Palms

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The International Palm Society

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FRONT COVER

Chamaedorea pauciflora in periodically flooded forest, Loreto, Peru. See article page 167 by J.-C. Pintaud and B. Millán.

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A well grown specimen of *Asterogyne martiana*, as seen on the recent IPS Biennial trip to the Lyon Arboretum, Hawai'i. IPS members will be saddened to learn that the Lyon Arboretum is now closed to the public. See News from the Word of Palms, p. 160. (Photo by S. Zona)

Another view of the same palm, *Asterogyne martiana*, shown on the back cover. (Photo by S. Zona)

NEWS FROM THE WORLD OF PALMS

During the IPS Biennial in Hawai'i last May, many IPS members were thrilled to see the spectacular palm collection at the Lyon Arboretum. We are now deeply saddened to learn that the Arboretum, operated by the University of Hawai'i, has been closed by UH officials as of 27 August 2004. Citing health and safety concerns, including structural instability of some buildings, electrical shortcomings and safety of pathways, UH officials closed the Arboretum to visitors. One building is open to staff members to carry on Arboretum business and upkeep, but several other buildings are closed until further notice. In a statement released to the press, Jim Gaines, UH Interim Vice President for Research, said, "We are reluctantly closing the facility to public access pending a more in-depth inspection and review of the buildings and grounds."

The Lyon Arboretum contains many beautiful specimens of rare palms seldom, if ever, cultivated elsewhere in the USA. IPS Biennial attendees will remember Ray Baker's presentation and introduction to the Arboretum, highlighting its historic legacy and its tremendous palm diversity. We sincerely hope UH will be able to make speedy repairs and reopen the Lyon Arboretum so that the public can again enjoy this treasure of a botanical garden.

On a happier note, the recent spate of hurricanes in the Caribbean and Southeastern US seemed to have spared many of the area's botanical gardens. While we are concerned for IPS members and others who have suffered significant storm damage from Hurricanes Charlie, Frances, Ivan and Jeanne, we are pleased to report no irreparable damage at the following gardens: the Atlanta Botanical Garden, Fairchild Tropical Botanic Garden, Huntsville Botanical Gardens, Harry P. Leu Gardens, the Montgomery Botanical Center, Marie Selby Botanical Gardens and the University of South Florida Botanical Gardens. Bok Tower Gardens, in Lake Wales, Florida, sustained some damage but has reopened. Dr. Angela Leiva, Director of the Jardín Botánico Nacional, Cuba, reported some losses in the palm collection, but redundancy in the collection prevented any species from being lost. The exception to this generally optimistic report is the Queen Elizabeth II Botanic Park in the Cayman Islands; we have heard reports of near total devastation. We hope the garden and its staff make a speedy recovery.

Away from the tropics, in the calm, windless conditions of the great Palm House at Kew, *Attalea butyracea* flowered in May this year for the first time. While this may not seem to be particularly newsworthy, the palm in question is the most massive of all the palms in the Palm House collection, and it has grown lustily since it was planted there in 1984 after the glasshouse was restored. Now virtually reaching the roof but with a scarcely evident trunk, it is a spectacular sight. It thrust out an inflorescence bearing both male and female flowers, which in itself is unusual, as species of *Attalea* tend to have entirely male inflorescences when they flower for the first time. Male flowers on the Kew palm appeared to have empty anthers so fruit set is unlikely.

Folks in South Florida will soon have the opportunity to see one of the marvels of the plant world: the flowering of *Corypha umbraculifera*. A plant at Fairchild Tropical Botanic Garden is putting out an inflorescence, which will produce thousands of flowers and fruits. After the fruit ripen, the palm will die. The dramatic event and heroic climax are much anticipated. The last time one flowered at FTBG was in 1984.

THE EDITORS

Hyospathe

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1. *Hyospathe macrorachis* in Ecuador - note the elongate inflorescence borne amongst the leaves, and red flowers.

Statistical analysis of characters displayed by herbarium specimens of a palm genus allows botanists to develop a more objective method of deciding how many species there really are in the genus, instead of relying on more subjective, intuitive approaches. Here this more objective approach is applied to *Hyospathe*.

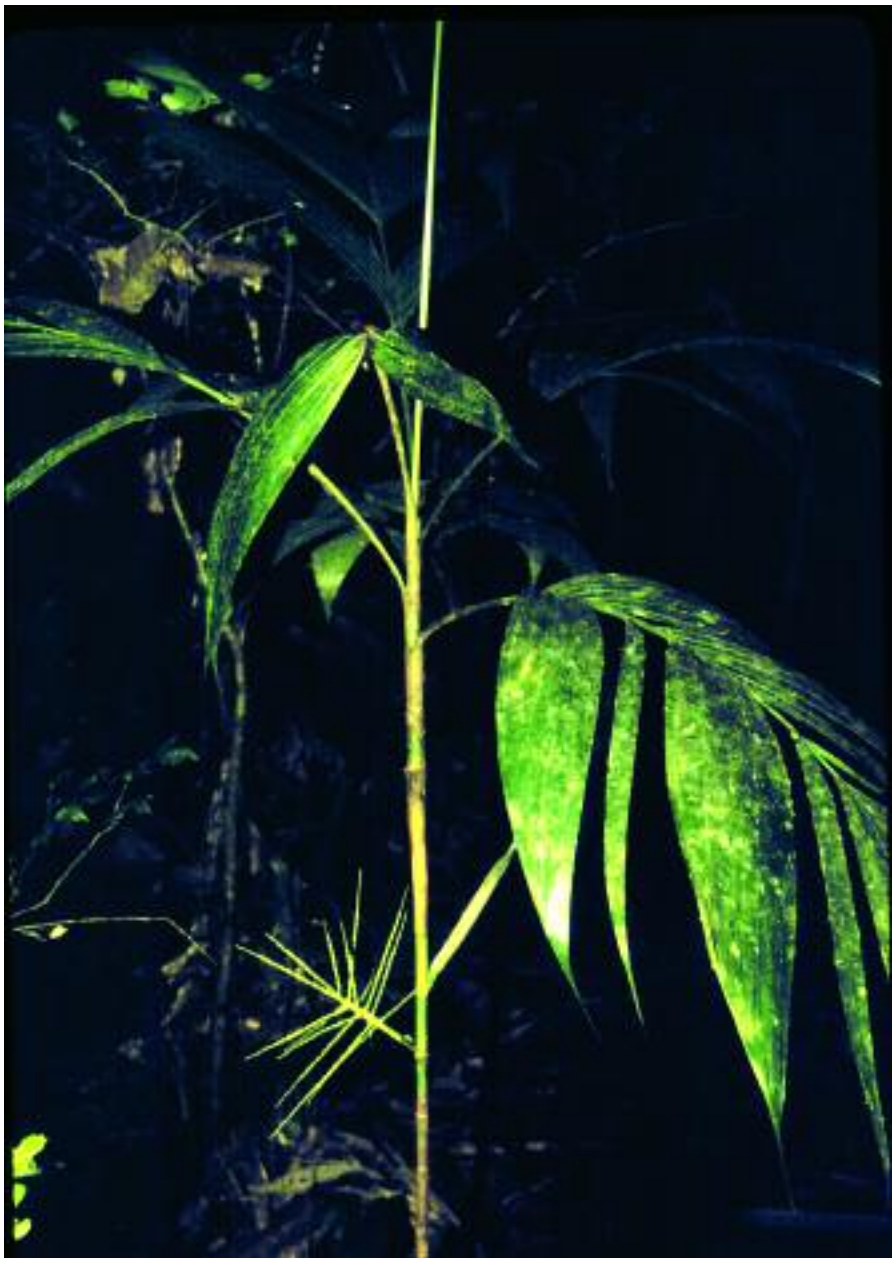
By 1964, the year the eminent German palm taxonomist Max Burret died in Berlin, there were 18 recognized species of *Hyospathe*, eight of them described by Burret himself. Twenty-five years later, only two remained (Skov & Balslev 1989). What, you may ask, happened to the other 16? Did they die too? Recently, I became interested in *Hyospathe*, inspired by some unusual specimens collected in Panama. I asked the same question as earlier taxonomists – how many species? – but I changed the way it was asked. How might we know, in a scientific way, how many species there are?

Traditional herbarium taxonomy, as practiced by most palm taxonomists, has produced widely differing estimates of the number of species per genus, not just in *Hyospathe*. The reasons for this are complex, but rest on one basic fact. There is no scientific method in herbarium taxonomy. The process by which taxonomists place specimens in species is not repeatable, quantitative, nor explicit. Rather it is based on intuition and subjectivity. When different taxonomists look at the same specimens, they come up with different numbers of species, with all the associated confusion in names. Furthermore, different taxonomists have different concepts of exactly what constitutes a species.

It was against this background that I began a study of *Hyospathe*. I wanted to carry out a logical sequence of steps that would lead to a scientific taxonomy of the genus, at the same time avoiding the pitfalls of earlier workers. I wanted to avoid, at least in the early stages of the work, 'species' altogether, and just analyze morphological variation of the specimens. The work is now published (Henderson 2004), and here I give a brief outline of the methods and results.

First, I assembled a sample of 538 specimens, borrowed from various herbaria in the United States. The first thing I noticed was the poor quality of many specimens, and I excluded 110

2. Inflorescence of *Hyospathe pittieri* from Colombia – note the inflorescences borne below the leaves and red flowers.



3. *Hyospathe elegans* subsp. *elegans* in the central Amazon – note small size of the plant, leaves with only a few, multi-fold leaflets, inflorescence borne below the leaves and yellow flowers.

(about 20%) from further analysis. I then looked through the specimens and searched for characters. These are any measurable attribute, qualitative or quantitative, of the specimens. An example of a qualitative character is the position of the inflorescence – borne among the leaves or below the leaves. In this case the character has two states (among or below), and each specimen has only one state. An example of a quantitative character is how many flowering branches there are on an inflorescence. In *Hyospathe* this ranges from two to 51. Having chosen a list of 33 characters, I then made a data matrix and scored each specimen for each character. Also included in the matrix were geographic data (latitude, longitude and elevation) taken from specimen labels.

When the data matrix was complete, I began the analysis. The first stage was to use qualitative characters to place specimens in groups, each group being defined by a unique combination of character states. This process is achieved using Cluster Analysis, and the results are unequivocal. I discovered six groups, each with a unique combination of states. The next stage in the

analysis was to study each of these groups in turn, using both quantitative characters and geographic distributions. In this way, sub-groups may be found which differ statistically in one or more characters and are geographically isolated from other sub-groups.

The final stage in the process is to apply a species concept and names to the groups discovered. In this study I used what is known as the Phylogenetic Species Concept of Nixon and Wheeler (1990), where species are defined as: "the smallest aggregation of populations....diagnosable by a unique combination of character states in comparable individuals." The great advantage of the Phylogenetic Species Concept is that it is 'operational.' It not only gives a definition but also an operation for delimiting species. There are many other species concepts, but few can be applied by the herbarium taxonomist. Because I found six unique character groups, I applied the Phylogenetic Species Concept to these and so recognized six species. Within some of these species I also found geographic and quantitative variation, and I applied a sub-species concept to these sub-groups. The final stage, application of names, is easy. Type specimens were included in the analysis, and the oldest named type specimen in each group of specimens determined the name of the species. If a group had no type specimen included, it then automatically became a new species and was described according to the well-established rules of naming new species.

Briefly, I will now describe the six species. The first is *Hyospathe macrorachis* (Fig. 1). This is very distinctive because it is the only species with an inflorescence borne amongst the leaves. It is also notable for its elongate inflorescence and male and female flowers that are borne on short stalks. The species occurs on eastern Andean slopes in Ecuador and Peru, at a mean elevation of 1630 m.

Very similar to *Hyospathe macrorachis*, but differing in its inflorescence borne below the leaves, is a new species, *H. peruviana*. This also occurs on eastern Andean slopes in Peru, at a similar mean elevation (1640 m).

Hyospathe wendlandiana is known only from the Central Cordillera of the Andes, in the department of Antioquia, Colombia, at a mean elevation of 1600 m. It differs in its tubular sepals of the female flowers.

Hyospathe frontinensis, another new species, is also from the Colombian Andes, but from the western Cordillera. It occurs at a mean elevation of 1370 m. It is distinctive in its mostly simple leaves and inflorescences with few flowering branches.

All the four species discussed so far come from small areas at higher elevations in the Andes. They have also been collected only a few times, and there are very few specimens in herbaria. The last two species are more widespread and much more commonly collected. *Hyospathe pittieri* (Fig. 2) is larger in size than the other species, with stems reaching a mean of almost 5 m in height. It also has regularly divided pinnate leaves and inflorescences borne below the leaves. It is widely distributed in montane areas in northern Venezuela and Andean Colombia, and just reaches Panama. Populations are scattered and the species does not appear common in any part of its range.

Finally, we come to the most widespread species, *Hyospathe elegans* (Fig. 3). This occurs in two areas; west of the Andes in Costa Rica, Panama and the Pacific coast of Colombia and Ecuador, and east of the Andes throughout the Amazon basin. In the western Andean region, I found that the range of the species is not continuous but is split into several discrete areas. When I compared quantitative variables of specimens from each area, I discovered that there were significant differences in several characters amongst the different areas. Because of these geographic and morphological differences, I recognized specimens from these areas as separate subspecies. So, for example, the subspecies from Costa Rica, subsp. *costaricensis* (Fig. 4), has tall stems over 4 m tall and 1.6 cm diameter, a leaf rachis 82 cm long with 22 leaflets per side (all figures here are means). In contrast, subsp. *tacarcunensis*, from higher elevations (1300–1400 m) on Cerro Tacarcuna, along the border between Panama and Colombia, has small stems only 2 m tall and 0.5 cm diameter, a leaf rachis only 8 cm long and simple leaves.

The subspecies from east of the Andes, subsp. *elegans*, is particularly variable, especially along the eastern Andean slopes in southern Colombia, Ecuador and Peru. However, separate groups cannot be distinguished. Variation in quantitative variables here was so great that I suggested that there might be a hybrid zone along the eastern Andean slopes, between the lowland Amazon plants of subsp. *elegans* and the higher elevation species *H. pittieri*. However, with only herbarium specimens as the data source, there was no way to test this hypothesis.

facing page

4. Tall, clustered stems of *Hyospathe elegans* subsp. *costaricensis* from Costa Rica – note large, regularly divided leaves with many, single-fold leaflets.

Multivariate analysis is a very powerful tool for taxonomists. Not only does it give insights that could not be made using traditional, intuitive taxonomy, but it also produces scientific results, i.e., ones that are based on an explicit methodology, are repeatable and lead to testable hypotheses. The method is certainly not without problems, the biggest of which are the poor quality of palm specimens in general and the few collections from some areas. This problem leads to missing data in the matrix, and missing data are the bane of multivariate analyses. There are also some kinds of variation where the method fails to resolve a taxonomic problem. We have seen one in *Hyospathe*, where we suspect that a hybrid zone occurs between two species, but we cannot analyze this using multivariate analysis of herbarium specimens. Another example of where the method fails is in species complexes. However, the advantages of multivariate analysis far outweigh the drawbacks.

The two-stage approach to herbarium taxonomy that I used in the study of *Hyospathe* – multivariate statistical analysis to delimit specimen groups and subsequent application of a specific species concept – has important implications for palms. This approach leads to a more realistic and certainly more scientific estimate of taxonomic diversity in the palm family than do traditional herbarium methods. It also appears to lead to a higher number of taxa. Using similar methods to those used in *Hyospathe*, I recognize 18 species of *Calyptrogyne* (Henderson, in preparation), whereas de Nevers (1995) recognized eight. Here I recognize six species of *Hyospathe*, whereas Skov and Balslev (1989) recognized two. Based on these few studies, the number of palm species may be more than double the currently accepted number of 2300!

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CLASSIFIED

Notes on *Chamaedorea* in Peru

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1. A beautifully grown specimen of *Chamaedorea fragrans* at Fairchild Tropical Botanic Garden, Miami.

Although *Chamaedorea* is one of the largest palm genera in the Americas, its representation in Peru is small but of great interest. This paper provides valuable new information on the genus.

Chamaedorea is one of the largest Neotropical palm genera. As in many genera of small highly diversified palms of tropical forest understory, the taxonomy of *Chamaedorea* is still problematic. Some species are very polymorphic, and many names have been published for each morph. Closely related taxa can be interpreted as several narrowly circumscribed species or as a single broad species. Such differences in taxonomic statements can be seen in comparing the treatment of *Chamaedorea* by Hodel (1992), which includes around 100 species and that of Henderson et al. (1995), which recognizes 77 species. Most species of *Chamaedorea* occur from Mexico to Central America, just reaching Colombia near the Panama isthmus, but there is a minor center of diversity in the Andes and nearby lowlands of the Pacific coast and in the western Amazon. However, the number of species existing in this region of South America has been much debated, especially in the widespread and polymorphic *C. linearis* complex. Gentry (1986) recognized five species within this

2. *Chamaedorea angustisecta* in seasonal forest, Madre de Dios.

3. The dry forest of the Tumbes Reserved Zone covers extensive areas of hills reaching 900 m elevation, and is home to two palm species: *Aiphanes eggersii* and *Chamaedorea linearis*.

group, Hodel (1992) three and Henderson et al. (1995) a single species. In their conservative taxonomy of *Chamaedorea*, Henderson et al. recognized five species for Peru, including one endemic.

Several field trips to various parts of Peru over the last few years allowed us to see all five species and make new observations on them, which we report here. Among the species found in Peru, *Chamaedorea fragrans* is of special interest, not only because it is endemic and little known in its natural habitat, but also because it is highly sought-after in cultivation. A handsome, very attractive palm, with thin stems and bifid leaves (Fig. 1), it produces very fragrant flowers, as its name indicates, and is easy to grow indoors or outdoors in warm climates. In contrast to its horticultural success, *C. fragrans* has seldom been collected in the wild and little is known about its ecology, other than that it grows in premontane rainforest in eastern Peru (Henderson 1995). Recently we were fortunate enough to observe *C. fragrans* at Pozuzo, its type locality in Pasco, and learn more about this rare and beautiful palm.

The other South American species of *Chamaedorea* are little known in cultivation, although they are common and often abundant in the wild. *Chamaedorea angustisecta* (Fig. 2), very rarely cultivated, is widespread in seasonal forests of central and southeastern Peru. In the wet, northeastern lowlands, another species nearly unknown in cultivation, *C. pauciflora*, is abundant (Front Cover). Typically an Amazonian palm, *C. pauciflora* extends to Brazil, and just reaches the lower Andes, where it is found with *C. pinnatifrons*. The most widespread *Chamaedorea* species, *C. pinnatifrons*, ascends to more than 2500 m elevation and ranges to Mexico. Finally, we observed *C. linearis* in the coastal region of Peru, in the sanctuary of the Tumbes dry forest, a few miles away from the extensive Peruvian/Chilean desert.

Chamaedorea linearis in Tumbes

The small region of Tumbes is located on the coast of northwestern Peru at the border with Ecuador. A remarkable characteristic of this region is the vast extension of protected areas, including the

4 (left). The bright red, large fruits of *Chamaedorea linearis* are especially attractive. 5 (right). *Chamaedorea fragrans* establishing in a humus deposit on rugged limestone.

National Sanctuary of Mangrove, the Tumbes Reserved Zone and the Cerros de Amotape National Park, the last extending southward into the region of Piura. These three entities constitute the northwestern Peru Biosphere Reserve and encompass 231,402 ha (INRENA 2002). The vegetation within the reserve is truly spectacular and well conserved thanks to the efforts of INRENA, the institute in charge of managing the protected areas. A vast expanse of mostly pristine forest is preserved at the edge of the Peruvian coastal desert. Most impressive is the dry deciduous forest, dominated by gigantic, baobab-like Bombacaceae species, including *Ceiba trichistandra* (*ceibo*) and *Cavanillesia platanifolia* (*petrino*), often covered with hanging *Tillandsia usneoides* (Fig. 3). Visiting the Tumbes Forest Reserve requires a permit and a guide from INRENA, the latter quite indispensable in order to find one's way in this wilderness sanctuary, and even more so to find a palm. First, a three to four hours' drive from the city of Tumbes with a good 4×4 vehicle will take you to the entrance of the reserve. Then, one needs to walk along seldom-used trails within the seemingly endless undulating forested hills near the Pacific coast. We walked 60 km round trip in two days in the forest to see two palm species – *Aiphanes eggersii* and *Chamaedorea linearis*. Palms are absent from most of the dry forest. At low elevation, only *A. eggersii* is to be found, and it occurs in wetter valley bottoms. In the transitional forest between the lowland dry deciduous forest and the premontane evergreen forest at 600–700 m elevation, *A. eggersii* becomes abundant, and *C. linearis* begins to appear. The latter is a medium-sized, solitary palm with pinnate leaves and slender trunk, not especially attractive except for its bright red fruits (Fig. 4), but still rewarding after walking so long in search of any palm. Above 700 m elevation in the premontane forest, *C. linearis* becomes dominant in the understory, while *A. eggersii* disappears.

Although *Chamaedorea linearis* is a common Andean species, it was very interesting to document its occurrence and ecology at the edge of its distribution on the Pacific coast of northern South America. The phytogeographical significance of the Tumbes dry forest has long been recognized. It is a very peculiar forest, with numerous endemic species, including large trees.

Moreover, this strange forest type forms a transition between two contrastingly different vegetation types, in the south with the hyper-arid desert of Peru-Chile, and the other in the north, in Ecuador with the wet forest of the Choco region. These sharp vegetation changes are due to the convergence at the Equator along the coast of South America of the cold Humboldt current coming from southern latitudes and the warm North-Equatorial Pacific current. Despite the great interest of the Tumbes forest, its palm flora remains poorly known. A single collection of *Chamaedorea linearis* from Tumbes, with incomplete data (*Simpson 391*, F) was previously recorded (Kahn & Moussa, 1994).

Chamaedorea pinnatifrons in the Andes

Chamaedorea pinnatifrons is a common component of Andean forests. In some cloud forests above 2000 m elevation, especially on steep slopes, it is sometimes the only palm species. In such habitats, it is frequent to find a bifid-leaved form of this species. Spruce (1871) described this form from the eastern Andes of Peru as a distinct species, *C. geonomoides*. As Hodel (1992) mentioned, the bifid and pinnate-leaved forms frequently occur together and seem to represent variability within *C. pinnatifrons*. In a cloud forest at 2100 m elevation in Pasco where we found the two forms growing together, the bifid form had very short erect inflorescences with stout rachillae (Fig. 5), while the most common pinnate-leaved form had larger inflorescences with drooping rachillae. However, Spruce described *C. geonomoides* as having thin, flexuous and drooping rachillae, which seems to indicate that these distinctive inflorescence characters are not consistently associated with differences in leaf shape, and thus it is justified to consider a single, variable species.

Chamaedorea angustisecta and *Chamaedorea pauciflora* in the Amazon lowlands

These two species are largely sympatric in the lowlands of eastern Peru and occur with *Chamaedorea pinnatifrons* as well, but unlike this species, they do not grow above 700 m elevation.

6. A large clump of *Chamaedorea fragrans* in forest on limestone rock, Pozuzo.

7. Hanging, flexuous stems of *Chamaedorea fragrans* on a vertical limestone cliff.

Chamaedorea pauciflora is very common and abundant in Loreto (Kahn & Mejia 1991), northeastern Peru, but *C. angustisecta* is apparently absent (Kahn & Moussa 1994). This region is very wet, with no dry season, and *C. pauciflora* grows there in a variety of habitats, including *terra firme* and periodically flooded forests. To the south the climate becomes more and more seasonal, and *C. pauciflora* is associated there with *C. angustisecta*, which become very abundant in the southeastern region of Madre de Dios and adjacent parts of Bolivia. The two species cannot be mistaken with each other, as *C. pauciflora* has bifid leaves while *C. angustisecta* has very regularly pinnate leaves with numerous, narrow leaflets.

Chamaedorea fragrans in the type locality

Spruce (1871) reported this species as "widely distributed along the eastern roots of the Peruvian Andes," which suggested that it was common at that time. *Chamaedorea fragrans* seems widespread in this region but with a very patchy distribution. It has been repeatedly collected from three small areas in the regions of San Martín, Huánuco and

8.The distinctive, olive-like fruits of *Chamaedorea fragrans*.

Junín, along with a few collections from isolated points in Pasco and Cusco. We recently visited the type locality of the species at Pozuzo in the central region of eastern Peru, and we finally understood the reason of this distribution pattern. *Chamaedorea fragrans* is restricted to forest on limestone rocks where it grows as a lithophytic species in pockets of humus deposited in the holes produced by the chemical alteration of the limestone by acidic water (Fig 5). It is very abundant and locally dominant in this habitat. It forms dense clumps composed of hundreds of thin stems, which are especially striking in the open under-storey of the forest on limestone rocks (Fig. 6), or hanging along vertical cliffs (Fig 7). The species immediately disappears outside the limestone outcrops. There are several of these outcrops in the Pozuzo area, each one supporting its own population of *C. fragrans*. Because limestone occurs as isolated and often distant outcrops in the Peruvian Amazon, *Chamaedorea fragrans*, which seems strictly associated to this habitat, has logically a disjunct distribution. On the other hand, limestone outcrops are very

distinctive, easily recognizable geological structures, so it would be easy to find more localities of *C. fragrans*. Because this habitat generally has no use, forest on limestone rocks is generally perfectly preserved, as is the case in Pozuzo, and the species is probably neither threatened nor declining. Another interesting observation is that the shape of the bifid leaves is different in Pozuzo from that of the commonly cultivated plants in the USA. In Pozuzo the leaves are narrow and the two lobes not much divergent (Fig. 6), while in cultivated plants, the lobes are strongly divergent and the leaf has a much more open shape (Fig. 1), suggesting that there is some degree of variation in this species as well.

Pollination in *Chamaedorea fragrans* would be very interesting to study. Hodel (1992) reported that it rarely fruits in cultivation, suggesting a deficiency in the pollination mechanism that probably requires specific insects. In Pozuzo, on the other hand, *C. fragrans* produces fruits in great abundance (Fig. 8). The emission of scent is certainly related to pollination and is one of the most attractive attributes of the species. Spruce gave a poetic description of it: "the Peruvian girls stick it in their hair, put it under their pillows and use it largely in decorating the little crosses which they set up at the junction of forest-paths. My specimens, dried fourteen years ago, still give out their fine odor of mignonette with a dash of primrose when hot water is poured on them."

New collections of *Chamaedorea* made in Peru

Chamaedorea angustisecta: Madre de Dios Río Madre de Dios upstream from Puerto Maldonado, Reserva Amazonica Lodge, Oct. 2002. *Millán & Pintaud 564* (USM). ***Chamaedorea fragrans:*** Pasco, Pozuzo, along road to Codo de Pozuzo, 700 m elevation, Feb. 2004, *Millán & Pintaud 835, 836* (USM). ***Chamaedorea linearis:*** Tumbes, Tumbes Reserved Zone, Cotrina control post, 03°50'27"S, 80°09'39"W, 750 m elevation, May 2004, *Millán & Pintaud 1016* (USM). ***Chamaedorea pauciflora:*** Loreto, mouth of Río Tigre, 04°26'37"S, 74°06'49"W, 130 m elevation, Mar. 2004, *Millán & Pintaud 926* (USM). ***Chamaedorea pinnatifrons:*** Pasco, Oxapampa, on road to Huancabamba, Cooperativa 2 de Mayo, 2100 m elevation, Feb. 2004, *Millán & Pintaud 828* (USM). Loreto, Río Corrientes in front of Villa Trompeteros, 150 m elevation, Nov. 2003, *Millán & Vegas 767* (USM).

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A Traditional Irrigation System Using Palmyra Palm (*Borassus flabellifer*) in Kerala, India

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1. A landscape of a typical village in Palghat showing palmyra palms and rice fields.

The multipurpose palmyra palm, *Borassus flabellifer* L., is still very important in village culture in India. This paper describes a hitherto undocumented traditional water engineering system prevalent in the Palakkad District of Kerala, India, involving the palmyra palm.

The genus *Borassus* is one of the most widely distributed palm genera, extending its range in a broad belt from western Africa and Madagascar to eastern Indonesia and Papua New Guinea (Davis & Johnson 1987). Species of the genus are commonly cultivated in India, Southeast Asia and occasionally elsewhere in other warm regions of the world, as an ornamental (Morton 1988).

Borassus flabellifer L., the palmyra palm, is a versatile tree of immense use to mankind of which no part is wasted. In this respect, *B. flabellifer* can be equated with the coconut tree (*Cocos nucifera* L.), the well-known *'Kalpavriksh.'* The palmyra palm is found along the coastal belts of India, N. Sri Lanka, the mainland of SE Asia (Davis & Johnson 1987), and eastern Indonesia and is most abundant in sandy drier plains, open savannahs and secondary forests. It avoids the perhumid areas of southeast Asia and West Malesia. The species exists both in the wild as well as in cultivation, ranging from sea level up to 760 m (Fischer 1931). In India, the cultivated populations are widespread in Kerala, Tamilnadu, Karnataka, Andhra Pradesh, Maharashtra, Orissa, Madhya Pradesh, Bihar and West Bengal (Fig. 1). Isolated patches are also seen in Assam, Gujarat and Uttar Pradesh (Anonymous 1948).

The palmyra palm is a solitary dioecious palm reaching a height of 25–30 m and with an average stem diameter of 50–60 cm. The young trunk covered with clasping leaf bases transforms to a smooth bole with narrow leaf scars in age and is black in color. The large fan leaves clustered at the tip of the trunk make a loose crown, and the leaf bases clasp the stem firmly. Inflorescences are interfoliar; the male inflorescence has stout terete branches, while the female inflorescence is more sparingly branched. Fruits are semiglobose to globose and deep brown to black when ripe.

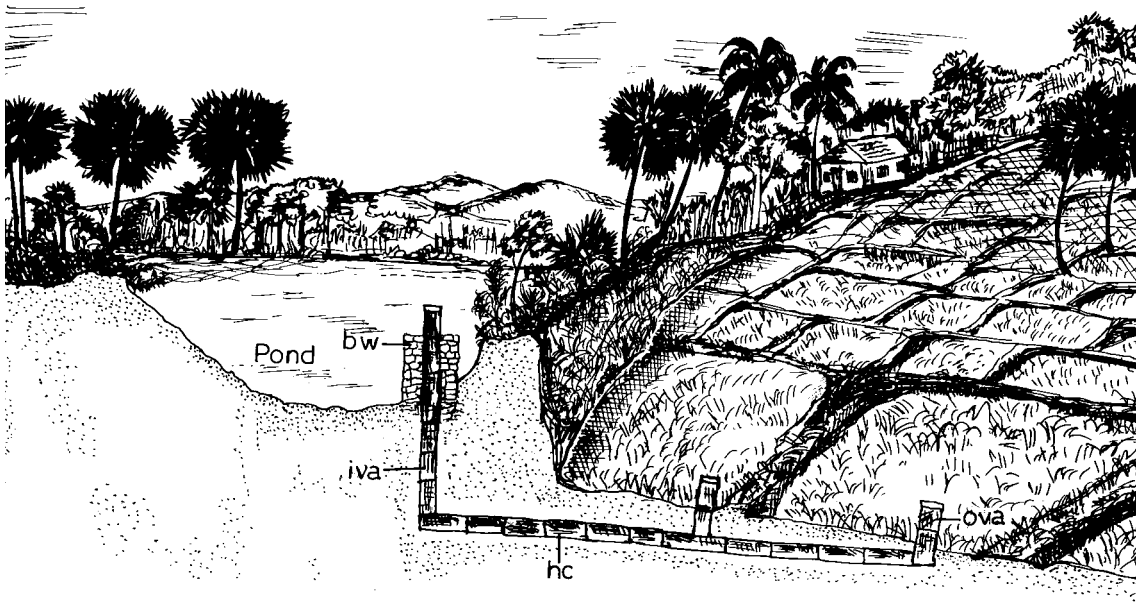
Palmyra palm and human life

The palmyra palm has been an inseparable part of human culture and tradition from very ancient times; each part of the tree is economically important. The palm yields timber, thatching material, fiber of various kinds, drinks, starch, sugar, famine food, firewood and many folk medicines.

The hard outer wood of the trunk is used for constructing the framework of roofs, house-hold posts and pillars, furniture and other utensils such as gutters and spouts (Morton 1988), rulers, walking sticks, etc.; the wood is also popularly used for furniture, windows grills and staircases.

The leaves yield excellent thatching material and are used for making mats, baskets, hand-held fans and other handicrafts; un-opened leaves are used as 'costumes' for decoration in festivals and formed the writing material for manuscripts in the pre-paper era. The petiole is a source of fiber and is

2. The village pond in which the traditional irrigation system is built.



3. Diagram of the traditional irrigation system using the palmyra palm. Key: bw- brick work; hc- horizontal conduit; iva- inner vertical arm; ova- outer vertical arm.

used as rope; fiber obtained from the clasping leaf bases is made into brushes and brooms.

Tapping the inflorescence yields *neera* – a valuable drink. Consumed in limited quantities *neera* is medicinal. Fermented *neera* yields toddy and on distillation yields arrack; on boiling *neera* crystallizes into palm sugar – the jaggery, candy or palm sugar toffee (Kamble 2003). On granulation it yields sugar resembling cane sugar. Jaggery is a coolant and the candy relieves coughs. The tender growing point of the tree (the palm heart or palm cabbage) is deliciously sweet and edible (Davis & Johnson 1987), and the sweet, gelatinous endosperm filling the tender fruit is a delicious healthy drink. The soft orange-yellow mesocarp pulp of the ripe fruit is sugary, dense and edible, and the enlarged embryo emerging from the germinating seed is highly nutritious and a famine food (pers. obs.). Germinating young shoots (unopened and solid) are boiled, salted and eaten. All parts of the palm are found used in folk medicine.

Parts of the tree such as immature wood, leaves, petiole, inflorescence and the soft central part of the stem are a good source of fuel, when dry; the immature wood is especially used as fuel in brick kilns.

The mature trunk of the palmyra palm is very durable and valuable. In addition to the conventional uses of the palm trunk mentioned above, Fischer (1931) mentioned that the stem is used as water pipes and troughs, though no documented report of its utility in irrigation or other water transport systems is available. Very recently we have come across a hitherto undocumented use of the palm in a traditional water engineering system, in a village called Vilayannur in the Palakkad District of Kerala, India, and we document it here, lest it should be lost.

The palmyra palm and the traditional irrigation system

In Kerala, among the many different crops cultivated, rice (paddy) is the most important, in respect of both area cultivated and the amount of associated employment. Palakkad district and Kuttanad of Alapuzha district are "the rice bowls of Kerala;" for a very long time rice has been the traditional crop cultivated in these areas, and together, the two districts contributed a lion's share of Kerala's annual rice production. Even in the current scenario of drastic reduction in the extent of rice cultivation in the State, in Palakkad rice cultivation is still a major source of livelihood and income for the rural population.

Rice is a water intensive crop that requires water for 90–100 days, depending upon the variety cultivated. Before the advent of modern irrigation

4. Pipelets made out of the trunk of the palmyra palm.

5. Two pipelets showing joinery.

systems and dams catering to the water requirements of the agriculture sector, farmers were solely dependant on monsoon showers, small diversions from river systems or small water bodies such as ponds or tanks. From ponds and lakes, water was lifted either manually or using cattle driven devices. Tapping the water bodies by breaking the bund a little on one side was the usual practice, but this method always had inherent problems, as the outlet frequently went out of control. Also, it is quite inconvenient to break the bund every time for tapping the water in installments and to close the same again, in order to allow the pond to fill up during the rainy season. The irrigation system using the palmyra palm emerged as an alternative that overcame the above difficulties.

The water engineering system consists of a pond (a miniature reservoir that collects water during the rainy season [Fig. 2]), the agricultural fields adjoining the pond and the pipe system carrying water from the pond to the fields (Fig. 3), as and when required. The pond has an area about 0.5 ha. The depth of the pond varies at the edges and the

center; it is shallow on one side (1.5 m), deeper on other sides (2.5–3 m) and deepest at the center (ca. 4 m). A 3–4 m deep well occupies the center of the pond. Two settlements and a farmhouse compound constitute the watershed of the pond. The monsoon fills the pond to the brim, and the water collected during the southwest monsoon (October–November, the second half of the rainy season) is used for irrigating the second crop of rice, the coconuts in homesteads, banana plantations and vegetable gardens between January and June, and for initial land preparation and sowing activities for rice cultivation until the arrival of the southwest monsoon. By the time the southwest monsoon arrives the water level in the pond will be very low. However, due to the vagaries of the monsoon and the consequent low rainfall, during the past 5–8 years, the pond has been filled with water from dams.

It is said that in the past when other farmers were cultivating only a single crop of rice each year, this farmhouse with its traditional irrigation system using palmyra trees, could harvest two or three crops a year using water from the pond. The topography of the area is such that the farmhouse gradually slopes towards the pond and subsequently to the rice fields. This relief feature is cardinal to the irrigation system and the bund of the pond at the sloping edge is kept 2 or 3 m thick, so as to withstand the pressure of the water.

The pipe system (Fig. 3) is an articulation of several pipelets (hollow cylinders 50–60 cm long [Figs. 4 & 5]), made from the stem of palmyra palm and consists of three units. 1. A horizontal conduit, 20–30 m in length and laid underground, one end of which is placed beneath the pond bottom and the other end outside the pond. 2. An inner vertical arm, connected to the blind end of the horizontal conduit below the level of the pond bottom and opening in to the pond. 3. An outer vertical arm, connected to the horizontal conduit at its extremity and opening into the rice fields. Sometimes an additional outer vertical arm may also be attached somewhere in the middle of the horizontal conduit.

The inner vertical arm opening into the pond is taller than the outer vertical arm(s) and consists of a few pipelets placed one above the other, of which four are removable. The inner vertical arm is situated in a pit in the pond, three sides of which are fortified with kiln bricks; this prevents sliding of the mud wall, while the fourth side remains open so that water intake to the pit is not hindered. Water drains from the pond to the inner vertical arm, passes through the horizontal conduit and comes out through the outlet(s), the outer vertical arm(s), situated in the rice field. The outer vertical arm(s) (Fig. 3) is made of two or three pipelets fixed one over the other with

6. View showing the outer vertical arm and its lid; note water coming through the outlet.

cementing material. Both the inner and outer vertical arms are closed with a lid (Fig. 6), usually made of granite, placed over them. The lid of the inner vertical arm acts as a valve whereas that of the outer vertical arm(s) prevents siltation into the pipe system while not in use. The horizontal conduit consists of many pipelets joined in a straight line using some crude cementing material made of lime, sand and gravel. In the Malayalam vernacular, the pipelets are known '*panayural*' (*pana* = palmyra palm, *ural* = mortar) and the lid, '*moodikallu*' (*moodi* = lid, *kallu* = stone).

Preparation of pipelets

A palm about 80–100 years old can yield a 25–30 m tall trunk. The basal 3–4 m portion of the trunk is the most mature and the strongest. Traditional carpenters believe that the amount of mature wood and its strength vary with the environment in which the palm grows, rather than its age. They infer the maturity of the palm from the resonance produced on striking the trunk of the standing tree near its crown with a wooden hammer. Unlike other trees, felling a palm tree requires special skills; the trunk has to be cut in to 3–4 m long billets and the billets brought down with the help of ropes, lest they split and become spoiled.

The outer and inner cores of the trunk differ in properties. The outer core of the stem being composed of closely packed interlacing vascular bundles is very hard. On the other hand, the inner core of the wood is a soft pith having only scattered vascular bundles and is hence susceptible to quick disintegration, especially when in contact with water. This structural difference is utilized in converting the billets to hollow pipelets. The billets are cut into pieces of required length and immersed in a marsh or swamp for three to four months so that hollowing the trunk is made easy. With a small crowbar or iron rod, the inner core is removed, and the pipelets are made. A crude finish is give to the inner surface of the pipelet by using a chisel; grooves are also provided at the ends for joining. The finished pipelet is 50–60 cm long and the inner diameter ranges between 15–20 cm with a wall thickness of 4–6 cm. Examination of old pipelets shows that their strength seems not to be compromised by age or attack by insects and other pests.

How the system works

When the system is not in use, the vertical arms (both inner and outer) are closed with the lids and any gaps with the lid(s) sealed with the help of hay or grass. The pipelets of the inner vertical arm are movable so that water can be drained from the pond in a controlled manner, stage by stage, as with a tap. When the lid over the inner vertical arm is removed, the amount of water available in the pond above the mouth of this pipelet can be drained for irrigation. When the water level of the pond reaches the level of the uppermost pipelet in the inner vertical arm, the intake of water through the system stops. If more water is required, the uppermost pipelet is removed so that water for a level further is released from the pond. In this way the pond can be emptied completely, to its bottom, stage by stage. Such a system suffices to cater to the requirements of a rice field of about 5–6 ha. for two crops a year.

Conclusion

With changing lifestyles, a major share of the vast lore of indigenous and traditional knowledge that paved the way for the development of modern science and technology has disappeared. Synthetic and health hazardous materials have found their place in our every day life in wanted and unwanted situations. There is great scope for the judicious use of much traditional and ethnic knowledge in place of unwanted synthetic materials in a variety of situations. However, traditional knowledge also vanishes at an irrecoverable pace, with the assimilation of many ethnic groups into modern society. A conscious effort needs to be made to document, assemble and explore the potentials of traditional ethnic knowledge.

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Photo Feature
pages 182 & 183

This image of *Maurtitia flexuosa* was taken by photographer Michele Falzone at Lake Sandoval, in the Tambopata National Reserve, Peru. More of Mr. Falzone's travel and nature photography can be seen on his website, www.michelefalzone.net.

Diversity of Use of Doum Palm (*Hyphaene compressa*) Leaves in Kenya

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1. Undegraded stand of *Hyphaene compressa*, Eastern Region, Kenya.

Doum palm leaves fulfill many subsistence and economic needs of the nomadic pastoralist and agro-pastoralist communities in the northern and eastern regions of Kenya. The leaves provide a range of products, which contribute to most aspects of their livelihoods.

2. Products made from sword leaves of *Hyphaene compressa*, Northern Region, Kenya.

Hyphaene compressa H. Wendl. (doum palm) is a widespread palm in eastern Africa, being particularly abundant along the coast of Kenya and Tanzania. In the dry lands of Kenya it occurs in isolated populations and is mainly confined to riverine forests (Fig. 1). The palm is common along the coastal strip, riverine ecosystems of the dry-lands and scattered within open savannah grasslands (Dale & Greenway 1961, Beentje 1994). It is most abundant in low sandy places and secondary forests. In the northern and eastern regions of the country, the species contributes significantly to the livelihood and welfare of the local communities, who are mainly nomadic pastoralists and agro-pastoralists. The species is used in several ways. Products ranging from thatch, ropes, baskets, nuts, dye and medicine are derived from the species. The doum palm dominates forests and woodlands, serves as sources of dry season grazing during drought and also protects the riverbanks. Along the shores of Lake Turkana fourteen different economic uses of the species have been recorded (Awuondo 1990). Among them leaf was the most used part of the palm. Leaves and petioles are the major building materials for the *manyattas* (traditional dome-shaped houses) and *makuti* (strips of mature green palm leaflets tied in a dense row along a leaf stalk) for the modern houses (see below). Leaves are used to make mats, carpets and baskets for sale. Ropes, webbed stick wheels (used for bundling fish) and wicker baskets (for catching fish) are made and sold to fishermen. However, information about the full array and magnitude of products derived from the leaves among communities living in the dry lands of Kenya is incomplete. Although palm leaf use by Turkana has been reported (Hoebeke 1989, Awuondo 1990), this is the first time the different uses by Tharaka, Kamba and Borana communities have been recorded.

The climate of the study area is characterized by erratic annual rainfall. Apart from famine relief, the availability of resources that support life, such as water and forage for livestock, is highly variable in time and space. When livestock productivity and herd numbers are low, the pastoralists will seek out alternative livelihoods. In most cases these will involve activities such as rain-fed agriculture, the making of *makuti* and the weaving of baskets. For instance, the drought of 1992 pushed most Turkana pastoralists to resort to craft activity. The creation of a United Nations High Commissioner for Refugees (UNHCR) refugee camp in the district fuelled the demand for palm-based crafts. With ever-increasing droughts, more pastoralists resorted to weaving, leading to over-harvesting of woodlands near urban centers (Amwatta 1993). Consequently this has led to reduction in quality of basketry.

In this study, I examined the diversity of use of the palm leaves among the four ethnic communities. The first objective was to document the uses of leaves for both domestic and commercial needs. The second objective was to assess the availability of the leaves for the various needs.

Study area

The study was done in the northern and eastern regions of Kenya. The regions lie between 3º 14′N 35º 1′E and 2º 39′S 39º 02′E. The vegetation is predominantly dry bush-land with pockets of

Table 1. Parts of palm leaf used by different pastoral communities

Pastoral community	Part of leaf used		
	Sword leaf	**Mature green**	**Stalk**
Turkana	Baskets, tablemats, brooms, carpets, ropes, baskets, floor mats, lampshades, hammocks and hats	Traditional thatch, *makuti,* webbed stick wheels and wicker	Decoration of commercial buildings; wicker chairs
Kamba	–	Mats, brooms	Wicker chairs, door shutters and cupboards
Borana	Sleeping mats and traditional thatch	–	Decorating shops; walls of food stores
Tharaka	–	Sleeping mats, hats baskets and brooms	Wicker chairs

montane/hilltop forests and inselbergs, which are hot spots of endemism. *Hyphaene compressa* is mainly observed at altitudes of 380 – 980 m above sea level along the margins of lakes, swamps and rivers. The mean annual rainfall varies between 150 and 600 mm, with mean annual temperature of 36ºC and 38ºC. The soils are calcareous, salty and alkaline (pH 9), which produces a poor physical structure. The shore of Lake Turkana, Turkwel River Ecosystems, Meru National Park and Tsavo West National Park are the areas where the palm is most abundant.

Methods

Interviews were conducted with farmers, pastoral women and men weavers, leaf harvesters, vendors and women's groups, to compile information on the products made, origin of products, the users, methods of harvest, prices and the period of availability. Major local and regional markets in the region were visited and doum palm based products being sold listed.

Results

Palm leaf use

The most commonly used material from the species is the leaf. The age at which the leaf is harvested is dependant on the product to be made from it. Depending on the age of the leaf when it is harvested and its treatment afterwards, uses among the different pastoral communities are shown in Table 1.

Sword leaf

The sword leaf (immature, still closed) is cut, processed and used to make mats, baskets, hats, brooms and trays (Fig. 2). The unexpanded leaf is skillfully cut by pushing a machete against the leaf base. The sword leaves, which are about 80–150 cm long, are opened by hand and sun dried, after which they are split up into long thin strips. The long strips are dyed and are then ready for use or sale to weavers. The number of colors and patterns used differ from community to community with Turkana and Borana exhibiting higher skills than Kamba and Tharaka. Among the Borana weavers, the leaf is cut, opened, split and woven into fine thatch (*gella*). The Turkanas beat the immature closed leaves with a wooden club on a stone anvil until fibers inside are freed to make ropes. The beaten fibers are also made into strings and then woven into open mesh hammocks. The other tribes did not mention these two uses. In Turkana, the type of use most common was making of laundry baskets, which are very popular with urban dwellers.

Beautiful laundry baskets, floor mats, fruit baskets, lampshades, tablemats and hats are made out of the young leaves. These handicrafts are destined for urban consumers and are traded at local, national, regional and international markets. The marketing of these products is specialized, involving producers, retailers and wholesalers. The handicraft cottage industry has played a crucial

3. Hut and fence made from mature dry leaves of *Hyphaene compressa*, Northern Region, Kenya.

role in raising the living standards of the pastoral women through the creation of jobs, directly or indirectly. The large Turkana women's handicraft co-operative society handles the sale of members' products. In the eastern region no such marketing society exists, and every weaver sells products either in the local market or to middlemen. Quality and prices varies from region to region. The highest quality and hence most expensive products are found among the Turkanas and Boranas. For instance, a wedding mat costs about $2 whereas the most expensive mat in Kamba would be less than half a dollar. On average there were 30–45 mat sellers in the regional markets in the eastern region. Buyers interviewed complained of deteriorating quality of mats due to scarcity of good quality sword leaves.

Mature leaf

The communities use mature green leaves for a number of purposes of which thatch (*makuti*) by the Turkana and basketry by other communities were the most important. Mature dry leaves are used for building purposes (Fig. 3) and fire-making. Nomadic architectural styles used by the Borana and Turkana communities are changing greatly at present from dome-shaped huts to modern rectangular huts. Turkana dome-shaped huts use dead leaves whereas the modern rectangular use *makuti*. The volumes of leaves used for the dome-shaped huts are low due to the need for mobility in the seasonal movements. The settled lifestyle has given greater scope for a range of architectural styles with corresponding higher volumes of leaves. Consequently, *makuti* has become a commercial commodity and is being sold in local markets and most of it is also used for roofing tourist restaurants and refugee camps established by UNHCR in the northern region. In an effort to support the local population the UNHCR encouraged *makuti* as the sole thatch for the refugee huts. However, this did not last long. The scarcity of weaving material in the vicinity of Lodwar and environs became apparent in 1993. By the year 2001, the shortage became alarming and UNHCR abandoned the use of *makuti* after protests from local environmentalists. At the time of this study *makuti* sale still took place on a small scale by the refugees (for repairs) and by local people for thatching new houses (Amwatta 2002).

In the eastern region mature green leaves are cut and opened into strips for weaving mats, baskets

and hats, and making brooms. The mature green leaves were bought from private farms at 2 US cents per leaf. Due to high demand for the leaves, cases of over-cutting of leaves were observed on all the farms visited. Frequent conflicts between the weavers and the national park managers due to poaching of leaves from the protected areas have been reported.

Leaf stalks

The leaf stalk is a secondary product in the northern region. The stalks are mainly collected from dry mature leaves free of charge. They are used for building, furniture, fencing and decorating tourist hotels/homes (Fig. 4). In the eastern region, stalks are sold to wicker chair makers. The traditional wicker chairs are very popular among the Kambas. Cases of people stealing leaves from private farms to make these chairs were often mentioned in Kamba area.

Fodder

Cattle and other livestock feed on fresh young palms or dry leaves during droughts. In the eastern region palms are left scattered in the pasturelands for this purpose. The leaves therefore provide the dry season fodder in the region. No mention was made of this particular use of the species in the northern region.

Palm leaf availability

Of the 56 weavers interviewed in Turkana, 52 (81%) said that they had difficulty in obtaining leaves for *makuti* making. Thirty (59%) complained that they had to travel a long distance (>3 km) to source the leaves. Twenty-eight (48%) of the Kamba and fifty-six (84%) of Tharaka weavers interviewed bought all the leaves they used. Seventy-two (82%) of all the weavers interviewed bought all the leaves they used. The dyed split sword leaves were sold at 2 US cents.

The species is in an incipient state of domestication in the study area. Turkana, Borana and Kamba agro-pastoralists spare mature doum palm trees scattered in the farmlands and pasturelands for provision of both products and services. Among these three ethnic communities no attempt to plant the species was reported. Planting of the species using seeds was reported among the Tharakas, showing that here the species is in a semi-domesticated state. The main primary product driving these domestication initiatives is leaf production.

Traditional management techniques

Exploitation of palm leaves was sustainable under the traditional resource management systems. However, the traditional management systems began to breakdown during the last decade (Barrow 1991). Following the settling of the pastoralists, over-exploitation of indigenous woody vegetation and over-grazing of the herbaceous vegetation layers have become intensive. This has resulted in localized loss of vegetation cover in general and of doum palm in particular around settlements (Amwatta1993). Among the Turkana weavers we established that some traditional management practices to ensure

4. Hotel veranda decorated with leaf stalks of *Hyphaene compressa*, Northern Region, Kenya.

sustainable leaf supply still exist. According to the leaf harvesters interviewed three rules are observed to achieve this namely:

Reduced leaf harvesting during dry seasons by concentrating on weaving products such as brooms and sleeping mats that use fewer leaves.

If two sword leaves are present, only the larger one is cut, while the other is left to develop into a fully expanded leaf.

Only sword leaves between 80–150 cm long are cut. Cutting a sword leaves shorter than 50 cm tall will tend to damage the growing point and may result in death of the shoot.

Discussion

Harvesting of doum palm products on a commercial scale will inevitably affect the riverine forests in one way or the other. Often the impact will be significant. *Makuti* has become a commercial commodity and is being sold in the local markets in Turkana district. Each piece of *makuti* consumes six mature green leaves (Hoebeke 1989). The species develops six leaves per year (Hoebeke 1989). Due to rapid increase in urban populations and settling of the pastoralists, the subsequent high demand for *makuti* has lead to over-utilization of areas near settled areas and urban centers in the northern region (Amwatta 1999). Awuondo (1990) found that destruction of the vegetation cover in Kalakol area was mainly by the poor and destitute who had been rendered stockless due to years of recurrent droughts. To them woodland products provide the major source of earning a living. Charcoal, firewood, building posts and basketry are some of the items in high demand in the urban centers, thus providing a stimulus for the extraction of woodland-based resources. He further observed that the over-exploitation of doum palm demonstrated the severity with which woodland cover could be mismanaged in a desperate attempt to make meager living in the absence of perceived or real alternative.

The species is already classified as threatened due to habitat degradation (Kigomo 1998). Very little empirical data exist on how the species could be sustainably managed. Ratsirarson (1996), while studying *Dypsis decaryi*, recommended that annual leaf harvesting be no more than 25 percent of the leaves per tree per year. Among some of the sites studied in both the regions, harvest level was 67 percent, which could affect the regeneration. However, intensive defoliation was found to increase density and the number of sucker shoots of the species (Oba 1990). However, there is concern over the possibility of reduction in the natural genetic diversity as a consequence of the increased asexual reproduction.

Conclusions

The palm leaf is a resource of significant economic value to the nomadic pastoralists and agro-pastoralists in the study area. It is the next viable livelihood alternative, after livestock, for the poor pastoralists women. The major threats to sustainable availability of the palm leaf resource are widespread over-harvesting, particularly around increasing permanent settlements. Clearance for agriculture along the few permanent watercourses is also a major problem. These factors threaten the palm leaf base hence the livelihood of the already poor communities.

Recommendations

Efforts should be made to build on and support the existing rudimentary management and informal cultivation initiatives by the agro-pastoralists. Research on the quantity of products and their availability should be conducted to develop management guidelines for leaf extraction.

Acknowledgments

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Introduction of a Multipurpose Palm, *Phoenix pusilla*, in Kuwait

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1. Two-year old male palm of *Phoenix pusilla* Gaertn. with inflorescence.

Dwarf date palm (*Phoenix pusilla*) has been successfully introduced in Kuwait through seeds collected in India. These palms are well adapted to the climatic conditions of Kuwait. Growth and development is normal, and flowering and fruiting occurs from February to August. Studies confirm the feasibility of utilization of this species for food, fuel, medicinal, landscape beautification and ornamental purposes.

Phoenix pusilla Gaertn., a multipurpose palm species closely related to the date palm, is commonly known as the small date palm in India, as it only grows to 100 cm tall (Barrow 1998). It is a beautiful and shrubby suckering palm with a very short stem enveloped in persistent leaf sheaths. A crown of about 15–17 leaves is produced every year. Just like the true date palm, *P. dactylifera*, it is dioecious (Gosh et al. 1987), producing male and female flowers on separate trees. It grows wild in dry areas in India at low elevations (Gamble 1967). Its flowering season starts in November and runs through January. Clusters of edible orange-red fruits turn into black drupes in the months of July and August (Mayuranathan 1994). Propagation of this species is only through seeds. In its natural habitat, this palm produces a mat of fibrous roots that anchors the palm firmly to the substratum, and a crown of leaves that touches the soil surface. In undisturbed areas in southern India, several areas often show pure stands of this palm that protect the soil from erosion. At one time in India, this beautiful palm occupied vast areas of scrub jungle. Recently, its natural habitat has been disturbed due to its overexploitation as a fuel for lime kilns and its tender shoots as food and leaves for brooms. This palm, along with some other species such as *Phoenix loureiroi, Bentinckia condapanna,* and *Borassus flabellifer* have been destroyed by broom industries, lime kilns and brick kilns (Padmanabhan & Sudhersan 1988, Davis 1985) and are facing the threat of extinction.

2. Female palm (two years old) with parthinocarpic fruit.

Phoenix pusilla is a low shrub growing to 100 cm tall. The stems are clothed completely with persistent leaf bases. The leaves are pinnate, 65–140 cm long; the leaflets are linear, fascicled, more or less in four ranks, rigid, and shining with an orange-red pulvinus at the junction with the rachis. The lower leaflets are transformed into stout, flat spines that are 5–7 cm in length. Male and female inflorescences develop from the axils of the leaves in separate palms. Each inflorescence is covered by a coriaceous protective sheath called a prophyll. The flowers are unisexual and trimerous. The male flower has a cupular calyx, three valvately arranged petals and six stamens. The female flower has three carpels, each containing one ovule and sessile stigmas. The fruit is 20–22 mm long, oblong, terete and fleshy. It is initially green, red at maturity, and ripening black. The seeds are oblong and ventrally grooved (Gamble 1967).

The pulp of the fruit is fleshy, sweet and mealy. The tender part of the palm is often eaten by the poorer people as a meal called *kanji*. The leaflets are woven into mats and the split petioles into baskets. Brooms were also made out of the leaves of this palm. Its fruit is used in herbal medicines, as it is sweet, sour, cooling and laxative, cardiotonic, aphrodisiac, carminative and roborant. The fruit is also used for hyperdipsia, burning sensation, fevers, consumption, cardiac debility, seminal weakness, gasteropathy and general debility (Varier 1995).

While travelling from Kanyakumari to Chennai in India in the month of July 2000, the author found a few small palms growing wild along the roadside in between the Madurai and Trichy areas. Most of the palms had bunches of fruit at the ripening stage and produced a sight along the roadside. Due to curiosity and an interest in palms, the author collected a bunch of fruit and a leaf for identification. The small palm was latter identified as *Phoenix pusilla* Gaertn.

In order to conserve and study the possible utilization of this multipurpose palm species in landscape beautification and soil conservation, the author collected seeds and brought them to Kuwait. A few seeds (50) from the collection were brought to the Biotechnology Department of the Kuwait Institute for Scientific Research (KISR) in Kuwait in the year 2000. The seeds were washed in a soap solution, and the clean seeds were soaked

3. Female palm with normal green fruit.

4. Female palm showing ripening fruit.

for 24 hours in freshwater. Of the 50 water-soaked seeds, 40 were planted in 10 cm diameter plastic pots containing sand and peat moss mixed at a 1:1 ratio, and 10 seeds were planted in sterile culture media. The cultures were maintained in a temperature- and light-controlled growth room. These seed cultures were used for studies of seed germination, seedling growth and development. The 40 pots were irrigated with fresh water while being maintained in the temperature-controlled greenhouse. After two weeks, 100% of the seeds germinated into seedlings. The seedlings were maintained in the same pots for three months and then carefully transferred to 15 × 15 cm-diameter pots without damaging the root system. During the germination, half of the cotyledon protruded out through the dorsal side of the seed opposite to the groove. The protruding cotyledon elongated 2.5–3 cm and formed a cotyledonary tube containing a radicle and plumule at its basal end. The other part of the cotyledon which remained inside the seed, developed into a haustorium that digested and absorbed the nutrients from the endosperm and supplied them to the growth point through the cotyledonary sheath. After the full growth of the cotyledonary

tube, the radicle entered the soil, and the cotyledonary tube swelled. Thus, the seed germination was hypogeal and remote (Tomlinson 1961, Biradar & Mahabale 1969). After the complete growth of the cotyledonary tube and the establishment of the primary root system, the first sheathing leaf emerged through a crack in the cotyledonary tube. This scale leaf enclosed the first green leaf (eophyll). The eophyll was simple, lanceolate and with an acute apex. About six such simple leaves developed prior to the development of the first pinnately compound leaf.

All 40 seedlings were maintained in the greenhouse until they produced compound leaves. They were planted in the open field at a spacing of 2 × 2 m in September 2001. Freshwater was used to irrigate the palms daily until field establishment. After the new leaf development in the field, the palms were irrigated once every 3 days during the summer months and once every 2 weeks in the winter months. Fertilizer, NPK 20:20:20, was added uniformly to all of the palms once a month regularly at a rate of 25 g/palm.

All of the palms planted in the field survived, and tolerated the cool winter (4–10°C) and hot summer (46–48°C) temperature conditions in Kuwait. Initially, it was difficult to identify the male and female palms from one another. During the second

5. A bunch of ripening fruit.

6. Isolated ripening fruit.

7. Black-colored, fully ripened fruit.

8. Seeds of *Phoenix pusilla.*

year of field growth, most of the palms started producing inflorescences. Approximately 60% of the palms were males, and the remaining 40% were females. All of the newly introduced young palms were uniform in size, and flowering occurred from February to April. Male inflorescence (Fig. 1) was about 25–30 cm long and produced a large quantity of pollen grains. Female plants showed two types of fruit: one parthenocarpic, red in color (Fig. 2) and the other normal green in color (Fig. 3). At the maturity stage, the green-colored fruits turned red (Figs. 4–6) gradually from the upper end, to the lower end and finally, at the ripened (Fig. 7) stage, fruits were black in color. The ripened fruits were sweet and edible. The seed was surrounded by a thin membrane. The seeds (Fig. 8) were smaller in size than those of the date palm, but similar in shape. Each seed had a furrow at one side, with the embryo embedded within the endosperm marked

by a depression at the middle region opposite to the furrow.

The vegetative growth of this palm species during the past 3 years showed that they can tolerate low temperatures of 4°C to high temperatures of 48°C. They have the ability to grow on open desert land as well as in coastal regions. The very short clustering stem with a crown of leaves touching the soil surface could be used for the protection of soil from erosion.

Both male and female *Phoenix pusilla* palms were successfully introduced and established on the Kuwait Institute for Scientific Research (KISR) campus in Kuwait. The fruits were small, edible and attracted birds during the fruiting season. The growth and appearance of the beautiful multipurpose palm species will attract people due to its ornamental, medicinal and soil conservation usefulness. Since there is no offshoot production, tissue culture is the only way to produce a large number of both male and female dwarf date palms in a limited time. Experiments conducted by the author showed that the pollen from this palm can be used for pollinating date palms and vice versa (Sudhersan et al. 2003).

Since there are no reports or detailed studies about this species, the author has showed great interest in its propagation and conservation. Studies are also in progress on using this species for date palm crop improvement programs, landscape beautification and ornamental purposes in Kuwait.

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New Species of *Livistona* (Arecaceae) from New Guinea

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1. *Livistona chocolatina*. Habit, Kuriva (Photo: J.L. Dowe).

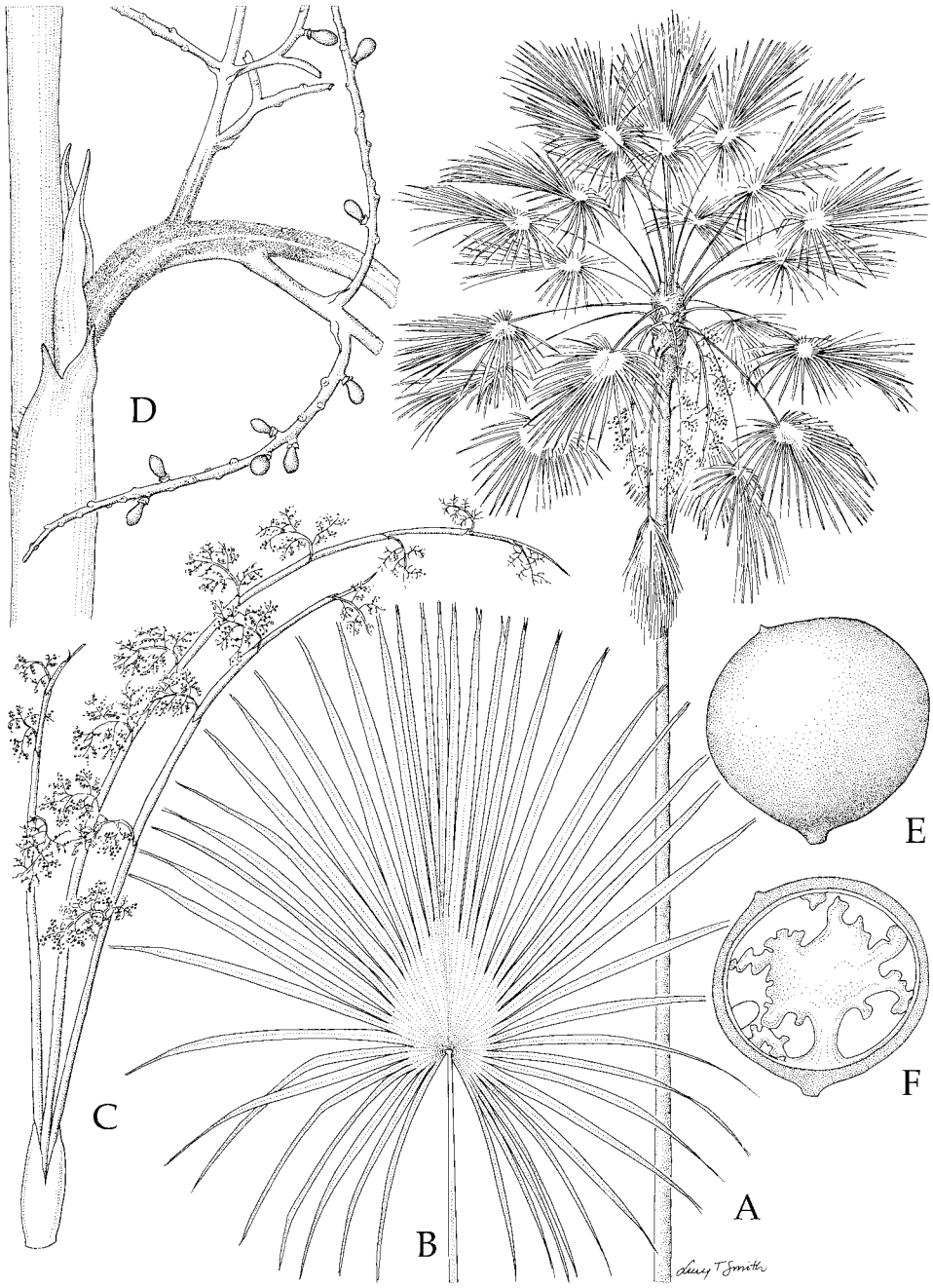
Two new species of *Livistona* are described from New Guinea, one from the high-rainfall areas of the Gulf, Central and Morobe Provinces, Papua New Guinea, and the other from coastal forest on ultrabasic rocks from Kawe Island, Raja Ampat in far western Papua, Indonesia.

The genus *Livistona* R.Br., over its entire range, is presently under revision by JLD. Recently, Rodd (1998) revised the Australian species, in which he described five new species and one variety, whilst new species have been described for Papua New Guinea and Australia (Dowe & Barfod 2001), and for Vietnam (Nguyen & Kiew 2000). Completion of the treatment of *Livistona* for New Guinea is part of the Palms of New Guinea project coordinated at the Royal Botanic Gardens, Kew. With the description of these new species, there will be nine *Livistona* species recognized for New Guinea. Of these, six are endemic.

The first taxon described here was recognized as distinct by Ferrero in 1998 and provided with the herbarium tag name *Livistona* sp. 'Kuriva' in recognition of the place at which it was found, near Kuriva Mission in Central Province, Papuan New Guinea. Barfod et al. made subsequent collections in 2000, also from near Kuriva [from which the type was chosen] and also from Morobe Province at Lababia. An older collection from Gulf Province by Lane-Poole, collected in 1922, is also attributable to the 'Kuriva' taxon.

The second new species described here was collected from Kawe Island, in the Raja Ampat group in the far western region of Papua, Indonesia. Takeuchi (2003) provided information on the expedition during which this taxon was collected by JPM. Of the more than 40 locations that were visited during that expedition, which commenced in Sorong and included Salawati, Batanta, Misool (in Wagmab, Masemta Bajampop, Kasim River, Waetama), Kofiau and Waigeo

2. *Livistona chocolatina*. Habit, Kuriva (Photo: J.L. Dowe).



3. *Livistona chocolatina*. **A** habit; **B** leaf; **C** inflorescence; **D** part of infructescence ×1; **E** fruit ×1; **F** vertical section of fruit ×1. **A**, **E–F** from *Kjaer 514*, **B–D** from *Barfod 466*. Drawn by Lucy T. Smith.

(Sayang Island, Aljoei Island, Kawe Island, Kabare), *Livistona* species were, surprisingly, seen only on Kawe Island. In addition to the new taxon, *Livistona rotundifolia* was also found on Kawe Island, which is an eastward extension of recorded distribution for that species. The two *Livistona* species do not occur sympatrically on Kawe: *L. rotundifolia* occurs in large colonies in low lying poorly drained areas, whilst the new taxon occurs on well-drained slopes on ultrabasic rocks at some distance from *L. rotundifolia*.

Taxonomy

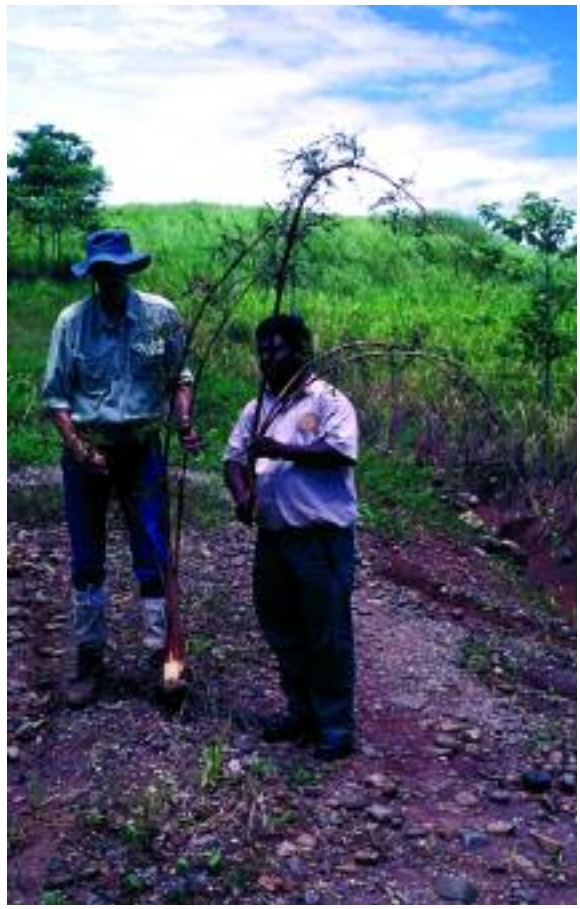
Livistona chocolatina Dowe **sp. nov**.

Palma alta, foliis flabelliformibus parvis rigidis, petiolis inermibus vel sparse spinosis primum

dense albo-farinosis, inflorescentia trifurcata, axibus utrumque bracteas pedunculares numerosas ferentibus, ramis et rachillis tomento badio dense tectis, fructibus globosis ad 25 mm diametro maturitate aurantiacis bene distincta. Typus: Papua New Guinea, Central Province, Kuriva Mission area, 4 km north of Haritano Hwy along forestry road, 9°00.821'S, 147°07.815'E, 300 m alt., 4 Mar. 2000, *A.S. Barfod 466* with *R. Banka, J.L. Dowe & A. Kjaer* (Holotypus: AAU; isotypi: BRI, CANB, K, LAE).

Solitary, hermaphroditic(?) palm. Trunk to 22 m tall, 16–18 cm dbh, erect, slightly broader at the base, light grey, nodes slightly raised, internodes narrow, petiole stubs not retained. Leaves 30–40 in a spherical crown; petiole 110–155 cm long, slightly arching, green, proximally ca. 3 cm wide, distally ca. 2 cm wide, triangular in cross section, adaxially flat, abaxially rounded, glabrous with a cover of deciduous white waxy powder, margins usually spineless, or with small single spines to 5 mm long only in the very basal portion; leaf-base fibers coarse, brown, persistent until leaf fall then readily deciduous; ligule short; hastula ca. 1 cm tall, 5 cm across with a central division; lamina sub-circular, flat, rigid, 100–120 cm long and wide, adaxially mid grey green, abaxially light grey green, glaucous waxy; segments 45–60, rigid, free for about 44% their length, apical split about 4% of length of free segment, apices rigid; mid-lamina segments 4–5 cm wide at the disjunction; parallel veins 7–8 each side of midrib; transverse veins more prominent, extending across 2–4 parallel veins, density 22–30 per unit area of 15 × 10 mm. Inflorescences trifurcate with ± identical axes, 195–225 cm long, but with central axis more robust than the lateral axes; each axis with 6–10 partial inflorescences, branched to 3 orders; prophyll 22–37 cm long, 8–15 cm wide, glabrous, chartaceous, lacerate-fibrous at the apex, basally brown, distally yellow; peduncle of central axis subterete, to 2.8 cm diam.; peduncle of lateral axes terete, to 1.6 cm diam.; each axis with 2–4 peduncular bracts; peduncular bracts glabrous, tubular, lacerate at the apex; rachis bracts 40–45 cm long, tightly tubular, fibrous, disintegrating at the apex with maturity, pubescent throughout but more densely so toward the apex, light reddish

4 (left). *Livistona chocolatina*. Leaves, Kuriva. 5 (right). *Livistona chocolatina*. Inflorescences, Kuriva (Photos: J.L. Dowe).



brown; bases of partial inflorescences with dense chocolate brown tomentum; rachillae 8–12 cm long, subterete to angular, 2–3 mm thick, basally with chocolate brown tomentum. Flowers solitary or in clusters of 2–4, tightly aggregated in bud and during anthesis, ca. 1.2 mm high; sepals fused, lobes long, triangular, ca. 1 mm long, apically acute, longitudinally nerved; petals triangular, obtuse, apically acute, occasionally shark-tooth like, ca. 1 mm long, ca. 1.2 mm wide at the base, adaxial surface with the impressions of the stamens; connective very thin, ca. 0.5 mm long; anthers ovoid, ca. 0.1 mm long; carpels ca. 0.8 mm high, stigmas pointed. Fruit globose, ca. 25 mm diam., orange-red, shiny; epicarp with scattered dot-like lenticels and light 3 mm long lines pointing in longitudinal direction toward the apex; stigmatic remains apical to slightly subapical; mesocarp fleshy, fibers thick, distributed throughout but more densely aggregated toward the endocarp and shallowly embedded in the surface of the endocarp; endocarp to 1 mm thick, bony; pedicel 4–5 mm long, 2 mm thick, jointed, green, with prominent scars of fallen flowers. Seed globose; endosperm intruded by the seedcoat to about two-thirds across, intrusion broadly kidney-shaped; embryo lateral. Eophyll 5-ribbed. *Manganau* (Lababia language). (Figs. 1–5).

SPECIMENS EXAMINED: PAPUA NEW GUINEA, Gulf Province, Vailala River, hills inland, Dec. 1922, *Lane-Poole 332* (BRI). Morobe Province, Lababia, Bulili Ridge, 400 m alt., 6 Apr. 2000, *Kjaer 514 with Magun* (AAU, LAE). Central Province, Kuriva Mission, 22 Mar. 1998, *Ferrero 980080, 980081, 980083* (LAE).

DISTRIBUTION, HABITAT AND ECOLOGY. Papua New Guinea, in Central Province, Kuriva area, in Gulf Province on hills near the Vailala River, and in Morobe Province near Lababia on Bulili Ridge. Grows in isolated colonies, sometimes locally common, on slopes with calcareous or clayey soils, at 300–400 m alt. Flowering January to February; fruiting March to May.

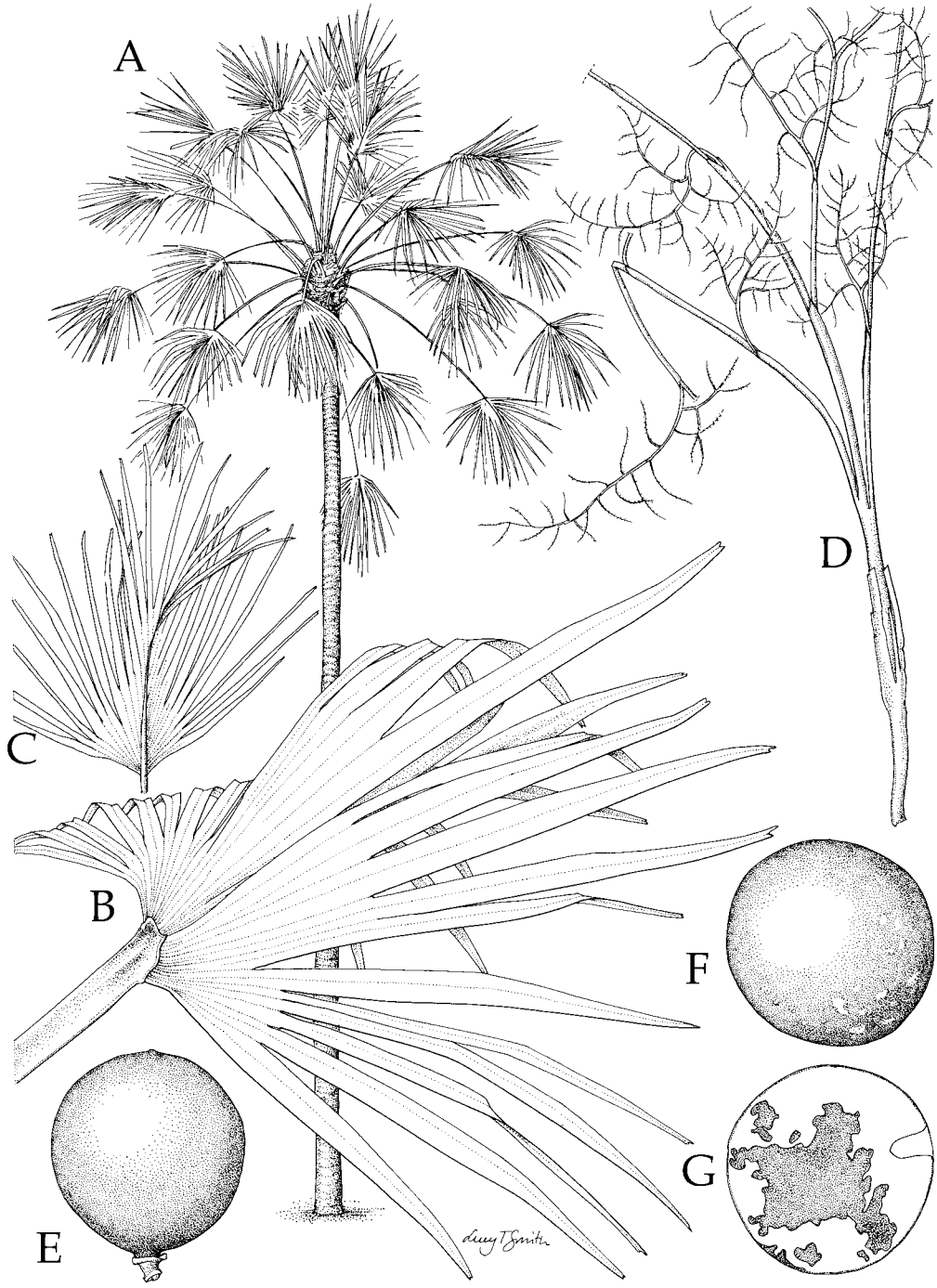
ETYMOLOGY. In reference to the brown color of the tomentum at the base of the partial inflorescences and rachillae.

Livistona chocolatina was first collected by Lane-Poole in 1922 as '*Livistona sp. No. 332*' (Lane-Poole 1925) from "hills inland from Vailala River." It was not collected again until 1998, by M. Ferrero, and then again in 2000 by Barfod et al., and from whose collections the type *Barfod 466* (AAU) was chosen. The species is distinguished by the usually spineless or only mildly spiny petiole that initially has a thick coating of white waxy powder, smallish rigid leaves, a trifurcate inflorescence with each axis having multiple peduncular bracts, distinctive chocolate brown tomentum on the basal surfaces of the partial inflorescences and rachillae, and globose fruit to 25 mm diameter that mature orange-red.

Livistona brevifolia Dowe & J.P.Mogea **sp. nov**.

Palma ad 22 m alta, foliis parvis, laminis semicircularibus, 62 × 55 cm, valde costapalmatis, supra smaragdinis, infra prasinis, segmentis rigidis vadoso-fissis, hastula non bene evoluta; inflorescentia trifurcata ramis rachillisque gracilibus, bracteis peduncularibus carenti; floribus in glomerulis 2–4; fructu globoso 10–12 mm diametro endospermio postamento irregulariter intruso. Typus: Indonesia, Papua, Kepulauan Raja Ampat, West Waigeo, Kawe Island, 0°02'41"S, 130°08'28"E, 17 Nov. 2002, *J.P Mogea 8171 with W. Takeuchi, D. Neville & F. Liuw* (Holotypus: BO; isotypi: K, L, MAN, NY).

Solitary, hermaphroditic (?) palm. Trunk to 22 m tall, ca. 12 cm dbh, erect, slightly broader at the base, narrowing to ca. 10 cm at the apex, light grey, nodes slightly raised, internodes narrow, petiole stubs not retained. Leaves 16–40 in a spherical crown; petiole ca. 110 cm long, slightly arching, green, proximally 29–42 mm wide, distally 12–13 mm wide, triangular in cross section, adaxially slightly concave, abaxially rounded, glabrous, with deciduous white waxy scales on the adaxial surface, margins spineless; leaf-base fibers course, woven in one layer, brown, persistent until leaf fall then deciduous; ligule 12–25 cm long; hastula poorly developed, strongly asymmetric; lamina semi-circular, strongly costapalmate, moderately folded, rigid, 55–62 cm long and 45–55 cm wide, adaxially mid green, abaxially light green; segments 22–25, rigid, free for 17–53% of their length, apical split 1–4% of length of free segment, apices rigid; mid-lamina segments 2–2.5 cm wide at the disjunction; parallel veins 5–7 each side of midrib; transverse veins more prominent, extend across 1–4 parallel veins, density ca. 60 per unit area of 15 × 10 mm. Inflorescences basally trifurcate with ± identical axes, 60 cm long, but with central axis slightly longer and moderately more robust than the lateral axes; each axis with 2–3 partial inflorescences, branched to 3 orders; prophyll 35–45 cm long, 2.5–3.5 cm wide, papyraceous, entire at the apex, glabrous; peduncle of central axis subterete to laterally compressed, 18–20 mm diam.; peduncles of lateral axes terete, 8–12 mm diam.; each axis lacking peduncular bracts; rachis bracts 15–25 cm long, tightly tubular, papyraceous, not disintegrating at the apex with maturity; bases of partial inflorescences with green tomentum;



6. *Livistona brevifolia*. **A** habit; **B** leaf; **C** leaf, abaxial view; **D** inflorescence ×1/8; **E** fruit ×2; **F** seed ×3; **G** seed in section ×3. **A–C** from photographs taken by J.P. Mogea, **D** from *Mogea 8171*, **E–G** from *Mogea 8224*. Drawn by Lucy T. Smith.

rachillae 4–9 cm long, rigid, subterete to angular, ca. 0.5 mm thick. Flowers not seen, but in clusters of 2–4 based on the number of persistent bracteoles on the pedicel. Fruit globose, 10–12 mm diam.; only immature but full-size fruit seen; epicarp thin, smooth, drying minutely tuberculate with scattered lenticels, not waxy; stigmatic remains apical; mesocarp thin, non-fibrous; endocarp thin, crustaceous; pedicel 2–3 mm long, ca. 1 mm thick. Seed globose, 8–10 mm diam.; endosperm intruded by the seedcoat to about 3/4 across, intrusion of soft tissue irregularly shaped

with minor intrusions extending to the outer edge of the endosperm; embryo subapical, ca. 1 mm long. Eophyll not seen. (Fig. 6).

SPECIMENS EXAMINED: INDONESIA. Papua, Kep. Rajah Ampat, West Waigeo, Kawe Island, 0°02'41"S, 130°08'28"E, 17 Nov. 2002, *Mogea 8224* with *W. Takeuchi, D. Neville & F. Liuw* (BO, K).

DISTRIBUTION AND HABITAT. Indonesia, in western Papua at Raja Ampat, at low altitude. Grows in open coastal forest on ultrabasic rocks at 10–20 m altitude, associated with a *Syzygium* sp. and *Pandanus* sp.

ETYMOLOGY. From Latin, *brevi*, short, and *folius*, leaf, in reference to the small leaves.

Livistona brevifolia was first collected by JPM during an ecological survey of the Raja Ampat Islands, Papua, Indonesia, conducted in November 2002. The small leaves relative to the palm's height immediately distinguish the species. Although other species of *Livistona* may have similarly small leaves, such as *L. humilis* R.Br. and *L. exigua* J.Dransf., those species do not reach the height that *L. brevifolia* does, and indeed are confined to the under-story or lower strata of the forest, whereas *L. brevifolia* emerges above the canopy. Morphologically it is closest to *L. woodfordii* Ridley from Milne Bay Province, PNG and the Solomon Islands. *Livistona brevifolia* is distinguished from *L. woodfordii* by much smaller leaves, smaller fruits and a seed coat intrusion into the endosperm that is irregular rather than regular. *Livistona brevifolia* also lacks the additional rachis bracts that are a feature of *L. woodfordii*. Otherwise, *L. brevifolia* falls within the '*Livistona rotundifolia*' group, distinguished by the trifurcately branched inflorescence and shallow clefts of the leaf segment apices.

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