some 15 species of *Mauritiella*

10. *Oenocarpus bacaba* growing in forest, Vaupés, Colombia. Photo by J. Zarucchi.

have been recognized from tropical Americas. The species most commonly found in Amazonian Colombia is *Mauritiella aculeata* (HBK.) Burret. It is known in the Vaupés as *caranaí.*

Oenocarpus

The genus *Oenocarpus* Mart. comprises up to 16 species of palms of northern South America and Central America. They are often lofty and majestic trees native to river banks that are not heavily flooded during the rainy season; some species, however, are lower and caespitose. They are tropical, no species ascending higher than 1,500 feet above sea level.

Oenocarpus bacaba Mart.

Widely known in the Amazon as *bacabá, Oenocarpus bacaba* occurs abundantly on high river banks of the Amazon and Orinoco drainage areas and is general in the dry virgin forests of the western Amazon (Fig. 10). With a strong trunk, usually devoid of spines, it may reach a height of 60–70 feet.

Although I have never seen *Oenocarpus bacaba* exploited by Indians for its fiber in Colombia, there are reports suggesting that the production of fiber of this species is worthy of study (2, 4). The literature can help us little in this respect, and it may be that the fibers supplied by this species represent not structural fibers but the remnants of persistent leaf bases, like those of *Leopoldinia piassaba* Wallace; they are, however, much stouter and stiffer than those of the *piassaba* palm.

The fruits, violet externally and greenish within, produce an oil (from 8–10% of the nutritive tissue) which has physical properties very similar to those of olive oil (5).

There are many other species yielding valuable structural fibers that Colombia ought to consider from the industrial point of view. Some are native Colombian plants; others are from far off foreign lands, but they could be easily adapted to Colombia's varieties of climate. I have mentioned only palms of the Colombian Amazonia—partly because I am personally acquainted with most of those plants. But I would be derelict if, in this brief and superficial report, I did not mention a few other plants to which Colombian fiber-producing operations should direct their attention. Some are well known plants; some are poorly known, but, as with the palms that I have discussed, they all merit research. Such a list might include *Ananas comosus* (L.) Merr., *Aechmea* spp., *Bromelia* spp. and *Karatas plumieri* E. Morr. of the Bromeliaceae or pineapple family; *Musa textilis* Nee of the Musaceae or banana family; and *Phormium tenax* Forst. and several species of *Sansevieria* of the Liliaceae or lily family. These, and others that might be mentioned, await proper exploitation or study as adjuncts to Colombia's future in an intensification of man's bending of the Plant Kingdom to human betterment.

In conclusion, I take the opportunity of dedicating this modest contribution to the late Professor Armando Dugand, outstanding Colombian scientist and expert in palms, under whose direction in 1941 I began my 35-year study of the economic potentialities of the Colombian flora.

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PALM LITERATURE

Recent Malaysian Studies on the Oil Palm

TURNER, P. D. (ed.) *Oil Palm Developments in Malaysia: Proceedings of the First Malaysian Oil Palm Conference.* 164 pp. The Incorporated Society of Planters, Kuala Lumpur. 1968. WASTIE, R. L. AND D. A. EARP (eds.) *Advances in Oil Palm Cultivation: The Proceedings of the International Oil Palm Conference.* 469 pp. The Incorporated Society of Planters, Kuala Lumpur. 1973. WILLIAMS, C. N. AND Y. C. HSU. *Oil Palm Cultivation in Malaya: Technical and Economic Aspects.* 205 pp. University of Malaya Press, Kuala Lumpur. 1970. TURNER, P. D. AND R. A. GILLBANKS. *Oil Palm Cultivation and Management.* 672 pp. The Incorporated Society of Planters, Kuala Lumpur. 1974. KHERA, H. S. *The Oil Palm Industry of Malaysia: An Economic Study.* 354 pp. Penerbit Universiti Malaya, Kuala Lumpur. 1976.

These five books reflect the breadth of investigations carried out in Malaysia over the past ten years on the oil palm, during a period wherein Malaysia came to be the world's leading producer of palm oil.

Considered in the order listed above, the first item is an edited collection of fifteen papers presented at a conference held in Kuala Lumpur in 1967. The papers cover a broad range of agronomic subjects including land preparation, nursery operations, cover crops, and harvesting methods. These are complemented with single papers on industrial processing, economic aspects, and the future of the oil palm in Malaysia. Each paper is followed by a short summary of the points from discussion, and some include black-and-white photographs.

Advances in Oil Palm Cultivation represents the edited proceedings of another oil palm conference held in Kuala Lumpur in 1972. Although billed as international in scope, nearly all of the thirty contributions specifically concern cultivation in Malaysia. The introductory paper by C. W. S. Hartley[1] is an exception, dealing with the worldwide expansion of oil palm planting. Cultivation is the main thrust of the volume, and both experimental and field results are presented on topics ranging from plant breeding to transportation of harvested fresh fruit bunches to the factory. Nutrition received the greatest attention with eight papers on the subject. Each of the papers is well documented, and the points from discussion are summarized.

Oil Palm Cultivation in Malaya is an original work intended as a basic book on oil palm cultivation, rather than a planting manual. The book is divided into two parts. Part One considers oil palm cultivation and begins with an important chapter on climate and soil conditions favorable to the palm. Following are eleven chapters on botany and the various agronomic practices through harvesting methods. Part Two, representing about one-fourth of the book, is a practical manual of recommended procedures for managing an oil palm plantation, along with an explanation of some of the underlying economic principles. The book is illustrated with black-and-white photographs, numerous figures and tables, and contains a bibliography and an index.

Oil Palm Cultivation and Management is another original work. It is a comprehensive manual for the practical planter in Malaysia and elsewhere, drawing together research results from Malaysia as well as from Africa and the New World. In scope it covers all aspects of oil palm cultivation, with fourteen chapters devoted to topics such as plantation design, weed control, diseases, and pruning and thinning. Additional chapters cover processing, oil palm products, and plantation management. The book is richly illustrated with photographs, many in color. It contains an exhaustive bibliography of nine hundred items, a glossary of technical terms, and an index. This study is by far the most impressive of the five books being reviewed, and should be on the bookshelf of every oil palm planter as well as those concerned with the plantation cultivation of palms in general.

Rounding out this group of studies is *The Oil Palm Industry of Malaysia.* The work is an economic study representing a revised version of the author's doctoral dissertation. The opening chapter introduces the oil palm, followed by a chapter that examines in detail the economic history and development of the oil palm industry in Malaysia. The seven succeeding chapters cover the economics of palm oil production in Malaysia, as well as world markets for palm oil and palm oil substitutes. The international scope of the economic discussion makes the study especially valuable. A final chapter puts forth policy recommendations for the industry in Malaysia. The book abounds with tables and statistical analyses, is well documented, and contains a lengthy bibliography.

In addition to the studies reviewed, I know of six others that have been published since 1966 by The Incorporated Society of Planters, Kuala Lumpur. They are: J. W. L. Bevan, T. Fleming, and B. S. Gray. *Planting Techniques for Oil Palms in Malaysia.* 156 pp. 1966; J. W. L. Bevan and B. S. Gray. *The Organisation and Control of Field Practice for Large-Scale Oil Palm Plantings in Malaysia.* 166 pp. 1968; P. D. Turner (ed.). *Progress in Oil Palm.* 321 pp. 1969; P. D. Turner (ed.). *The Quality and Marketing of Oil Palm Products.* 295 pp. 1969; P. D. Turner and R. A. Bull. *Diseases and Disorders of the Oil Palm in Malaysia.* 247 pp. 1967; B. J. Wood. *Pests of Oil Palms in Malaysia and Their Control.* 204 pp. 1968.

[1] See review of C. W. S. Hartley, *The Oil Palm* in *Principes* 13(3): 110, 1969.

Furthermore, in 1976 Kuala Lumpur was the site of the Malaysian Agricultural Oil Palm Conference, and the proceedings will be published.

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NEWS OF THE SOCIETY

News from Texas

Palm Society members will be interested to learn that another local group has been formed, this time in Houston, Texas. Their first pre-organizational meeting was August 27, 1975; another was held in October, at which time various aspects of forming a chapter were discussed. Members Alton Marshall and Jim Cain had many palms to display and Jim even had some *Parajubaea cocoides* seeds from Quito to give, hoping this palm too might acclimatize itself in the area as have other high altitude palms.

The organizational meeting was held February 10, 1976. Slides were shown and Gary Outenreath told how to protect palms from cold. Jim Cain showed slides of South American palms. It was stressed that the group's objective was to market palm culture in Houston and to expose the public to more plantings of the uncommon species. On May 19, 1976 another meeting was held at the Busch Bird Park where Gary Outenreath again showed slides, this time those taken on his travels to obtain plants for Busch. A tour of the gardens greatly impressed those in attendance. On September 9, 1976 a large group attended a meeting at the Houston Arboretum in Memorial Park. Dues are being assessed at $5 per year or $7.50 per couple. Bill Basher spoke on palms at the Arboretum where lack of help has created various problems. The group expressed a desire to help with care and maintenance as a future project. Also at this meeting a large group of palms for display was again furnished by members Alton Marshall and Jim Cain.

A Steering Committee meeting was held September 15, 1976 to review membership status, draft a set of bylaws and select temporary officers. At a second Steering Committee Meeting Jim Cain presided as temporary President with Bonny Ruhland as temporary Secretary. The final draft of the constitution and bylaws was presented. They were approved at a general meeting on November 30 so the group is now fully organized with a total membership of 26. They have a lot of very interesting and knowledgeable people so we look forward to hearing more about them and their activities.

News from Florida

A group of Palm Society members in and near Jacksonville, Florida met on August 1, 1976 at the home of Jim and Gaye Menge and decided that indeed there should be a North Florida Chapter of The Palm Society. They looked at the Menge's palm collection and discussed various matters concerning the formation of their new group.

Marianne Betkowski, Secretary-Treasurer, reported that the newly-formed North Florida Chapter of The Palm Society held its second meeting October 24, 1976 at the home of Mr. and Mrs. Walter Rogers. Ten members with their wives were present to tour the Rogers' collection and enjoy the steak dinner arranged through the Rogers' hospitality. Host Rogers spoke about the palms he had tried since 1950 and gave out copies of the list of palms that he had grown both successfully and unsuccessfully, stating reasons for the latter. New officers elected as follows: President—Jim Menge; Vice-President—David Moomaw; Secretary-Treasurer—Marianne Betkowski. A meeting was planned for February 6 to visit Dent Smith's palm collection but was called off due to the effects of the freeze in January. Other matters discussed were the possibilities of increasing the number of palms to be tried in the colder North Florida area, and to make up an information sheet for new members as well as a sales letter indicating the availability of extra seedlings. Mary Noble, editor of the Garden News in the Florida Times-Union, ran a notice of the formation of this new chapter.

On Saturday, January 29, 1977, the Miami area members met at Paul Drummond's garden and from there proceeded to Fairchild Garden. The meeting had been planned before the disastrous freeze of January 19. Due to the freeze the meeting turned into a tour to see the effects already apparent on the palms of the low temperature. In many spots it was the lowest temperature ever recorded. All veitchias have brown leaves, latanias are all brown and the bismarkias have turned white! The cycad collection was badly hit; many of the beautiful plants are just a mass of brown leaves. At the Garden it went to 27°F (–3C) in the open. Oddly, the licualas were apparently undamaged, but carpentarias, *Ptychosperma elegans*, *Caryota*, *Aiphanes* and many others were burned. Most will probably recover but it is still much too soon to tell how bad the actual damage will be. *Heterospathe elata* was undamaged as were the *Phoenix*. A request has been sent to all Florida members to find out as much as possible about the cold and its effects on palm plantings. It may be a year or so until it can all be correctly assessed.

Notice

Back issues of PRINCIPES, starting with Vol. 3 no. 3 through current issue are available at a cost of $1.50 each, which includes postage and handling. The 11 earlier issues (Vol. 1 has five issues) have been reprinted and cost $2.50 each issue or a total of $27.50 for the set. Purchasers of all 11 reprints at one time may deduct 10 percent from the cost, paying $24.75 instead of $27.50. All can be ordered through the office of The Palm Society, 1320 S. Venetian Way, Miami, FL 33139, USA. Also available are two reprints about hardy palms for 75¢ together, including postage and handling.

TEDDIE BUHLER

PALM BRIEFS

A Growing Campus Palm Collection

At Ventura College in Ventura, California, a new palm garden is coming into being in a most unlikely manner. It is the brainchild of swimming coach Jim Tallman who, in May of 1975, proposed to the College's Committee on Campus Development that palms be planted near the swimming pool instead of the oak and pepper trees planned for the site, whose leaves would blow in the pool and need constant care for removal. A palm frond, however, could be picked out easily. So, in his proposal he outlined the species he wanted, the timetable for planting, stated reasons and need—to enhance the campus, to provide a place for people to see and learn about palms, and to put in foliage that doesn't require a lot of maintenance. Tallman felt he could procure the desired palms through donations and so far he has succeeded. When his group sees a palm they like, if it is growing in someone's front yard, they ring the doorbell and ask the owners if they may have the palm for the palm gardens at the college. Sometimes they hear that palms are to be uprooted as progress puts in concrete. Two of the tallest palms, nearly 50 feet, were acquired in this way. Hauling these large plants to their new home was a double-team effort involving Bill Ayala, instructor at Oxnard College in a course in operation of heavy equipment, the heavy equipment, and more students.

Tallman has 75 students in his crew so labor is no problem. Most of them excel at swimming and he feels they can excel at palm gardening or anything else if they read enough books. Tallman himself learned a lot about palms from books and from Joe Sullivan who, until his death, was a valuable friend. And now Joe's widow, Pauleen (Secretary of The Palm Society) is helping with the project. Emphasis is on variety of palms, and all society members have been asked to be generous in their contributions to enhance this collection which will in time be a great asset, as the climate in Ventura is more suitable than at Huntington Gardens, the closest larger palm collection. Help has come from even as far away as Puerto Rico. And, as one of the swimming team said: "For taking swimming, you get to do this for free," as he and another student dug a 3½-foot-deep hole to hold the garden's latest acquisition.

TEDDIE BUHLER

Variegation in Rhapidophyllum hystrix

In 1972 while engaging in field work for a study of the needle palm, *Rhapidophyllum hystrix,* I discovered two variegated plants in a swamp located just north of the town of Oviedo, Seminole County, Florida. To my knowledge, this is the first record of variegation in this species. Unfortunately the variegation was not permanent, for subsequent fronds produced by both plants were completely green. The cause of this temporary variegation is not known. It is regrettable that it was not permanent since a palm like the one pictured would

make a striking cultivated plant. The stripes varied from cream to almost yellow-cream in color.

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New Palms from the Pacific, IV

Physokentia avia H. E. Moore, *sp. nov.*

Folia regulariter pinnata pinnis utrinque ca. 26 acutis unicostatis sine ramentis. Fructus ater, depresso-globosus, 13–15 mm. in diam., endocarpio ca. 9 mm alto, 10 mm in diam., fragili, carinis indistinctis, seminis endospermio ruminato.

Holotype: *Stevens & Isles LAE 58394* (BH).

Trunk solitary, to ca. 15 m high, with prop roots to 2.5 m long.

Leaves regularly pinnate, 1.5–2 m long; sheath 5–8 dm long, puncticulate with depressions of deciduous scales basally, densely brown floccose-lepidote below petiole or puncticulate with brown bases where scales have disappeared; petiole 20 cm long or more, rounded beneath, shallowly channelled above, densely brown floccose-lepidote or puncticulate where scales have disappeared;

rachis densely brown or pale floccose-lepidote; pinnae about 26 on each side, rather glossy dark green above, paler beneath, floccose-lepidote above when young, becoming brown-puncticulate, densely brown-puncticulate beneath, midrib elevated on upper surface, secondary veins 1–2 on each side, tertiary veins numerous, midrib somewhat floccose-lepidote at base beneath but lacking ramenta, basal pinnae ca. 20–70 cm long, 0.2–5 cm wide, often continued into a rein, pinnae near the middle ca. 50–65 cm long, 3.5–4.5 cm wide, apical pinnae ca. 20–26 cm long, 1.5–1.7 cm wide.

Inflorescence (21–) 45–55 cm long, glabrous, 2 (–3?) times branched; peduncle dorsiventrally flattened, 7.0–8.5 cm long, ca. 2 cm wide and 0.5 cm thick at insertion of prophyll; prophyll bicarinate, thick, open abaxially and incompletely encircling the peduncle at insertion, ca. 24.5–34 cm long, 8 cm wide; peduncular bract thin, 32–33 cm long including a rostrum 2–5.5 cm long; rachis 15–23 cm long with about 13 branches, the lowermost branch to ca. 41 cm long, including a peduncular base ca. 5 cm long, and with 5 branches, the lowest of these probably again branched, middle branches once-branched, to ca. 28.5 cm long, apical branches unbranched, ca. 25 cm long; rachillae bearing triads to the middle or nearly to the apex, rarely only with paired or solitary staminate flowers; bracts subtending the triads prominent, often acutish, to 3 mm long; bracteoles of flowers brown, membranous, low.

Staminate flowers markedly asymmetrical, color not noted, ca. 4.5–7.5 mm long; sepals broadly ovate, 2–3 mm long, acute to rounded at apex, keeled, the outer often with minutely laciniate or denticulate membranous margins; petals drying lineolate, ovate to asymmetrically ovate, 4.5–7 mm long, 3–4 mm wide near base, acute, more or less grooved internally to match anthers; stamens 6, filaments broad, briefly inflexed at apex in bud, anthers 3–4 mm long; pistillode somewhat variable but usually about half as long as stamens, ovoid to columnar, mostly deeply to very deeply trifid: pistillate buds about half as long as staminate flowers at staminate anthesis; sepals in fruit ca. 4 mm long, 5 mm wide, acute; petals in fruit ca. 6 mm long, 7 mm wide, acute, sometimes ciliate near base; staminodes 3, dentiform.

Fruit black when mature, depressed-globose, with stigmatic residue in upper fourth, 13–15 mm in diam., drying minutely pebbled; mesocarp reddish when fresh; endocarp ca. 10 mm in diam., 9 mm high, fragile, shallowly and somewhat irregularly sculptured with roundish depressions, operculum broadly rounded, basal: seed ca. 9.5 mm in diam., 9 mm high, conforming to sculpturing of endocarp, testa brown, raphe branches ascending and lateral, anastomosing; endosperm ruminate.

Specimens examined: PAPUA NEW GUINEA: NEW BRITAIN: EAST NEW BRITAIN, SUBDISTRICT POMIO; helicopter pad (mapping), Mt. Lululua, 5° 43′ S. Latitude, 150° 58′ E. Longitude, alt. 1830 m, common in *Nothofagus*-dominated moss forest, 12 May 1973, *P. F. Stevens & R. S. Isles LAE 58394* (BH, holotype; L, LAE, isotypes); lower slopes of Mt. Lululua, 5° 43′ S. Latitude, 151° 02′ E. Longitude, alt. 1525 m, common in *Nothofagus*-dominated montane forest, 6 May 1973, *P. F. Stevens & Y. Lelean LAE 58276* (BH, LAE); Mt. Sule, about 25 miles NNE of Fulleborn Harbour, 5° 50′ S. Latitude, 150° 50′ E. Longitude, alt. 1500 m, in *Nothofagus* forest with thick undergrowth of *Nastus*, 7 May 1973, *J. R. Croft & P. Katik LAE 14936* (BH, LAE).

Physokentia avia represents a second species having seeds with ruminate endosperm and the endocarp with shallow, nonangular sculpturing. It differs from *P. insolita* H. E. Moore in having regularly pinnate leaves lacking large scales (ramenta) on the midrib of the pinnae beneath, and in having black rather than red fruit. The relationship is close, however; the endocarp and seed very much resemble those of *P. insolita.*

The westward range of *Physokentia* is substantially increased by the finding of this species. The epithet *avia* (from the Latin *avius*, out of the way, untrodden) suggests both this distance and the nature of the type locality which was reached by helicopter. The genus is now to be looked for on Bougainville and Choiseul which lie between the New Georgia Group, formerly its western limit, and New Britain.

HAROLD E. MOORE, JR.

Taveunia and Cyphosperma

When *Taveunia tanga* was described from Fiji in 1965, I had an erroneous concept of the monotypic New Caledonian genus *Cyphosperma* H. Wendland ex J. D. Hooker. In the interim, I have had occasion to study *Cyphosperma balansae* (Brongniart) H. Wendland ex Salomon at three localities in New Caledonia and to make comparisons between *Taveunia* Burret and *Cyphosperma* based on experience with both in the field and on study of herbarium specimens and preserved materials. The differences are so slight—less prominently sculptured endocarp and seed and presence of a dorsal ridge rather than furrow on the endocarp and seed of *Taveunia*—and the resemblances so marked otherwise that it no longer seems possible to maintain *Taveunia* apart from the older genus *Cyphosperma.* A more detailed analysis is in manuscript, but appropriate names are needed for a treatment of palms in a new flora of Fiji that is now being prepared for the printer. These names are therefore published here.

Cyphosperma tanga (H. E. Moore) H. E. Moore, *tr. nov.*
Taveunia tanga H. E. Moore, Candollea 20: 98. 1965.

Cyphosperma trichospadix (Burret) H. E. Moore, *tr. nov.*
Taveunia trichospadix Burret, Bishop Museum Occasional Papers 11(4): 13. 1935.

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