Palms

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FRONT COVER

The seldom-seen *Wettinia maynensis*, near the Cordillera Galeras, Ecuador. See article by Thomas L.P. Couvreur et al., p. 94. Photo by Thomas L.P. Couvreur.

Palms (formerly PRINCIPES)

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Acanthophoenix rubra at L'Etoile. See article by N. Ludwig et al., p. 77. Photo by N. Ludwig.

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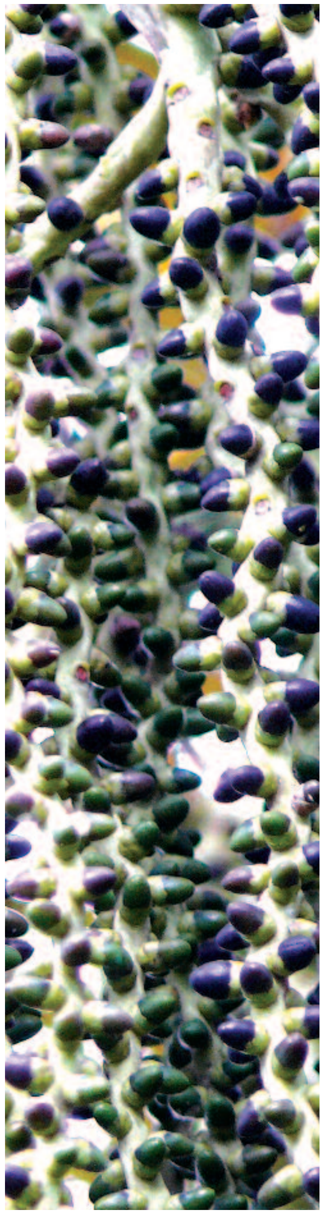
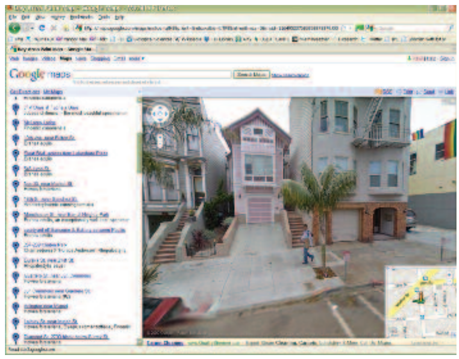


Acanthophoenix rubra infructescence rachillae with slightly immature fruits. See article by N. Ludwig et al. p. 77. Photo by N. Ludwig.

PALM NEWS

Based in Britain, Plant Heritage is the world's leading garden plant conservation charity. It manages the UK's National Plant Collection® scheme. The 650+ collections in Britain are "living plant libraries," each dedicated to a specific genus of garden plants. We have just learned of a newly designated national collection – **the National Plant Collection of *Trachycarpus***. It belongs to Martin Gibbons of the Palm Centre at Ham near Richmond. Martin has assiduously brought together living representatives of all species of the genus, and these are now available for viewing along "The *Trachycarpus* Trail" in the nursery.



Take a tour of the San Francisco Bay Area's most significant palms. IPS member Jason Dewees is creating a **Google Map of the palms of the Bay Area**. With help from other palm enthusiasts, Jason is producing a map of the remarkable diversity of palms now growing along the streets and in the gardens in front of residences and businesses. The Street View feature of Google Maps means that you do not have to be in California to see these palms. Just click and drag the little homunculus onto the street map and enjoy a virtual tour. In most cases, the palms are readily visible and recognizable. It is the next best thing to visiting the Bay Area. A link to the Google map can be found here, on the Flora Grubb Gardens blog: http://floragrubb.com/pbBlog/?p=25.

A new ecological study by Verónica Cepeda-Cornejo and Rodolfo Dirzo will be **of interest to growers of *Chamaedorea* palms**. "Sex-Related Differences in Reproductive Allocation, Growth, Defense and Herbivory in Three Dioecious Neotropical Palms," published in the free-access, on-line journal PLoS One in March of this year, reported on resource allocation in *Chamaedorea alternans*, *C. pinnatifrons* and *C. ernesti-augusti*. The researchers found that growth (as measured by height and leaf production rate) was higher in male plants of all three species than in females. Female plants allocated more of their resources to defense and to reproduction. While male plants grew faster, there was a trade-off: the leaves of female plants contained more defensive chemicals than those of male plants and suffered less herbivory. Growers take note: male plants may grow better, but their leaves may be more vulnerable to pests.

The **2010 IPS Biennial in Rio de Janeiro, Brazil**, was an enjoyable and memorable event for all who attended. Attendees enjoyed field trips to the Serra dos Órgãos National Park to see palms in the wild and tours of parks and gardens to see palms in cultivation. The iconic avenues of Imperial Palms (*Roystonea oleracea*) at the Botanical Garden were impressive, as were the many towering *Corypha umbraculifera* palms fruiting at Flamengo Park, which was designed by renowned landscape architect Roberto Burle Marx, whose home, now a Brazilian cultural site, was also on the itinerary. Many attendees also participated in a pre-Biennial riverboat tour of the Amazon, and post-Biennial tours of gardens and wild palms in the Brazilian interior.

Palms and Palm Communities in the Upper Ucayali River Valley – a Little-Known Region in the Amazon Basin

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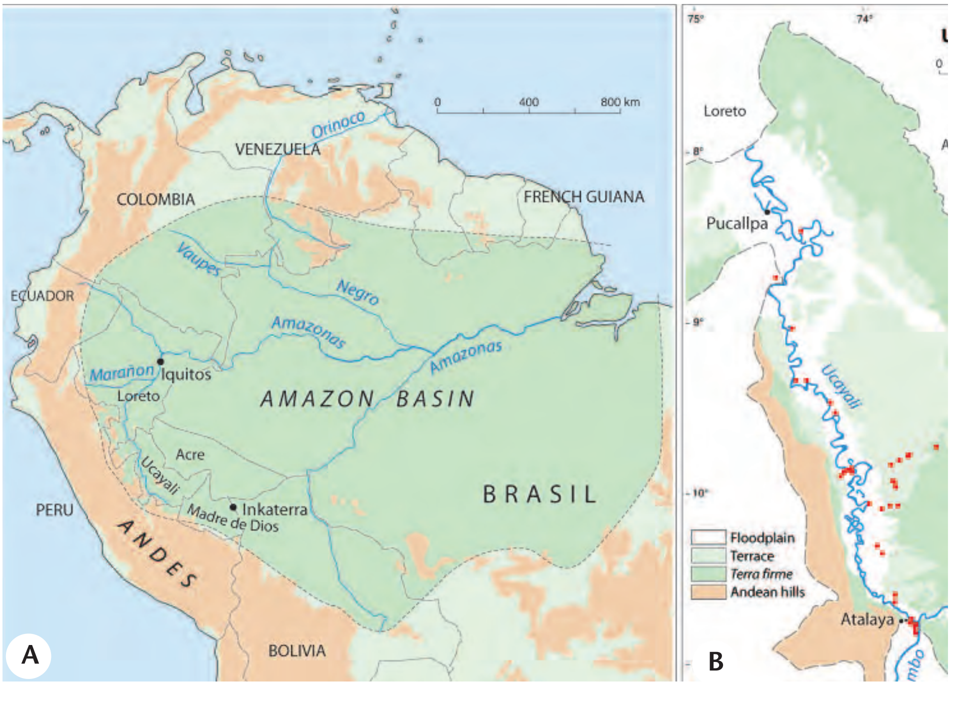
The Amazon region and its palms are inseparable. Palms make up such an important part of the rain forest ecosystem that it is impossible to imagine the Amazon basin without them. Palms are visible in the canopy and often fill up the forest understory. Palms – because of their edible fruits – are cornerstone species for the survival of many animals, and palms contribute substantially to forest inventories in which they are often among the ten most important families. Still, the palms and palm communities of some parts of the Amazon basin remain poorly studied and little known. We travelled to a little-explored corner of the western Amazon basin, the upper Ucayali river valley. There, we encountered 56 different palms, 18 of which had not been registered for the region previously, and 21 of them were found 150–400 km beyond their previously known limits.

The importance of palms in the Amazon basin attracted the attention of early European travellers in the region. When Alexander von Humboldt (1769–1859) explored the Americas from 1799 to 1804 he was impressed with the role of palms in the lives of the people he met. He was particularly impressed with the majestic *Mauritia flexuosa,* which he observed when navigating the rivers along the northern fringe of the Amazon basin along the Orinoco and its tributaries (Humboldt 1850). Carl Friedrich Philip von Martius (1794–1868) was sent to Brazil from 1817–21 by the king of Bavaria to explore the plant richness of that remote region. He travelled extensively along the Amazon river and its tributaries and became fascinated with the palms – so fascinated that upon his return to Europe he immersed himself in the study of the palm family – and a few years later published the first volume of what was to become the most complete monograph of any plant family, the famous *Historia Naturalis Palmarum* (3. vols. 1823–1853). Thirty years later, between 1848 and 1852, the young naturalist Alfred Russel Wallace (1823–1913) travelled along the Amazon, Rio Negro and Vaupes in search of birds and butterflies but – as with earlier travellers – palms impressed themselves so much upon him that he took special notes and made a series of pencil sketches of them. Although Wallace lost most of his collections in a shipwreck on his way back to Europe he managed to save his drawings and later published the *Palm Trees of the Amazon and Their Uses* (Wallace 1853), a handsome little book that underscores the importance of palms to people in the Amazon. The great explorer of the Amazon and the Andes, Richard Spruce (1817–1893) spent 13 years in the region (1849–1862) and again – even if his purpose was different – he developed a special liking for the palms of the region and published a detailed account of his findings under the title *Palmae Amazonicae* (Spruce 1871). The Brazilian government, duly impressed with the results of the palm explorations, particularly those of Martius, contracted João Barbosa Rodriguez (1842–1909) to continue the exploration of the region's palm resources. Barbosa Rodrigues efforts produced two important references for Amazon palm botany, *Enumeratio Palmarum Novarum* (Barbosa Rodrigues 1875) and *Sertum Palmarum Brasiliensium* (Barbosa Rodrigues 1903). On one of his travels Barbosa Rodrigues was accompanied by the physician James Trail (1851–1919) who, fascinated with palms, went on to study and make botanical collections of them, and upon his return to Europe published his results in the *Journal of Botany* with descriptions of 72 new palm taxa from the Amazon (Trail 1876, 1877). More recently Andrew Henderson compiled and critically evaluated all information and collections of Amazon palms and published the monograph



1. A. Northern South America with indication of the position of the Ucayali region in the Peruvian Amazon and other localities mentioned in the text. B. The Ucayali region with indication of the Ucayali river valley and the landforms that characterize the region (floodplain, terraces, *terra firme,* and Andean hills. The positions of the 35 transects are indicated with red squares.

2. A. The crew of boatmen and "macheteros" who cut and marked our transects. In the background the riverboat *El Delfincito,* which was our home and laboratory for the five weeks on the upper Ucayali river. B. The team at work identifying palms along the transect, and collecting and photographing them. C. Pressing a *Socratea salazarii* on the boat deck. D. Walking through cultivated land to reach tall forest.

The Palms of the Amazon (Henderson 1995) in which he accepted 151 palm species. Apart from its wealth of information about the Amazon palms, Henderson's treatment clearly demonstrates that many parts of the Amazon basin remain unexplored or under-explored as far as palms are concerned. One such region is the upper Ucayali river valley in the western part of the Amazon basin, right at the foot of the great Andean cordillera in central Peru (Fig. 1A). This paper is an account of the palm flora of the upper Ucayali river valley, based on five weeks of exploration in 2008.

The Ucayali Region

The Ucayali region forms a narrow band on the western edge of the Amazon basin between the great cordillera of the Andes and the vast flat plain of the mighty Amazon river and its tributaries (Fig. 1A). Politically Ucayali is a part of the Peruvian Amazon, inserted between the Loreto and Madre de Dios regions and the

Brazilian state of Acre. The region's main coherence is due to the Ucayali river (Fig. 1B) that flows northwards and continues into the Loreto region, where it discharges into the Marañon that eventually becomes the Amazon river. In the northern part of Ucayali lies Pucallpa, the region's capital and largest city with close to 200,000 inhabitants, and towards the South lies Attalaya, a small town with maybe 30–40,000 inhabitants. The Ucayali river originates near Attalaya at the confluence of the Urubamba and Tambo rivers, both of which originate high in the Andes. The Ucayali river is up to one kilometer wide and flows in a very flat valley, where it meanders through a 20–100 km wide floodplain.

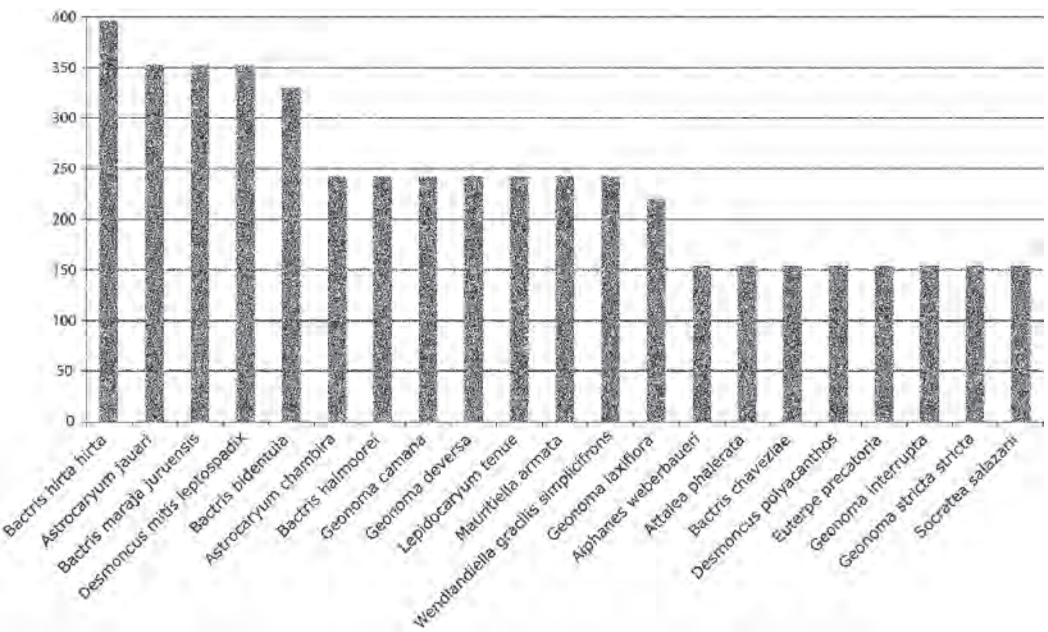
Fieldwork

During five weeks (22 September to 26 October, 2008) we travelled on the riverboat *El Delfincito* (Fig. 2A) along the Ucayali river between Pucallpa and Attalaya, stopping whenever convenient to explore the palm flora and the palm communities ashore. We made special efforts to explore as many different habitats as was practically possible, collecting herbarium specimens of palms and collecting data about their abundance in transects.

We collected 334 numbers of herbarium specimens (Fig. 2C), each one with a duplicate for the herbarium of the Universidad Nacional Amazonense de Peru in Iquitos (AMAZ), and one for the herbarium at Aarhus University (AAU). The collections represent all stages of the palms from seedlings over juveniles to adults. This may be unusual, since most herbaria accept only fertile material of mature individuals. Because the purpose of our research is also ecological it has become an important part of our field protocol to be able to identify palms in all stages of development. Consequently we collect specimens that represent the juvenile and seedling phases, which are valuable in our subsequent analysis of the ecological data, and in our elaboration of identification keys that help us putting names on individuals representing all stages of the palms.

To determine the abundance of individual species of palms and other ecological parameters, we made 35 transects (location on Fig. 1B) each one five meters wide and 500 meters long. In subunits of 5 × 5 meters we counted and identified all palm individuals, from the smallest seedlings to the largest adults and we noted the developmental stage of the individual as seedling, juvenile, subadult or adult. In total we counted and identified close to 31,000 palm individuals. The transects were laid out so that they would represent the variation in vegetation types as we could see them on satellite images that we brought along. After selecting a site we would approach its position as closely as we could on the river and then reach it overland using GPS (Fig. 2D). Once at the site our three *macheteros* would

3. Range extensions of 150–400 km for 21 species of palms encountered in the upper Ucayali river valley.



4. Floodplain and floodplain palms. **A**. Dicot tree in the flood plain with mud marks about 3.5 m above the ground, indicating the level of the most recent flooding episode. **B**. *Attalea phalerata,* a common large tree palm on the flood plain. **C**. *Bactris bifida,* a locally abundant, colonial, understory palm on the floodplain. D. Stand of colonial *Bactris brongniartii*. **E**. Fresh leaves of *Bactris brongniartii,* showing the very characteristic large yellow spines.

cut a straight trail, avoiding any damage to the palms along the trail, and placing sticks for every five meters and marking each stick with a pre-printed paper label with the transect number and subunit number (Fig. 2B). Then followed a team of three consisting of the person identifying the palms (HB), one person filling in the numbers of individuals on a pre-printed list of all species expected in the region (DP), and one person who measured ecological variables along the transect such as light penetration through the canopy, inclinations of the ground, etc. (CG). The tail of our team included a plant collector (WE) who was assisted by two students and a photographer. With this menagerie of 13 people we could

Table 1. The upper Ucayali river valley palm community with indication of name, literature reference, collecting number, number of individual encountered in 35 5x500m transects (total 8.75 hectares), and the average number of individuals/species in each of four habitat types (floodplain, terrace, terra firme and Andean hills).

						Individuals per hectare						
Species name	New to Ucayali (•) or previo-usly reported reference	Collected HB-number	Seen and not collected	Not seen	Number of individuals counted in 35 transects	Andean hills (8 transects)	*Terra firme* (1 transect)	Terrace (13 transects)	Floodplain (13 transects)	pal architecture	Growth form	Leaf architecture
Lepidocaryum tenue Mart. var. *tenue*	•	7605			13823		2384	4070		Col	MsT	pal
Geonoma brongniartii Mart.	1,3,4	7552			2580	131	640	434	230	Sol	Shr	pin
Astrocaryum chonta Mart.	4	7658			1803	15		226	320	Sol	LaT	pin
Bactris brongniartii Mart.	2,4	7542			1486			3	454	Col	MsT	pin
Oenocarpus bataua Mart. var. *bataua*	4	7606			1377	31	44	401	1	Sol	LaT	pin
Iriartella stenocarpa Burret	1,4	7562			1233	259		220		Ces	MsT	pin
Wettinia augusta Poepp. ex Endl.	4	7550			1015	247	84	154		Ces	LaT	pin
Geonoma macrostachys var. *acaulis* (Mart.)Skov	1,4	7590			883	9	12	264	1	Sol	Aca	pin
Geonoma stricta var. *trailii* (Burret) Henderson	1	7869			739	55	112	186		Ces	Shr	pin
Geonoma maxima var. *chelidonura* (Spruce) Henderson	3	7626			580	214		47		Ces	MsT	pin
Bactris bifida Mart.	2,4	7875			574				177	Col	Shr	pin
Iriartea deltoidea Ruiz & Pav.	1,4	7723			548	149	372	48		Sol	LaT	pin
Attalea phalerata Mart. ex Spreng	1	7752			459	3		25	115	Sol	LaT	pin
Euterpe precatoria Mart.	4	7569			431	9	32	121	4	Sol	LaT	pin
Oenocarpus mapora H.Karst.	1,4	7563			280	26	16	69		Ces	LaT	pin
Bactris maraja Mart. var. *maraja*	2,4	7596			194	8		75	4	Ces	MsT	pin
Bactris concinna Mart.	2,4	7780			246				76	Col	MsT	pin
Socratea salazarii H.E.Moore	1,4	7594			237	72	132	19		Sol	LaT	pin
Socratea exorrhiza (Mart.) H. Wendl.	1,4		•		230	73	28	23	1	Sol	LaT	pin
Bactris hirta Mart. var. *hirta*	•	7603			187	75		21		Ces	Shr	pin
Hyospathe elegans Mart.	4	7574			210	74	4	19		Ces	MsT	pin
Attalea maripa (Aubl.) Mart.	1,4		•		137	17		32		Sol	LaT	pin
Geonoma deversa (Poit.) Kunth	4	7641			127		136	29		Ces	MsT	pin
Bactris maraja var. *trichospatha* (Trail) Henderson	2	7835			265	9		33		Ces	MsT	pin
Bactris simplicifrons Mart.	2,4	7591			94	21		16		Ces	Shr	pin
Phytelephas macrocarpa Ruiz & Pav.	1,4		•		91	5		7	18	Ces	MsT	pin
Bactris halmoorei Henderson	•	7595			81	1		25		Ces	MsT	pin
Astrocaryum jauari Mart.	•	7778			71				22	Ces	LaT	pin
Wendlandiella gracilis var. *gracilis* Dammer	4	7570			71			22		Col	Shr	pin
Bactris maraja var. *juruensis* (Trail) Henderson	•		•		2	34				Ces	MsT	pin
Chamaedorea pauciflora Mart.	1,4	7694			68	8	148	5		Sol	Shr	pin

The growth form of each species is indicated as MsT (=Medium sized tree, Shr(=shrub), LaT (=large tree), Aca (=acaulescent), Lia (=liana), and the palm architecture is given as Col(=colonial), Sol (=solitary), Ces (=cespitose), and the leaf architecture is given as pal (palmate), pin (=pinnate) and cop (=costapalmate).

Chelyocarpus ulei Dammer	1,4	7623			65	10		14		Sol	MsT	pal
Bactris chaveziae Henderson	•	7749			63	4		2	15	Ces	MsT	pin
Desmoncus polyacanthos Mart. var. *polyacanthos*	4	7776			65	2		3	15	Ces	Lia	pin
Geonoma stricta (Poit.) Kunth var. *stricta*	4	7583			55	5		14		Ces	Shr	pin
Wendlandiella gracilis var. *simplicifrons* (Burret) Henderson	•	7747			40	20				Col	Shr	pin
Desmoncus mitis var. *leptospadix* (Mart.) Henderson	•	7579			36	1		10		Ces	Lia	pin
Astrocaryum chambira Burret	•	7621			35		12	10		Sol	LaT	pin
Geonoma arundinacea Mart.	4	7858			37			11		Ces	Shr	pin
Bactris acanthocarpa Mart.	•	7604			3	2		10		Ces	MsT	pin
Desmoncus giganteus Henderson	•	7708			20	5		5		Ces	Lia	pin
Geonoma interrupta (Ruiz & Pav.) Mart. var. *interrupta*	3,4	7669			24	12				Sol	MsT	pin
Geonoma macrostachys Mart. var. *macrostachys*	1,4	7665			24	12				Sol	Aca	pin
Mauritia flexuosa L.f.	1,4		•		24			7		Sol	LaT	cop
Bactris bidentula Spruce	•	7546			22				6	Ces	MsT	pin
Chamaedorea pinnatifrons (Jacq.) Oerst.	1,4	7649			20	6	8	2		Sol	Shr	pin
Geonoma camana Trail	4	7592			19	1	8	5		Sol	MsT	pin
Geonoma leptospadix Trail	1,3,4	7632			16			5		Sol	Shr	pin
Bactris corossilla H.Karst.	2,4	7575			9			3		Ces	Shr	pin
Geonoma laxiflora Mart.	•	7847			7				2	Ces	Shr	pin
Geonoma triglochin Burret	•	7827			7		28			Sol	MsT	pin
Aiphanes weberbaueri Burret	•	7648			6			2		Sol	Aca	pin
Bactris macroacantha Mart.	2,4	7601			5			2		Ces	MsT	pin
Desmoncus orthacantos Mart.	•	7820			5			2		Ces	Lia	pin
Mauritiella armata (Mart.) Burret	•	7834			1				1	Ces	LaT	cop
Aiphanes aculeata Willd.	•	7663								Sol	MsT	pin
Aphandra natalia (Balslev&Henderson) Barfod	1			•						Sol	LaT	pin
Attalea butyracea (Mutis ex L.f.) Wess.Boer	1		•							Sol	LaT	pin
Attalea tessmannii Burret	1,4			•						Sol	LaT	pin
Bactris gasipaes Kunth var. *gasipaes*	2		•							Ces	LaT	pin
Bactris riparia Mart.	2			•						Col	MsT	pin
Chamaedorea angustisecta Burret	1,4		•							Sol	MsT	pin
Chamaedorea linearis (Ruiz & Pav.) Mart.	4			•						Sol	MsT	pin
Geonoma stricta var. *piscicauda* (Dammer) Henderson	4			•						Ces	Shr	pin
Syagrus sancona H. Karst.	1,4		•							Sol	LaT	pin
Syagrus smithii (H.E.Moore) Glassman	1,4			•						Sol	MsT	pin
Total number of pal individuals					30730	3244	1050	21956	4746			
Number of pal individuals per hectare					3512	1622	4200	6756	1460			
Number of species in each habitat type:					55	36	18	44	18			

References: 1. Henderson(1995); 2. Henderson (2000); 3. Henderson personal information (*Geonoma* database); 4.Kahn and Moussa 1994a; • reported here

5. Floodplain palms in the upper Ucayali river valley. **A.** *Astrocaryum jauari,* a large tree palm, which is characteristic along river margins and low laying floodplains. **B**. Petiole of *Astrocaryum jauari,* showing the characteristic red-brown colour which helps in the identification of seedlings and juveniles. **C**. Colony of *Bactris concinna,* a medium sized tree palm that forms large colonies on the floodplain. **D**. Infructescence of *Bactris concinna.*

locate, mark and collect data in one or two transects on a good day, assuming that we had access to suitable places which was, however, not always the case, giving an average of about one transect per day over the five weeks of fieldwork. The data that goes with each of the 334 herbarium specimens and 750 cross-referenced photos are uploaded on the Aarhus University Herbarium webpage and can be viewed at: http://herb42.bio.au.dk/aau_herb/search_form.php (enter collector "Balslev" and number range "7542-7876")

6. Terrace forest in the upper Ucayali river valley. **A**. View along old logging trail showing the tall dicot trees and the dense understory of medium sized tree palms. **B**. *Lepidocaryum tenue* var. *tenue,* a dense colony of this medium sized tree palm; note transect stick with mark in center. **C**. *Oenocarpus bataua,* old infructescence; note horse-tail shape. **D**. *Chelyocarpus ulei,* the only palm of subfamily Coryphoideae in our area; note palmate leaves with white undersurface.

The size of the Ucayali palm flora

We collected 51 taxa of palms including five varieties (Tab. 1). In addition we encountered five species in the transects for which we did not make voucher collections because they were very common and well-known species. Finally we saw *Bactris gasipaes, Chamaedorea angustisecta* and *Attalea butyracea* along the river and *Syagrus sancona* near Attalaya, but not where we made collections or transects. Consequently we observed 60 taxa of palms during our fieldwork. In his *Palms of the Amazon* and his monograph of *Bactris,* Henderson (1995, 2000) cited 34 taxa for the

Ucayali region. Of these we did not see four (*Aphandra natalia, Syagrus smithii, Attalea tessmannii, Bactris riparia*). In addition Kahn and Moussa (1994a) reported *Chamaedorea linearis* and *Geonoma stricta* var. *piscicauda* from Ucayali. All this taken together, the upper Ucayali river valley palm flora includes 60 documented species (in 21 genera) and six additional varieties or a total of 66 taxa. Of the 66 taxa, 18 are here reported for the first time from the Ucayali region (Tab. 1). These 66 taxa correspond to over one-third of the entire Amazon basin palm flora and 40–50% of the entire Peruvian palm flora. Compared to other areas in which Ucayali is not nested, the region harbors over two-thirds as many species as found in the 10 times larger area of Bolivia. Such richness of species is not unheard of. Ecuador, for instance, which has only one quarter of the area of Bolivia, has 130 palm taxa, and the one degree square (111 × 111 km) where the Peruvian Amazon's capital Iquitos is located has 71 palm species. The accumulation of many species in small areas is a general feature of tropical rainforests, and although this local richness in species is variable, the Ucayali palm flora is no exception to that general pattern (Tab. 2).

Range extensions

Many of the taxa we encountered as new to the Ucayali region represented extensions of their known ranges. In other cases our recording of taxa new to the Ucayali region were simply filling of gaps. We measured the distance that these known range extensions represented by calculating the distance from the center of the one degree square in which we found the taxon to the center of the nearest one degree square in which it was reported to occur according to the dots maps reproduced in Henderson's book *Palms of the Amazon* (Henderson 1995). In this way we could demonstrate that 21 species had been recorded anywhere from 150–400 kilometers from their nearest previously known occurrence (Fig. 3). The most impressive thing about these range extensions is not the distance from the previously known occurrence and the newly documented occurrence, but rather the fact that about one-third of the recorded species were found outside their previously known ranges. This testifies to the patchy nature of the present state of knowledge of Amazon palms.

The palm communities

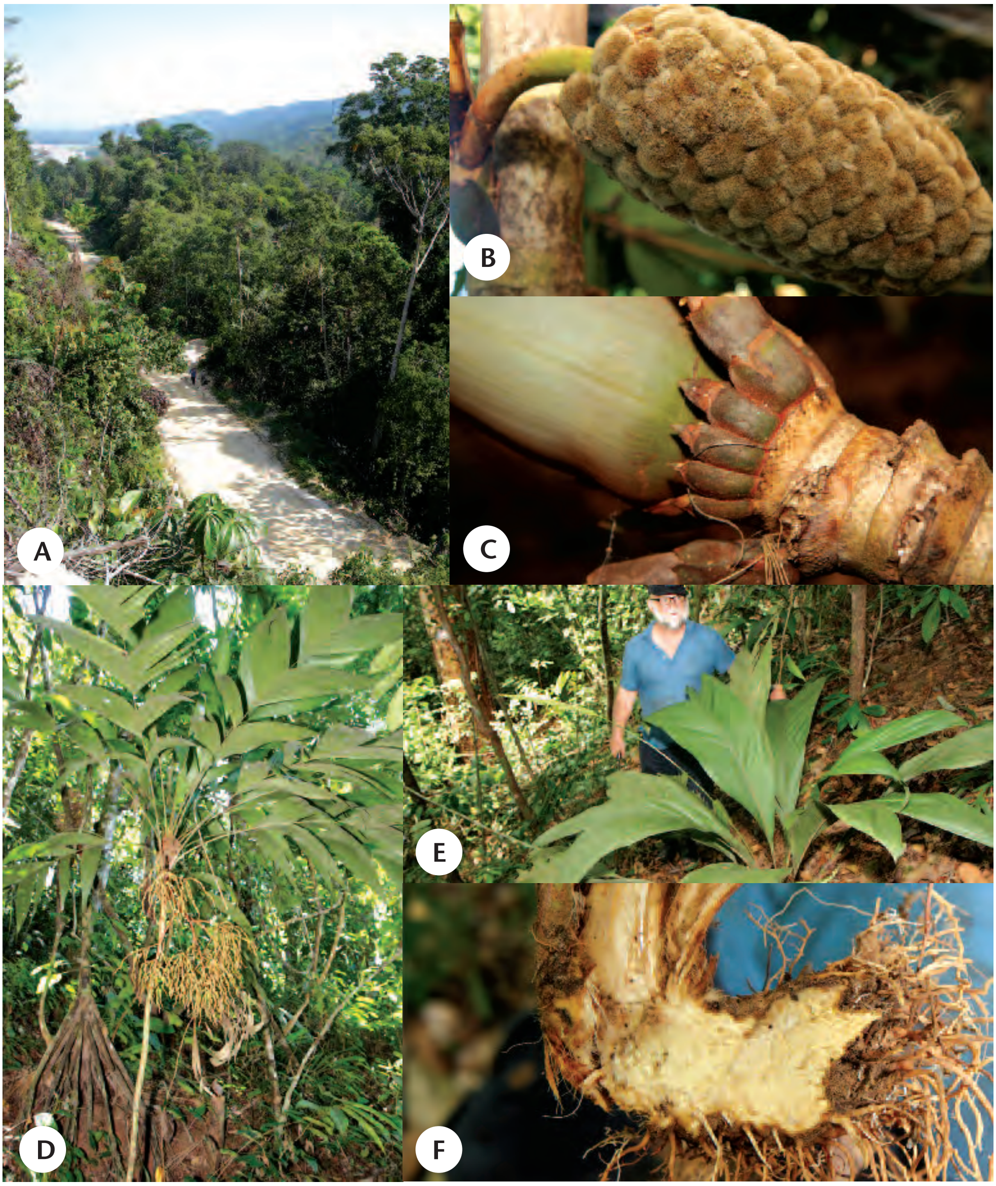
Palm communities in different habitats – The upper Ucayali river valley includes a series of habitats with different conditions for the growth and development of palm communities.

Close to the river and sometimes stretching for tens of kilometers beyond the river channel, the floodplain (Fig. 1B) forms a very flat and gently sloping plain which is subject to flooding during the rising and falling cycles of the river. The parts of the floodplain closest to the river would be flooded annually at high water whereas more distant parts of the plain are flooded only during extreme events of high water (Fig. 4A). This transition from annually flooded to rarely flooded parts of the plain is mirrored in a gradient of plant communities, generally from communities with few species to ones with a species richness that approaches what is found on the never-flooded *terra firme*. We placed 13 of our transects in such floodplain sites. The density of palms in the floodplains was 1460 individuals per hectare, and we encountered a total of 18 species in them (Tab. 1; Figs. 4 & 5). The most abundant floodplain palms were *Bactris brongniartii* (Figs. 4D & E), *Astrocaryum chonta, Geonoma brongniartii, Bactris bifida* (Fig. 4C) and *Attalea phalerata* (Fig. 4B). These were all restricted to, or occurring primarily on, the floodplain, except for *Geonoma brongniartii,* which appears to be a generalist species that happens to be very abundant on the floodplain. Less abundant but certainly conspicuous in the floodplain palm community were *Bactris concinna* (Figs. 5C & D) and *Astrocaryum jauari* (Figs. 5A & B), which are both habitat specialists on the floodplain and along river margins.

The floodplain is bordered by a system of terraces (Fig. 1B) formed by prehistoric floodplains over the past two million years or more. These old terraces are flat and, although they are built of fluvial sediments, they are never flooded by the river in its current cycles of high and low water levels. These terraces have become "lifted" above the active flood plain through tectonic movements or erosion of the river channel. Terraces therefore share some features with flood plains such as flat topography (Fig. 6A) and alluvial sediments, but they differ in never being flooded. We placed 13 transects on terraces and we measured an average density of 6756 palm individuals per hectare. We encountered a total of 44 species in the terrace palm community (Tab. 1; Fig. 6). The most abundant of these were *Lepidocaryum tenue* (Fig. 6B), which was

7. *Terra firme* forest palms in the upper Ucayali river valley. **A**. *Geonoma triglochin,* a disjunct and range restricted species that we encountered in a single transect. **B**. Inflorescence of *G. triglochin* in pistillate flower. **C**. *Socratea salazarii,* leaf, note entire pinnae which distinguishes this species from the related and sympatric *S. exorrhiza*. **D**. *Geonoma brongniartii,* an unusually large individual of this very variable palm.

super-abundant, *Geonoma brongniartii* and *Oenocarpus bataua* (Fig. 6C), all of which were also found in other habitats. The Coryphoid *Chelyocarpus ulei* (Fig. 6D) was also conspicuous on the terraces. More interesting may be a series of taxa found in the terrace palm



8. Andean hills and their palms. **A**. Landscape south of Atalaya. **B**. *Wettinia augusta,* mature infructescence. **C**. *W. augusta,* multiple inflorescence buds at the node just below the crownshaft. **D**. *Geonoma interrupta,* a medium sized tree. **E**. *Geonoma macrostachys* var. *macrostachys,* one of the very few acaulescent rosette palms in the upper Ucayali river valley forest. **F**. *G. macrostachys* var. *macrostachys,* longitudinal section of the below-ground stem.

community but not in other habitats (*Wendlandiella gracilis* var. *gracilis, Geonoma arundinacea, Mauritia flexuosa, Geonoma leptospadix, Bactris corosilla, Aiphanes weberbaueri, Bactris macroacantha, Desmoncus orthacanthos*). These species appear to be habitat specialist, but each of them would need to be evaluated individually, including an assessment of the habitats in which they have been found outside of our study area to determine their status. In any case the tail of less abundant and possible habitat specialists is much longer in these terrace palm communities, contributing to making them the most species rich community in the upper Ucayali river valley.

East of the Ucayali floodplain and in a few places towards the Andes, the terraces give way to upland *terra firme* (Fig. 1B). This landform is shaped by old geological deposits dating back to Miocene and Oligocene some 20–30 million years ago. These old sediments have subsequently been transposed, lifted, tilted, etc. through tectonic movements and then eroded from the top through climatic processes. Consequently, they form a landscape of rolling hills with valleys that have been carved out by creeks and streams. The soils on the upland *terra firme* are typically red clay soils which are nutrient poor because they have been subject to millions of years of leaching; in the erosion creeks, however, deposits of alluvium may create small patches of nutrient rich soils. The rain forest on this *terra firme* is typically very tall and often has enormous local species richness. During our field work we were able to reach such *terra firme* forest only at a single locality. We therefore have only one transect representing this habitat type and our data are clearly insufficient to represent fully the palm communities found in it. Based on a single transect (0.25 ha) we calculated a density of 4200 palms per hectare. We found 18 species of palms in our single transect (Tab. 1). The most abundant species were *Lepidocaryum tenue*, *Geonoma brongniartii* (Fig. 7D) and *Iriartea deltoidea; Socratea salazarii* (Fig. 7C) and *Geonoma deversa* were also common in this habitat. The only species restricted to this habitat type was *Geonoma triglochin* (Figs. 7A & B), which is a range-restricted species that occurs disjunctly in a relatively small area in the Ucayali river valley. Much more data about this habitat type in the Ucayali river valley is needed to truly assess its palm communities; the 18 species reported here surely represent only a fraction of the entire palm community.

To the west the terraces are bordered by Andean hills (Figs. 1B, 8A) resulting from the immense folding of the South American continental plate where is collides with the Pacific Nazca plate. The hills rise rather steeply from the lowland Amazon plain, and the folding exposes deep rocks, and the slopes therefore are rocky, often with shallow soils and cliff outcrops. The soils are loamy and appear to be rich in nutrients. Like the flat plain below, they are covered with dense, tall broadleaf forest with high diversity of trees, shrubs, epiphytes, herbs and also some lianas. We were able to place eight transects in the Andean hills. The density of palms was 1622 palm individuals per hectare, and the community was made up of 36 species (Tab. 1). The most abundant species on the Andean hills were *Iriartella stenocarpa* and *Wettinia augusta* (Figs. 8B & C), and *Geonoma interrupta* (Fig. 8C) also grew here. Species found on the hills but not in any of the other habitats were *Bactris maraja* var. *juruensis, Geonoma macrostachys* var. *macrostachys* (Fig. 8D & E) and *Wendlandiella gracilis* var. *simplicifrons* (Fig. 8). Elsewhere these are typical *terra firme* species but not necessarily limited to Andean premontane forests.

The four habitats shared five taxa (*Geonoma brongniartii, Oenocarpus bataua, Geonoma macrostachys* var. *acaulis, Euterpe precatoria, Socratea exorrhiza*), but more characteristically they were dominated by different sets of abundant species, and of the 55 taxa encountered in the transects 19 were restricted to one of the four habitats (Tab. 1). The floodplain forests palm communities were not very dense with an average of 1460 individuals per hectare, and the number of species growing in the flood plain forest was 18, which was

9. Abundances of species in the upper Ucayali river valley palm communities. The number along the vertical axis is the total number of individuals encountered of each species in 35 transects of 5 × 500 m, i.e., 8.75 hectares in total.

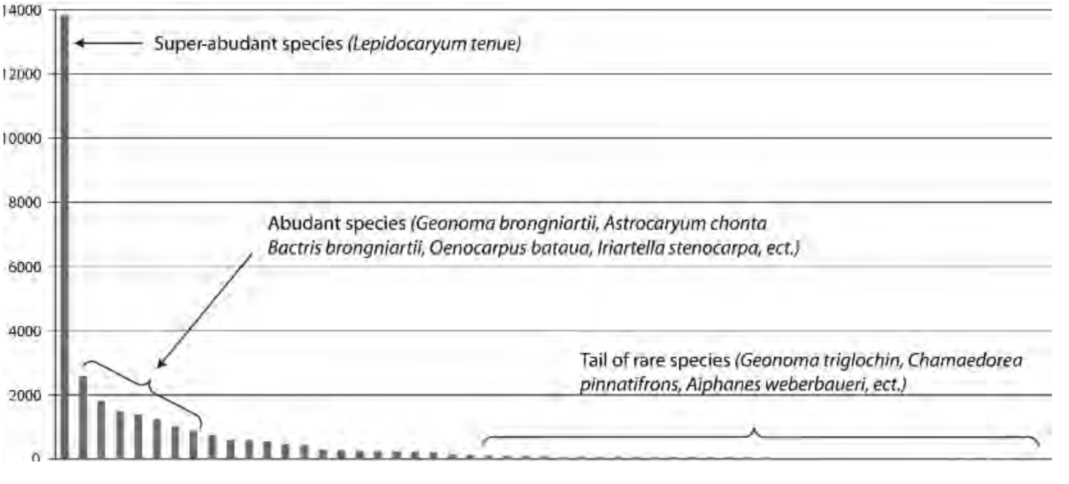


Table 2. Number of palm species encountered in nine Neotropical areas of variable extent.

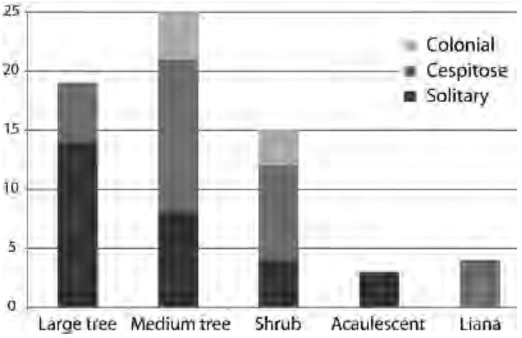
Place	area (x1000 km^2)	Species	Reference
Inkaterra	0.0001	20	Valenzuela et al. 1992
Central French Guiana	0.0013	34	Mori et al. 1997
Iquitos 1 degree square	12	71	Bjorholm et al. 2005
Ucayali	102	59	this study
Ecuador	256	120	Borchsenius et al. 1998
Bolivia	1098	80	Moraes 2004
Peru	1285	140	Kahn and Moussa 1994b
Peru	1285	105	Henderson et al. 1995
Amazon basin	8235	151	Henderson 1995

low compared to the other habitats (disregarding *terra firme* on hills where we made only one transect); the Andean hills were intermediate in species richness and palm abundance (36 species; 1622 individuals/ha) and the terrace palm transects were by far the most dense and species rich palm community in the Ucayali river valley with 6756 individuals per hectare and 44 palm taxa in the transects. These differences between the palm communities show that the diversity of the Ucayali palm flora is driven also by high between-habitat turnover of species, the so-called beta-diversity. Understanding the Ucayali palm community beta-diversity would, however, require further and more detailed sampling.

The four habitats we have defined here separate very coarsely defined types, and within each of them there are much finer divisions that contribute to structuring the palm community. The flood plains have zones with different length and depth of flooding, oxbow lakes, back swamps and several other habitat types. The terraces are rather uniform, but have a fine topographic variation depending on proximity to the creeks that traverses the terraces. The *terra firme* hills have crests, slopes and valley bottoms with differences in the palms occurring in them. Finally the Andean hills have similar divisions depending on slope, humidity, etc., that need more sampling to be described and understood.

Rare and common species – A general feature of ecosystems is that some species (usually a few) are abundant and others (usually many) are rare and scarce. This is also true in the Ucayali palm communities (Tab. 1, Fig. 9). *Lepidocaryum tenue* is by far the most abundant species making up almost 45% of all individuals found in the 8.75 hectares covered by our 35 transects. This super-abundant species had more than five times as many individuals as the second most abundant species, *Geonoma brongniartii*. The reason why some species are very abundant may vary. Some abundant species have wide ecological niches and tolerate great variation in growth conditions; they may be able to grow on both wet and dry soils, on both flat and sloping terrain and in both shade and light exposed places. Others are abundant because they are able to produce very large numbers of individuals when they occur in their favorite habitats. *Lepidocaryum tenue* belongs to this latter category; it was very abundant on the terraces, but absent from the Andean hills and the floodplain transects (Tab. 1). Another very abundant species, *Bactris brongniartii,* is likewise restricted but in this case almost entirely to the floodplains where it forms large colonies in wet depressions. *Genoma brongniartii* and *Oenocarpus bataua,* two other very abundant species, have a more even occurrence in several different habitat types and accordingly represent the other type of abundance, i.e., abundance attained by having a broad ecological niche.

Rare species, likewise, may be rare for different reasons. Among the ten rarest species encountered in our transects, *Chamaedorea pinnatifrons* is very widespread in the western Neotropical area from Mexico to Bolivia, but wherever it is found there are only few and scattered individuals. Others are rare because they have very restricted distribution ranges; *Geonoma triglochin* is an example of a range-restricted species that we found in only one of our 35 transects. Other species are rare because



10. Relative abundances of growth forms (large tree palms, medium sized palms, shrubs, acaulescents, lianas) among the species in the upper Ucayali river valleys, and indication of the relative proportions of solitary, cespitose and colonial species.

they are restricted to special habitats; both *Mauritia flexuosa* and *Mauritiella armata* grow in permanently water logged soils, a habitat that we did not sample well in our transects.

So the observation of a single super-abundant species, several abundant species and a long tail of species with low abundances in our palm community corresponds to a standard pattern in rain forests and in other ecosystems in general. But both abundance and rarity are driven by different mechanisms in different species, so for one to understand the species' relative position along the gradient from the most abundant to the rarest, each species must be looked at and interpreted individually.

Palm guilds – Rain forest organisms are sometimes grouped in guilds, depending on which part of the forest they exploit for resources. The most common growth form among the Ucayali palms was medium sized trees (Fig. 10), i.e., palms with stems up to five meters tall and five centimeters thick, reaching the lower mid-canopy layers in the forest. This category included 25 of the 66 taxa in the Ucayali river valley. Among the medium sized tree palms were very abundant ones such as *Lepidocaryum tenue, Bactris brongniartii, Iriartella stenocarpa* and *Geonoma maxima* var. *chelidonura*. The next most common growth form we found was large tree palms with tall stems to 40 centimeters in diameter and tall enough to reach the canopy; they were represented by 19 species of which the most abundant ones were *Astrocaryum chonta, Oenocarpus bataua* and *Wettinia augusta*. Shrub palms, that is small palms less than a couple of meters tall but with a clearly visible aboveground stem were represented with 15 species in our sample, and these included the very abundant *Geonoma brongniartii* and *Geonoma stricta* var. *trailii*. Acaulescent rosettes, i.e., palms with a subterranean stem and with only the leaves and inflorescences sticking above the ground, were not very rich in species and represented by only two varieties of *Geonoma macrostachys* and by *Aiphanes weberbaueri*, which elsewhere grows with aerial stems, but apparently not in this area. Finally we encountered four taxa of liana palms, all belonging to the genus *Desmoncus* (Fig. 10). This shows that in these upper Ucayali river valley rain forests the largest diversity of palms is found in the mid-canopy level, where 38% of the palm species, i.e., the medium sized tree palms, thrive, whereas the layer above (canopy), where the large tree palms (29%) occur, and below (lower canopy), where the shrub palms (22%) occur, have slightly lower species richness. The ground level (acaulescent rosette palms) and the liana palms make up much smaller fractions (5% and 6%, respectively) of the overall palm species richness. Such division of phylogenetically related species into guilds that occupy different strata of the rain forest have been given as one of the mechanisms that contribute to the packing of very high numbers of species in tropical rain forest ecosystems. Although previous examples have related to birds and other organisms (Terborgh 1992), our observations suggest that it may also be true for palms.

Palm architecture – A little less than half of the palms – 30 of the 66 taxa – in our study area had a cespitose growth, i.e., with stems originating through lateral budding at or below the ground level. Cespitose growth was found in several species in each of the different growth forms except acaulescent rosettes (Fig. 10). Solitary growth was found in 22 species representing all growth forms except the lianas. Solitary growth was particularly common among the large tree palms of which 14 of 19 species were solitary. Colonial growth, in which the stems are attached through below-ground rhizomes and forming dense stands over extended areas, was registered in seven species, four medium-sized trees and three shrubs, and it was absent among the large trees, acaulescent rosettes and lianas (Fig. 10, Tab. 1). Cespitose and colonial growth are two different ways of securing vegetative reproduction whereas the solitary palms depend entirely on sexual reproduction through seeds to survive. This division of the palm guilds into groups with different architecture (cespitose, colonial, solitary) can be interpreted as adaptations of reproductive strategies to divide the community into more complex niche structures in which the species competition is more finely differentiated, eventually making it possible for more species to co-exist and thereby increasing the local species richness.

Leaf architecture – All except four of the species have pinnate leaves. *Mauritia flexuosa* and *Mauritiella armata* have costapalmate leaves, and *Lepidocaryum tenue* and *Chelyocarpus ulei* have palmate leaves. The dominance of pinnate leaves among the species in the Ucayali palm community reflects the prevalence of lineages with pinnate leaves (subfamilies Ceroxyloideae and Arecoideae). The American rainforests are simply very poor in costapalmate and palmate-leaved palms.

After five weeks of field work in the Ucayali region we were tired and ready to go home, but we left the region with a feeling that much more could be done to understand fully the upper Ucayali palm flora. As expected we had encountered a very rich palm community with over 60 taxa and we also found very high local species richness, especially on the terraces above the floodplains. We were only able to scratch the surface of the enigmatic *terra firma* far away from the flood plains and hard to reach. Elsewhere the *terra firme* forest communities are known for their extremely high local species richness, and we would have liked to explore that further. The flood plains were relatively poor in species and also low in overall palm abundance. The palms occupied all strata of the forests from the ground level, where shrubby and acaulescent palms were common, to the canopy in which several large tree palms competed for the favorable light conditions. However, the richest stratum was the mid-canopy where about one-third of the species thrived. Another third of the species were found beyond their previously known distributional ranges, a testimony to the patchy nature of our knowledge of the Amazon palms and palm communities, and a reminder of the need for continued exploration of the magnificent Amazon rainforest and its palms.

Acknowledgments

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Literature Cited

Barbosa Rodrigues, J. 1875. Enumeratio Palmarum Novarum. Brown & Evaristo, Sebastianopolis.

Barbosa Rodrigues, J. 1903. Sertum Palmarum Brasiliensium, 2 vols. Veuve Monnom, Brussels.

Bjorholm, S., J.-C. Svenning, F. Skov and H. Balslev. 2005. Environmental and spatial controls of palm (Arecaceae) species richness across the Americas. Global Ecology and Biogeography 14: 423–429.

Borchsenius, F., H. B. Pedersen and H. Balslev. 1998. Manual to the Palms of Ecuador. Aarhus University Press, Aarhus.

Henderson, A. 1995. The Palms of the Amazon. Oxford University Press, Oxford and New York.

Henderson, A. 2000. Bactris. Flora Neotropica Monographs 79: 1–181.

Henderson, A., G. Galeano and R. Bernal. 1995. Field Guide to the Palms of the Americas. Princeton University Press, Princeton, New Jersey.

Humboldt, A. von. 1850. Aspects of Nature. Lea & Blanchard, Philadelphia.

Kahn, F. and F. Moussa. 1994a. Las Palmeras de Perú. Instituto Francés de Estudios Andinos, Lima.

Kahn, F. and F. Moussa. 1994b. Diversity and conservation status of Peruvian palms. Biodiversity and Conservation 3: 227–241.

Martius, C. 1823–1853. Historia Naturalis Palmarum, vols 1–3. Weigel, Leipzig.

Moraes Ramirez, M. 2004. Flora de Palmeras de Bolivia. Instituto de Ecologia, La Paz.

Mori, S., G. Cremers, C. Gracie, J.-J. de Granville, M. Hoff and J.D. Mitchell. 1997. Guide to the Vascular Plants of Central French Guiana. Part 1. Pteridophytes, Gymnosperms, and Monocotyledons. The New York Botanical garden, New York.

Spruce, R. 1871. Palmae Amazonicae. J. Proc. Linn. Soc. Bot. 11: 65–183.

Terborgh, J. 1992. Diversity and the Tropical Rain Forest. Scientific American Library, New York.

Valenzuela G., L., G. Calantayud H., J. Farfán V., I. Huamantupa Ch., A. Monteagudo M. and E. Suclli M. 1992. Flórula de la Reserva Ecologica Inkaterra. Missouri Botanical Garden and Inkaterra, Lima.

Wallace, A. R. 1853. Palm Trees of the Amazon and their Uses. Van Hoorst, London.

Potential Harvest of *Desmoncus polyacanthos* (Arecaceae) in the Peruvian Amazonia

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People extract the stems of *vara casha* (*Desmoncus polyacanthos*) for weaving baskets and sieves and for tying various items (Henderson et al. 1995). The most common *vara casha* products in Iquitos are seats and backing for arm chairs, rocking chairs and sofas (Henderson & Chavez 1993, Hübschmann et al. 2007). The stems are sturdy and flexible as well as resistant to decay, and furniture made from it can last 25–30 years (Hübschmann et al. 2007). These characteristics make *vara casha* a substitute for "rattan," the stems of Old World climbing palm belonging to subfamily Calamoideae. This paper discusses the population structure and potential harvest in Peru.

Desmoncus polyacanthos Martius is distributed from east of the Andes in Colombia, Venezuela, Trinidad, Ecuador, Peru, Brazil and south to Bolivia (Henderson et al. 1995, Henderson 1995). It is called *vara casha* by the inhabitants of the Peruvian Amazon, *jacitara*, *titara* and *espera-ai* in Brazil, *bejuco alcalde*, *enredadera*, *yasitara* in Colombia, *kamawarri* in the Guyanas, *bambakka*, *bamba maka* in Surinam and *voladora* in Venezuela (Henderson et al. 1995). In Peru it is found in the Departments of Cuzco, Madre de Dios (Tambopata), San Martín (Mariscal Cáceres), Ucayali (Coronel Portillo), and Loreto (Maynas, Requena) (Kahn & Moussa 1994, Henderson et al. 1995). The species occurs on river banks, in lowland forest, forest gaps, secondary forest, along forest margins and in disturbed places and open areas (Kahn & Moussa 1994, Henderson et al. 1995, Henderson 1995, Goulding & Smith 2007). *Vara casha* is a liana, and it can often form very dense thickets; the stem is flexible and climbs into the mid-layer of the forest by means of reflexed grapnels (modified leaflets) that arise from the leaf tip.

Methodology

Field work was carried out near Lake Sahuasupay, located in the lower Ucayali river, approximately 6 km from the town of Jenaro Herrera (73°40′ W; 4°55′ S), in the Province of Requena, Region of Loreto, at 130 m above sea level The climate of the zone is warm and humid, with a monthly average temperature of 25.9 °C ± 2 °C, an annual precipitation of 2715 mm and the annual evaporation of 566 mm, with a monthly relative average of 47 mm (Kvist & Nebel 2001). The soils are entisols, with horizon A between 5–10 cm and horizon B with clay content that exceeds 50%, with increasing proportion of sand with increasing depth (Nebel et al. 2001). The vegetation that surrounds the lake is typical seasonally flooded alluvial forest, including high *restinga* and low *restinga*, influenced by human agricultural practices (Lamotte 1990). The most common plant families are Moraceae, Fabaceae, Euphorbiaceae and Annonaceae.

From May 2004 to April 2006, 50 contiguous 10 m by 10 m plots were laid out in two types of habitat: low *restinga*, subject to the seasonal flooding of the Ucayali river for three to four months and to a maximum depth of six meters, and high *restinga*, subject to the seasonal flooding of the Ucayali River for one to two months and to a maximum depth of 0.20 m (Fig. 1).

The population structure of *vara casha* was determined by censusing the number of individuals in the seedling, juvenile and adult stages. An individual plant was considered to be a seedling if it was derived from a seed, had a single stem and was not connected to a second individual; a juvenile was defined as a plant that had multiple stems but not sufficiently developed for harvest; and finally, adult, if the plant had several mature stems along with sprouts of new stems developing from rhizomes.

The potential harvest was estimated by counting the number of green, mature and woody stems in an adult individual, and the yield was estimated by measuring the length and weight of the stems.

According to local inhabitants, a stem is classified as "mature" and ready for harvest when it is flexible and can withstand any angle of bending; in addition, these mature stems are light to dark brown and in certain cases almost black in color, the leaf sheaths usually come off easily in the hands and the basal part of the plant generally does not possess spines.

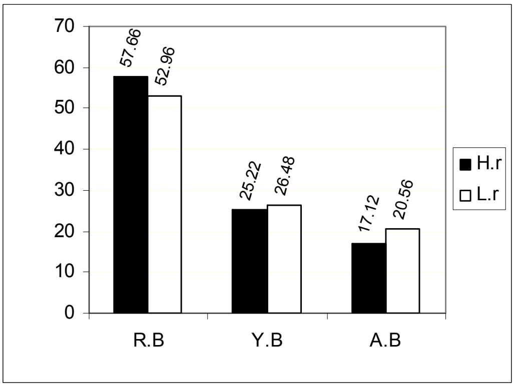
For the phenological study 15 adult individuals were selected at random and marked in each type of habitat, and monthly observations of these plants were taken for three years.

Results and discussion

During the study 355 individuals were inventoried with 2,141 stems/0.5 ha in low *restinga*; 111 individuals with 508 stems/0.5 ha in high *restinga* (Table 1).

The number of individuals/10 m^2 recorded in low *restinga* (X=7.08; sd=4.09), was significantly greater than the number found in high *restinga* (X=2.32; sd=1.34) (Mann-

1. *Desmoncus polyacanthos* in a seasonal flooding area of the Peruvian Amazonia. Photo: Cesar Delgado.



2. Population structure in low and high restinga habitat. RB = Seedling; YB = Juvenile and AB= Adult stages.

Whitney p<0.001). Comparing the stem data, we found that the differences are even stronger between low *restinga* (X= 42.54, sd=44.98) and high *restinga* (X=10.16, sd=20.85). Similar results were observed in a preliminary study carried out in the Yanayacu river, basin of the Marañon (Delgado, unpublished).

The population structure in both types of habitat is similar, with levels of regeneration of the plants that vary between 52.96 to 57.66% (Table 1, Fig. 2). This result suggests that the species has strong regenerative capacity, which will help sustain its survival in the future. From the total number of inventoried adult individuals, 20.76% had mature and harvestable stems in high *restinga* and 21.63% in low *restinga*, with the rest at green and woody stages (Table 2). In both types of habitat percentages of woody stems are greater than other stages, which suggests under-exploitation of this resource. On the other hand, the high percentage of woody stems present in high *restinga* could be present because of a satisfactory supply of the product also occurs in low *restinga* (which is closer to where people live), and thus makes it unnecessary for people to travel greater distances to collect *vara casha*. Extractors will always harvest products that are easily available, demanding less time and effort. Hübschmann et al. (2007) reported that people extract *vara casha* for the furniture industry in many places near Iquitos, and travel to places as close as half-an-hour away to harvest it.

A greater yield of stems was observed in low *restinga*, with 3901.4 m and 148.54 kg, whereas in high *restinga* we measured 913.5 m and 41.38 kg (Table 3). The yield percentages in weight and usable length were similar in both types of habitat, with stem percentages being between 70.39 and 73.6% of the length, and between 75.24 and 79.58% of the weight in high and low *restinga* respectively. The longer period during which *vara casha* is flooded seems not to affect the development of stems, nor their quality.

Phenology.

Vara casha starts its flowering period in September and finishes in February, with major peaks of production in December and January, when the river Ucayali is at its high water mark. The fruiting period begins in April and finishes in July, during the period when the river is at its lowest level. In 2006 we observed a second fruiting period between October and November. This behavior perhaps was in response to the irregular flood of the river that occurred in 2006. The fruits are ellipsoid or globose and wine-red or yellow-orange. The development of the inflorescence lasts 25 days and of the fruit 34 days, making a total of 59 days.

Conclusions

Vara casha is a species with great potential for the continued development of the industry using non-timber forest products (NTFPs) in the Peruvian Amazon. The population structure and large percentage of woody stems demonstrate that the species is currently under-utilized with no existing threats of over-exploitation. Our findings reported here for the preference of *vara casha* for low *restinga*, its phenological behavior and other ecological data, can provide a foundation for efficient sustainable harvest of this species on a large scale.

Table1. Population structure in low and high *restinga* habitat. Number of individuals (percentage of population).

Habitat	Seedlings	Juveniles	Adults	Total of individuals	Total of stems
High *restinga*	64 (57.7%)	28 (25.2%)	19 (17.1%)	111	508
Low *restinga*	188 (52.9%)	94 (26.5%)	73 (20.6%)	355	2141

Table 2. Adult individuals with mature and non-usable stems.

Habitat	Adults with usable stems	Green stems	Mature stems	Woody stems	Total of stems
High *restinga*	05 (26.3%)	91 (31.5%)	60 (20.8%)	138 (47.8%)	289
Low *restinga*	30 (41.1%)	778 (52.1%)	323 (21.6%)	392 (26.3%)	1,493

Table 3. The yield percentages in length and usable weight stems.

Habitat	Total length of stems, m	Usable length, m	Total weight of stems, kg	Usable weight, kg
High *restinga*	1,241	913.5 (73.6%)	55.70	41.38 (75.2%)
Low *restinga*	5541.87	3901.4 (70.4%)	186.64	148.54 (79.6%)

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LITERATURE CITED

GOULDING, N. AND N. SMITH. 2007. Palmeras: Centinelas para la Conservación de la Amazonía. Asociación para la Conservación de la Cuenca Amazónica. ACCA. Lima – Perú. 356p.

HENDERSON, A. AND F. CHÁVEZ. 1993. *Desmoncus* as a useful palm in the western Amazon basin. Principes 37: 184–186.

HENDERSON, A., G. GALEANO AND R. BERNAL. 1995. Field Guide to the Palms of the Americas. Princeton. University Press. Princeton, New Jersey.

HENDERSON, A. 1995. The Palms of the Amazon. Oxford University Press, New York.

HÜBSCHMANN, L.K., L.P. KVIST, C. GRANDEZ AND H. BALSLEV. 2007. Uses of Vara Casha – a Neotropical liana palm, *Desmoncus polyacanthos* – in Iquitos, Peru. Palms 51: 167–176.

KAHN, F. AND F. MOUSSA. 1994. Las Palmeras del Perú: Colecciones, Patrones de Distribución Geográfica, Ecología, Estatutos de Conservación, Nombres Vernaculares, Utilizaciones. Instituto Francés de Estudios Andinos, IFEA. Lima-Perú. 180 p.

KVIST, L.P. AND G. NEBEL. 2001. A review of Peruvian flood plain forests: ecosystems, inhabitants and resource use. Forest Ecology and Management 150: 3–26.

LAMOTTE, S. 1990. Fluvial dynamics and succession in the lower Ucayali River basin. Peruvian Amazonia. Forest Ecology and Management 33/34: 141–156.

NEBEL, G., L.P. KVIST, J. VANCLAY, H. CHRISTENSEN, L. FREITAS AND J. RUIZ. 2001. Structure and floristic composition of flood plain forests in the Peruvian Amazon I. Overstorey. Forest Ecology and Management 150: 27–57.

Notes on the Conservation Status of Mauritian Palms

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1. Blue latan savannah on Round Island; photo by C. Lavergne.

Mauritius, the uninhabited Round Island and several smaller islets are part of the Republic of Mauritius. These islands, with La Réunion and Rodrigues, constitute the Mascarene archipelago located in the Indian Ocean, off the east coast of Madagascar. They have a unique flora and fauna. Many Mauritian palms are more common in cultivation elsewhere in the world than they are in the wild. This paper investigates the precarious state of the palms of Mauritius in their natural habitat (Fig. 1).

Table 1. The nine native palm taxa described in Mauritius.

Scientific name	**Local name**	**Endemic range**
Acanthophoenix rubra (Bory) H. Wendl.	Palmiste rouge	Mauritius & Reunion
Acanthophoenix sp. Florin	Palmiste piquant	Mauritius
Dictyosperma album (Bory) H. Wendl. et Drude ex Scheff. var. *album*	Palmiste blanc	Mauritius & Reunion
Dictyosperma album var. *conjugatum* Moore et Guého	Palmiste de l'Île Ronde	Round Island
Hyophorbe amaricaulis Mart.	No local name recorded	Mauritius
Hyophorbe lagenicaulis (L.H. Bailey) H.E. Moore	Palmiste bonbonne	Round Island
Hyophorbe vaughanii L.H. Bailey	No local name recorded	Mauritius
Latania loddigesii Mart.	Latanier bleu	Round Is., Gabriel Islet, Gunnar Coin
Tectiphiala ferox H.E. Moore	Palmiste bouclé	Mauritius

The Mauritian palm flora consists in nine taxa (see Table 1), including seven endemic taxa and two (*Acanthophoenix rubra* and *Dictyosperma album* var. *album*) that are native to both Mauritius and Réunion. This total is subject to change, as there may be more than one species of *Acanthophoenix* present in the wild in Mauritius (see below). The conservation status of these palms in their natural environment is extremely critical, with the exception of *Hyophorbe lagenicaulis* and *Latania loddigesii*, both species endemic to Round Island, where action to restore the ecosystem was taken with the eradication of goats and rabbits (Bullock et al. 2002). This *in situ* rescue was accompanied by culture *ex situ*, and both *H. lagenicaulis* and *L. loddigesii* are grown widely as ornamental species, in the Mascarene Islands as well as throughout the Tropics.

These notes are the result of two surveys conducted in March/April 2006 (Lavergne 2007), and in June 2008. These missions made it possible to evaluate the state of conservation of the endemic and indigenous palms in Mauritius and to study protective measures implemented in the wild, especially on Round Island. On our itinerary we visited the Botanical Garden in Curepipe, the Black River National Park, state forests of Gouly Père and Declerc, l'Étoile private Estate on the northern slope of Montagne Bambou, Île aux Aigrettes near Mahébourg, and in the north of Mauritius, Round Island, Flat Island and Gabriel's Islet.

The single specimen of *Hyophorbe amaricaulis* in the Curepipe Botanical Garden

Located at 550 m above sea level, the Curepipe Botanical Garden is home to the only known specimen of *Hyophorbe amaricaulis* (Fig. 2). The species was first described in the 18th century by French naturalist Commerson on Mount Pieter Both, where the species was reputed to be abundant in the past. Nowadays, it must be regarded as extinct in the wild, since it survives only in Curepipe garden, and we do not know if that specimen was planted or is a remnant wild palm that was incorporated into the garden's collection. In the late 1970s, when H.E. Moore took the photograph that illustrates Flore des Mascareignes (Moore & Guého 1984), this *Hyophorbe amaricaulis* was approximately 6 m tall and not yet caged in an ugly protecting frame (Fig. 3). Almost 30 years later, it is just over 8 m tall, suggesting that this specimen grows very slowly.

The species is closely related to *Hyophorbe indica* or "*palmiste poison*" from Réunion; it differs in inflorescences branched to two orders and large sub-globose fruit (3.8 × 3.3–3.5 cm), orange-red to dark red when mature. Although it produces many fruits and seeds, no successful germination occurs. The protandry of this unique specimen might cause pollination problems although, of 20 fruits dissected, 18 had apparently normal embryos (Wyse Jackson et al. 1990). In 1987, G.C.

2. The single specimen of *Hyophorbe amaricaulis* in the Curepipe Botanical Garden; photo by N. Ludwig.

Douglas attempted *in vitro* cultivation of embryos on Murashige and Skoog medium with charcoal added. After culturing 15 embryos for four months, three developed roots, and two produced shoots. One germinated embryo produced a true leaf. Unfortunately transfer to soil was not achieved (Douglas 1987). More recently another attempt was made under the control of the Mauritian Ministry of Agriculture. From ripe fruits

3. *Hyophorbe amaricaulis* inflorescence (left) and erect young inflorescence enclosed in the prophyll (right); photo by N. Ludwig.

cropped in 2007, five embryos were collected for *in vitro* cultivation. They all germinated and produced seedlings, developing rootlets, and the experimentation is still in progress. The prospect for an *in extremis* rescue is not completely excluded; attempts at seed germination on sterilized medium should be carried out since it is difficult to understand why mature seeds with normal embryos do not germinate. See also Sarasan et al. 2002.

Black River National Park: a sanctuary for critically threatened palms

The remaining natural vegetation (primary forest) in Mauritius occupies only 2% of the available land surface and is subject to protection under the management of the Forest Services within the framework of the National Park. Pétrin, Mare Longue, Florin and Montagne Cocotte are the spots which we visited in the National Park. State forests Gouly Père and Land Declerc are Nature Reserves under the administration of Forest Department.

The Gouly Père and Land Declerc Nature Reserves cover a 200 ha surface of upland wet forest (600–680 m elev.), between Grand Bassin and Montagne Cocotte, in southwestern Mauritius. Some 40 years ago, the area was reforested with exotic species of trees for wood production, including *Cryptomeria japonica, Eucalyptus robusta* and *Pinus elliottii*. Invasive exotic plants also threaten the environment; in addition to *Psidium cattleianum*, we should list *Ardisia crenata, Clidemia hirta, Ligustrum robustum, Rubus alceifolius* and *Ravenala madagascariensis*.

With an average annual rainfall of over 4000 mm, Gouly Père and Land Declerc are very humid. The native remnant vegetation consists of a wet thicket ecosystem or "upland marshes" (Vaughan & Wiehe 1937). In an enclosure where eradication of *Psidium cattleianum* (goyavier) by manual uprooting is all but completed, we observed 5 adults of *Tectiphiala ferox* (possibly 40–50 years old). The stems are 1.6–4.2 m tall, with basal circumference up to 40 cm. The crownshaft is swollen and covered with a dense thorny coating, characteristic of the species. The palms (Fig. 4) grow in a swampy environment, on acid soil (low humic gley), as indicated by the presence of many *Sphagnum* patches. In late March, the beginning of the fruiting season, some infrutescences developed abortive fruits.

4. *Tectiphiala ferox* in the wet thicket ecosystem at Land Declerc; photo by N. Ludwig.

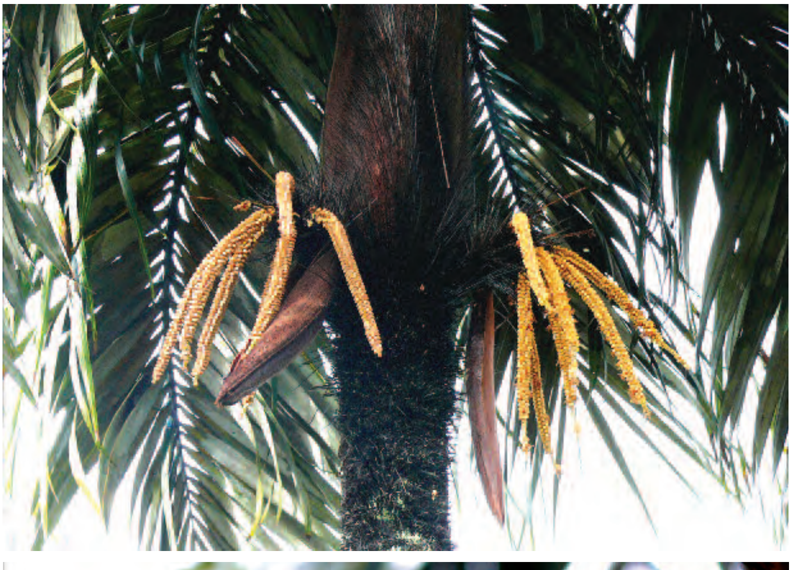
The best specimens of *Tectiphiala*, including the one used by H.E. Moore to describe the genus, are found on Land Declerc and were first discovered by Marc d'Unienville in 1969. In late June, they show bright orange inflorescences with staminate flowers bearing lemon yellow anthers (Figs. 5 & 6). In 1994, the inventory carried out on the spot numbered 14 adult specimens. Now this *Tectiphiala* population does not exceed nine specimens. The reasons for this drastic reduction in the *Tectiphiala* population are not understood, but may include poaching of palm cabbage despite forest agent supervision. Also, in the same location, we observed a few *Acanthophoenix rubra* specimens.

On its southern edge, Gouly Père and Land Declerc plateau extends onto a grassy slope toward Trou Mille Pieds. Obviously this area has been deforested to create grazing land. It would not be of major interest without the presence of around twenty *Acanthophoenix* specimens gathered on a sloping ledge, some 50 m below the rim. More or less of the same size and same age (35–45 year old?), with no seedlings under the palm trees, they do not look like a wild population. It seems that seeds were planted on this spot a few decades ago. Although these *Acanthophoenix* resemble *A. rubra* in overall morphology, the characteristics of the infrutescence, fruit and seed make it appear distinct. The infructescence is infrafoliar, pendulous, 60–85 cm long, branching to two orders, with 18–27, green rachillae bearing globose fruit (10–12 × 9–11 mm); mature fruit are black with persistent green perianth and the stigmatic scar is slightly off-center.

On Montagne Cocotte, three other specimens of *Tectiphiala ferox* were seen. This area culminates at an elevation of 744 m above Gouly Père and Land Declerc. The vegetation is a remnant mossy forest where fog develops from late morning and maintains high humidity.

The Pétrin Information Center (600 m elev.) is located at the main entrance to the National Park and Plateau de Mare Longue. This is a very humid area with an average annual rainfall of 3500–4500 mm. Behind the office grow five small *Tectiphiala ferox* planted 10 years ago from seeds collected in Florin. The palms are currently less than one meter high.

The Florin Conservation Management Area or CMA (650 m elev.) was established on Plateau de Mare Longue in 1996; it covers a 2.5-ha enclosure where the vegetation consists of



5. A *Tectiphiala ferox* specimen bearing two young infructescences; photo by N. Ludwig.

6. A rachilla segment of *Tectiphiala ferox* densely covered with flowers; photo by N. Ludwig.

7. An *Acanthophoenix* population on a grass slope at Land Declerc; photo by N. Ludwig.

different palms and other endemic species. Within the CMA limits the fence protects the vegetation against deer and wild pigs. The invasive alien species, mainly *Psidium cattleianum* and *Wikstroemia indica*, have been manually removed, twice a year at first, then once a year, and finally one intervention every two years. Among the endemics, a few specimens of several hundred year old *Sideroxylon puberulum (*manglier rouge) are the only trees being present.

The palms recorded are *Acanthophoenix rubra, Dictyosperma album* var. *album, Hyophorbe vaughanii* and *Tectiphiala ferox*.

Another *Acanthophoenix* (Figs. 7 & 8) is present with two adult specimens (along with two juvenile specimens near the fence, outside the CMA.). It was reported as *A. rubra*, and a description of the palm was made 40 years ago on a specimen (Fig. 9) conserved in the Mauritius herbarium (*Guého and Vaughan 13151*, MAU, 11 July 1968). On our second visit in 2008, we had the opportunity to see inflorescences and flowers in situ and to study dry material at the Mauritius Herbarium in order to prepare a description of the Florin *Acanthophoenix*. The Florin *Acanthophoenix* is not *A. rubra*; it is closer to *A. crinita* (staminate flowers very similar) but differs by several characteristics: stem apex armed with persistent strong black spines at the adult stage, crownshaft armed with strong erect black spines, especially on leaf sheath median axis. Inflorescence is short, with 5–11 rachillae, branching approximately from the same point, and fruits and seeds are globose. It combines some characteristics of *A. crinita* (general morphology, staminate flowers) and some of *Tectiphiala ferox* (black spines, inflorescence structure); this emphasizes the phylogenetic link between *Acanthophoenix* and *Tectiphiala* (Lewis 2002). Should this *Acanthophoenix* be considered as a distinct species despite its dramatically small population?

It is quite interesting to compare the measurements given by Guého (1968) with ours, concerning the same specimen's growth over 40 years. In 1968, the height was 1.52 m and the trunk diameter was 8 cm. Lavergne (2007) reported the trunk to be 2.20 m tall and 10 cm in diameter. These measurements point out the very slow growth of this palm, also confirmed by the close prominent leaf scars on the trunk; the harsh environmental conditions could explain this slow growth.

Within the CMA limits, five specimens of *Tectiphiala ferox*, including three adults, are present, and 15 young plants were planted there in 1998. On the same site, and in their natural habitat, three wild *Hyophorbe vaughanii*

8 (left). Land Declerc *Acanthophoenix*: close up on rachillae bearing unexpected blueberry like fruits; photo by N. Ludwig. 9 (right). Herbarium specimen of Florin *Acanthophoenix* collected in 1968 by R.E. Vaughan and J. Guého; photo by N. Ludwig.

remain, their stems respectively 2.00 m, 1.80 m and 1.70 m tall and 6–7 cm in diameter. This species is close to *H. amaricaulis* but differs by the widely spaced insertion of leaflets on the rachis, orange staminate flowers and globose fruits (4–4.5 × 4.4 cm) with cork-like pericarp (Fig. 10). A young *H. vaughanii* coming from a seed collected in Florin was planted in the reserve in 1994 (Fig. 11). It grows very slowly compared to other specimens of the same age planted in the Mare Longue CMA, which already bear fruit.

In conclusion, the Florin CMA includes, in a small area, a significant number of Mauritian endemic species, including rare palms. However, this floristic richness should not obscure the fact that the majority of the plants are scraggy, are sometimes in poor health, grow very slowly and do not regenerate. It seems that the drastic eradication of *Psidium cattleianum* caused an important modification of the soil. Perhaps organic components were washed away during cyclones. In spite of significant rainfall, the ground does not retain moisture and dries quickly. Humus is rare and confined at the foot of old *Sideroxylon* trees and at the base of palm stems, forming ringlike deposits. The scarcity of humus and the probable lack of trace elements combine to create harsh conditions for the palms surviving inside the Florin CMA.

10. *Hyophorbe vaughanii* globose fruits with characteristic corklike pericarp; photo by C. Lavergne.

11. Forestry agent Mario Allet shows a specimen of *Hyophorbe vaughanii* he planted 15 years ago in the Florin CMA; photo by N. Ludwig.

On the Mare Longue plateau, outside the Florin CMA, the shrubby vegetation is denser, mainly because of the presence of *Psidium cattleianum*. This is a wet thicket ecosystem on low humic gley substrate, with sedges, *Dicranopteris* ferns, lycopods and many hollows colonized by *Sphagnum*. In this environment we have noticed several *Acanthophoenix* whose characteristics suggest *A. rubra*; but we saw neither the inflorescences nor the fruit, only one dry spiny infrutescence collected under one palm tree.

Closer to Mare Longue Reservoir in a section of upland wet forest, Mario Allet of the National Forest Commission planted a group of ten *Hyophorbe vaughanii* between 1994 and 1996. The seedlings were grown from seeds of the last three wild specimens from Florin. Nowadays, some *H. vaughanii* bear abundant fruits.

L'Etoile Private Estate: the domain of *Acanthophoenix rubra*

L'Etoile Private Estate is located in southeastern Mauritius on the northern slope of Montagne Bambou, between Grande Rivière Sud-Est and the mountain ridge. This estate covers 1200 ha and is owned by CIEL Group. Farming lands on the north bank of Grande Rivière Sud-Est are covered with sugar cane. In recent years the south bank and the mountain slope were developed into a green leisure center and a deer hunting land. On the lowest slopes the forest is heavily invaded by exotic species.

The trail to Pic Grand Fond (521 m elev.) leads to a grade A (70% natives and endemics; 30% exotics), intermediate sub-humid forest (average annual rainfall 2500 mm) that covers the slopes of Montagne Gingembre (200–250 m elev.). In this forest ecosystem the rate of endemic and native species is quite high and the presence of *Acanthophoenix rubra* is of note (Figs. 12 & 13). We counted some 50 adult specimens either emerging from the canopy or alongside the trail. In two different places we have seen juveniles whose thorns and spines are an efficient protection against deer.

In Vallée de l'Est, on a location near L'Etoile, the wild population of *Acanthophoenix rubra* has been re-enforced by the recent planting of 80 young specimens in a program initiated by the Mauritian Wildlife Foundation. Another estimated population of 75 individuals of *A. rubra*, both adults and juveniles, has been located on deer hunting land in Midlands. The palm is present also in the Curepipe Botanical Garden and in private gardens; the species is also grown in Réunion.

Île Ronde: a sanctuary for palms and reptiles

Located 24 km off Cap Malheureux, northeast of Mauritius, Round Island or Île Ronde covers a surface of 219 ha and is 276 m at its highest point. The island is the result of recent volcanic activity (100,000–25,000 years ago). The foliate volcanic substrate constituted by aphyric hawaiites is often visible (Big Slab) due to severe erosion. The soil was partly cleared of its vegetation cover by goat and rabbit overgrazing before their eradication; then the heavy rains finished the job and washed away much of the soil to the ocean, though the average annual rainfall is less than 1000 mm.

There are three palms endemic to Round Island, a fact which, given the small size of the island, is remarkable. These species were close to extinction after goats and rabbits were introduced onto the island during the course of the 19^{th} century. Goat eradication was carried out between 1975 and 1979, and rabbits were eradicated in 1986. By the time the exotic animals were eradicated, only one wild specimen of *Dictyosperma album* var. *conjugatum* remained, along with three original *Hyophorbe lagenicaulis* (Fig. 14) and a few *Latania loddigesii* over 90 year old, whose extinction was expected around year 2010 if nothing was done.

Twenty five years after the rabbit eradication was completed, the blue latans are the main element of a wooded savannah landscape ("open palm-rich forest" of Bullock et al. 2002). On the windward side of the island the latans colonize stepped ledges going down to the sea; they grow as well on pyroclastite or in hollows with organic matter deposits. The blue latans grow in colonies with an average of five males, five females and two sub-adults in a grassy environment. Seedlings are numerous under the palm trees with an average of five per m^2. The dead fronds attract many decomposer insects and lizards such as the Telfair's skink (*Leiolopisma telfairii*) whose color resembles dry palm fronds; some marine birds such as the Pacific puffin (*Puffinus pacificus*) nest under the palms. Thus, the presence of latans generates an important biological niche. They also play a major role in the ecosystem: creating micro-habitats, interactions between species, producing organic matter, preserving moisture on the ground, aiding anti-erosive action. On the slopes exposed to the spray (windward side), the vegetation is dominated by blue latans and some *Pandanus vandermeeschii*; trees, once present, have completely disappeared from the landscape. Some blue latans get protection from the wind in the gullies excavated by erosion, especially near the field station.

12 (top). A wild population of *Acanthophoenix rubra* on the slope of Montagne Gingembre (L'Etoile Private Estate); photo by N. Ludwig. 13 (bottom). Close up on immature infrutescences of *Acanthophoenix rubra* at L'Etoile; photo by N. Ludwig.

Above the camp, at around 250 m, are the three oldest *Hyophorbe lagenicaulis*, the last to survive the pressure of the herbivores. Trunks are 2.3–3.0 m tall with circumference 1.7–1.9 m and sheaths are 60–80 cm long. The stem bulges in the direction of the slope and thus stabilizes *H. lagenicaulis*. This species seems to do better in the wind than blue latan since it is particularly resistant in the windy zone just below the summit. The presence of lichens on trunks testifies to their age. Abundant seedlings (Fig. 15) and juveniles 10–50 cm tall are present under the remnant population. Geckos (*Phelsuma guentheri* and *Phelsuma ornata*) and the skink *Leiolopisma telfairii* are very abundant and take part in the pollination of the palm trees.

There is but one specimen of *Dictyosperma album* var. *conjugatum* which survives on the island. It is located on the leeward side (19°50.590′ S, 57°47.020′ E) in a savannah. Its stem is approximately 7 m tall and 13 cm diameter. The individual is very old and does not show any flowering or fruiting. An old infructescence found on the ground bears about 120 marks of fruit on rachillae. Obviously this palm is directly threatened by erosion or future cyclones; its survival is a matter of a few years at the most.

14. One of the 3 original specimens of *Hyophorbe lagenicaulis* which resisted predators before their eradication from Round Island; photo by C. Lavergne.

Îlot Gabriel and Île Plate: a ruined coastal ecosystem

Fifteen kilometers off Cap Malheureux in northern Mauritius, Îlot Gabriel is a 42 ha coral islet connected to Flat Island, or Île Plate, by a channel through the reef. On Flat Island little of the original habitat remains, following a lazaret installation (leprosy hospital) in 1807. Currently the major problem is the presence of *Leucaena leucocephala* which occupies much of the 253 ha surface of the island.

Compared to Flat Island, the conservation status of the ecosystem on Îlot Gabriel is much better. In the southwest of the islet, on less than one hectare of sandy soil grow a few *Latania loddigesii* (Fig. 16) in a thicket overrun with *Psiadia arguta* (baume Île Plate) and *Lantana camara*. This blue latan population consists of five males and three females, all 6 m tall and probably over 50 years old. The stems exhibit close leaf scars. There are abundant seedlings under the female individuals, but surprisingly no juveniles (< 2.5 m tall); two other specimens lie on the ground, probably hit by cyclone winds. Many hermit crabs live in the litter of dry fronds; they seem to consume the fruit pericarp. The observation of a seed obviously eaten by a rodent shows that there are still rats on Îlot Gabriel despite official eradication. The reintroduction of rats must be due to tourist activity on the island, with many boats coming every day on picnic cruises with no guarantee of quarantine! The only other palms present on Îlot Gabriel are date palms (*Phoenix dactylifera*), relics of a palm plantation dating back to the lazaret period.

Île aux Aigrettes: a totally restored coastal ecosystem

This is a 25 ha low coralline island of the Mahébourg lagoon where the Mauritian Wildlife Foundation (MWF) completed a remarkable restoration of the coastal forest ecosystem. All 45 endemic or native species grown locally, in the plant nursery, were intended for further plantation on Île aux Aigrettes and Round Island. The restoration started in 1986, and rats were eradicated by 1991.

Early Dutch visitors reported that Île aux Aigrettes was covered with palm trees. The MWF collected seeds of *Dictyosperma album*

Table 2. Conservation status of the Mauritian palms.

Species name	Site locations	Natural population	IUCN Red List Categories & Criteria proposed*	Population trend	Conservation	Remarks
Acanthophoenix sp.	Florin	4 individuals	CR B1+2ab(iii), D, E	Decreasing	Very urgent	Only 2 adult specimens
Acanthophoenix rubra	L'Étoile, Gouly Père NR, Midlands	> 200 individuals	EN A4c, B1+2abc, C2ai	Increasing	Urgent	Reinforcement of populations in progress
Dictyosperma album var. *album*	Florin	Unknown	DD	Unknown	Not urgent ?	
Dictyosperma album var. *conjugatum*	Round Is.	1 individual	CR B1+2ab, C1+2ab, D, E	Decreasing	Very urgent	
Hyophorbe amaricaulis	Curepipe Bot. Gard.	1 individual	EW	Decreasing	Very urgent	Individual planted or original?
Hyophorbe lagenicaulis	Round Is.	ca. 100 individuals	EN B1+2, D, E	Increasing	Not urgent	Reinforcement of populations achieved on Round Island
Hyophorbe vaughanii	Florin	3 individuals	CR D, E	Increasing	Urgent	And 11 other specimens planted (reinforcement)
Latania loddigesii	Round Is., Flat Is., Gabriel Is., Gunner Coin, Ambre Is.	Several populations	EN B1+2a	Increasing	Not urgent	Main population on Round Island
Tectiphiala ferox	Gouly Père and Land Declerc NR, Florin, Plaine Champagne, Montagne Cocotte	ca. 21 individuals	CR D, E	Decreasing	Very urgent	

**IUCN Red List Categories & Criteria version 3.1*, applied at regional levels: Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN) and Data Deficient (DD). Additional criteria are explained in IUCN (2001, 2003).

15. Seedlings under a female specimen of *Hyophorbe lagenicaulis* on Round Island; photo by C. Lavergne.

var. *conjugatum* from Round Island and sowed them in the MWF nursery. Twelve years later, about 20 individuals of *Dictyosperma album* var. *conjugatum* are planted on Île aux Aigrettes (Fig. 17); they grow slowly and barely exceed one meter in height. Initially MWF considered transplanting some of these specimens to Round Island in order to re-establish a population there. This palm transfer appeared doubtful, due to technical and quarantine requirements. It seems more realistic to wait until the Île aux Aigrettes population bears fruits, in order to launch a large scale program of multiplication, including a nursery unit on Round Island to produce the young palm trees that would achieve the restoration of the Île Ronde ecosystem.

Current assessment and new prospects

The results summarized in Table 2 show that, after four centuries of deforestation and over-exploitation, the introduction of invasive plant species and the extinction of some animals, the conservation status of Mauritian palms in their specific ecosystems is very critical. Of course, the restoration work undertaken on Round Island, the rescue of *Hyophorbe lagenicaulis* and that of *Latania loddigesii* (Fig. 18) are impressive and also very encouraging. Nevertheless, the problem of *Dictyosperma album* var. *conjugatum* survival remains. It is not yet resolved, though the young plants cultivated on Île des Aigrettes offer the possibility, in a decade or so, of the re-introduction of this palm to its homeland.

Among the threatened taxa, there are *Hyophorbe vaughanii*, *Tectiphiala ferox* and atypical *Acanthophoenix*, all confined to the central plateau. With limited fruiting, malformed seeds, almost no regeneration and, for the young subjects which were planted, very slow growth, the few palm trees seem ill-adapted to the actual environmental conditions. On suitable medium *H. vaughanii* seeds germinate easily. Quite recently, Jean-Marie Sauzier, who owns a nursery at Cap Malheureux, initiated the cultivation of the Land Declerc *Acanthophoenix* for further re-introduction in the wild; from about 30 seeds sown on a mixed medium of bagasse, clinker, fly ash and horse manure, he obtained 12 seedlings with V-shaped eophyll and successive leaves pinnate. This is an excellent start.

16. The remnant *Latania loddigesii* population on Îlot Gabriel; photo by C. Lavergne.

17. One of the juvenile *Dictyosperma album* var. *conjugatum* grown on Ile aux Aigrettes from seeds cropped on the last Round Island wild specimen; photo by N. Ludwig.

Tectiphiala ferox seeds are often parasitized by mites, insects or fungi; precautions of culture are necessary (sterilization of germinating boxes, medium and seeds) in order to obtain a better germination rate (see Appendix).

Whatever the causes of this extreme scarcity, it is necessary to constitute for these palm species, including *Dictyosperma album* var. *conjugatum*, a reserve of several thousand young plants, to be subsequently re-introduced in the wild, as well as in private estates or gardens. This necessitates the creation of a modern propagation facility. Such a structure exists in Robinson, close to Curepipe, (Native Plant Propagation Centre), but the palms were not included in that program! The MWF nursery on Île aux Aigrettes is a creditable initiative that works successfully for the restoration of the islet ecosystem. However, the lack of space and sufficient water supply, as well as local climatic conditions and insular isolation, do not permit large scale multiplication of the most threatened palm species. The establishment of another nursery site must be considered, but we think that it is also necessary to favor a low altitude location like Pamplemousses to avoid the need for germination in a heated greenhouse in winter.

An early attempt at cultivating *Latania loddigesii* on Île Plate was doomed from the start. The idea was to up-root by hand the acacia bush (*Leucaena leucocephala*) that chokes the island and then plant young latans in the landscape. For that purpose 10,000 latan seeds were sown in very tight rows on a shaded sandy bed… and then forgotten. In March 2006, the dense crop of seedlings looked like a short grass prairie, making transplantation all but impossible. Obviously the operation was established in total ignorance of the remote tubular germination of latan seeds. The seed produces a rather long white tube which sinks deeply into the soil prior to the emergence of the eophyll; in such conditions, any attempt at transplantation breaks the tube, killing the seedling.

On the same site some seeds were put in plastic bags to germinate but, with no water and no weeding, there was practically no chance of success. These failures illustrate that setting up a propagation unit in the field requires qualified people and minimum equipment. It also shows that eradication of an invasive species from a protected area does not mean automatic restoration of a palm population; it is merely a complementary measure.

For *Hyophorbe amaricaulis*, it is almost too late. If there is still a future for the Curepipe Botanical Garden palm, it is in the hands of the scientists who manage the *in vitro* reproduction techniques. However, at best, this project results in a single small, genetically homogeneous population.

The rescue of threatened Mauritian palms is a long-term undertaking. NPCS and MWF have been working on the project for several decades and, in some respects, the results are quite impressive. However, much still has to be implemented without delay to avoid complete extinction of some species. Private nurseries could participate in the rescue, at least for palms having ornamental qualities.

Acknowledgments

These notes are the result of two surveys led in March/April 2006 and in June 2008. These missions to Mauritius and islets would have not been possible without the assistance of the National Forest Commission and the National Park & Conservation Services in Mauritius, the Mauritian Wildlife Foundation and the Mauritius Herbarium (MSIRI). We want to express thanks to the editors who accepted our manuscript and gave useful advice. Special thanks to Claudia Baider of the Mauritius Herbarium. We are grateful to Mario Allet of the National Forest Commission and Marc d'Unienville for the assistance they provided in the field. We also thank all the persons who helped and the contribution of Clément Duret, Luc Gigord, Lauricourt Grosset and Lucas Reichsteiner who participated to the first mission. Thanks are also due to Steve Swinscoe who proof-read the English manuscript.

Literature Cited

Bullock, D.J., S.G. North, M.E. Dulloo and M. Thorsen. 2002. The impact of rabbit and goat eradication on the ecology of Round Island, Mauritius. pp. 53–63, In C.R. Veitch and M.N. Clout (Eds.), Turning the tide: the eradication of invasive species. Proceedings of the International Conference on Eradication of Island Invasives. IUCN, Switzerland.

Douglas, G.C. 1987. Embryo culture of a rare plant, *Hyophorbe amaricaulis* Martius (Palmae). J. Plant Phys. 130: 73–77.

Appendix: Germination of *Tectiphiala* seeds

The germination of *Tectiphiala* seeds is reported to be very tricky by the very few who have attempted it. Three different techniques are compared here.

The first method consisted in sowing seeds on a rough, non-sterilized medium of 60% small grade volcanic scoria and 40% crumbled cow manure. The result: 10% of seedlings (about 30) germinated within 3 months and were repotted upon emergence of the second eophyll to 4/5 garden soil and 1/5 crumbled cow manure. All but one dried and died within a week after they were repotted. Three years later, of 300 seeds sown, only a single young palm, 40 cm tall, remains.

Another non-sterilized medium, which is commonly used for sowing *Acanthophoenix* seeds, consists of 1/3 perlite and 2/3 peat (TKS1™ – a peat-based medium, with added nutrients and lime). This medium has been tested on *Tectiphiala*. Of seven seeds, three germinated and produced seedlings. Eighteen months later only two *Tectiphiala* remain, 30 cm tall and growing fast.

A much more elaborate technique can be used successfully for *Tectiphiala* as well as for other palm species whose seed germination might be difficult. Fruit pericarp is removed before seeds are treated with miticide and fungicide solutions for 15 minutes. The germination container is disinfected with sodium hypochlorite (bleach). The medium is moistened fine vermiculite sterilized 15 minutes in microwave oven and sprayed with fungicide and miticide. The seeds are put on the medium surface and the container hermetically closed with tape. The container is placed in a heated room whose day temperature reaches 30–35°C while night temperature is maintained at 20–25°C. The first seedlings will develop within few days or few weeks.

18. *Latania loddigesii* is a dioecious palm; however, this specimen shows male inflorescences ending with immature fruits (*pommes latanier*). Photo by C. Lavergne.

IUCN. 2001. Red List Categories and Criteria: Version 3.1. IUCN, Gland, Switzerland and Cambridge, UK. ii + 30 pp.

IUCN. 2003 Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. Ii + 26 pp.

LAVERGNE, C. 2007. Les Palmiers Menacés de Maurice et de ses Îlots – Rapport de mission 22 mars au 2 avril 2006. Unpublished report, 36 pp.

LEWIS, C.E. 2002. A phylogenetic analysis of the palm subtribe Oncospermatinae (Arecaceae) based on morphological characters. Brittonia 54: 78–91.

MOORE, H.E., JR. AND J. GUÉHO. 1984. Famille 189. Palmiers. In: T.L. BOSSER, J. CADET, J. GUÉHO AND W. MARAIS (eds.), Flore des Mascareignes. The Sugar Industry Research Institute, Mauritius, ORSTOM, Paris, and the Royal Botanic Gardens, Kew.

SARASAN, V., M.M. RAMSAY, AND A.V. ROBERST. 2002. In vitro germination and induction of direct somatic embryogenesis in 'Bottle Palm' [*Hyophorbe lagenicaulis* (L. Bailey) H.E. Moore], a critically endangered Mauritian palm. Plant Cell Reports 20: 1107–1111.

WYSE JACKSON, P.S, Q.C.B. CRONK AND J.A.N. PARNELL. 1990. Notes on a critically endangered palm from Mauritius, *Hyophorbe amaricaulis* Mart. Botanic Gardens Conservation News 1: 24–26.

Palms of the South-West Cordillera Galeras, a Remote Premontane Rain Forest in Eastern Ecuador

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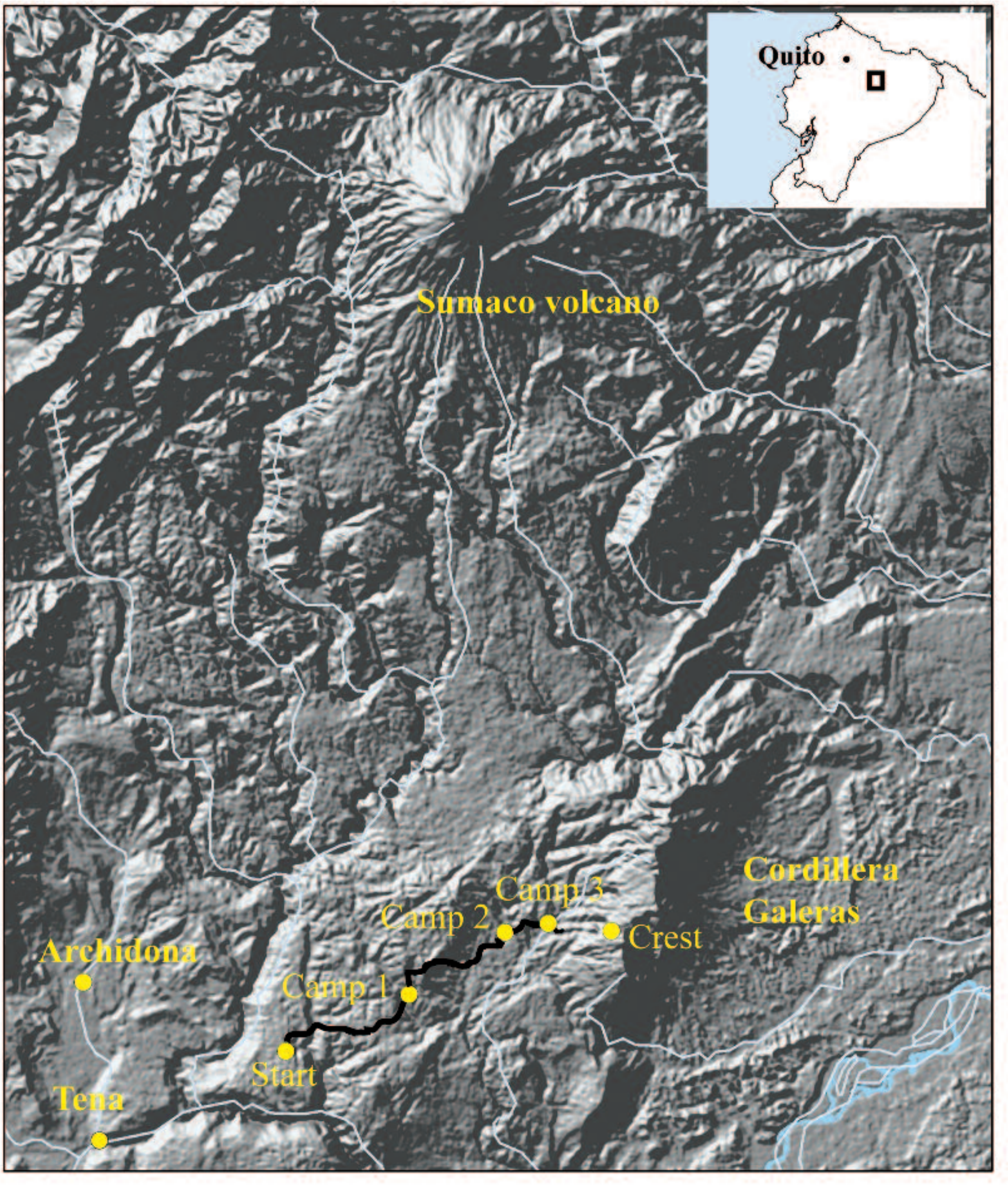
The Sumaco Napo-Galeras National Park in western Ecuador was recently awarded a World Biosphere reserve status, yet it is one of the least botanically known regions in the country, mainly because it is hard to reach. We present here some preliminary results of palm diversity documented during a field trip in June 2009 to the south-west part of the Cordillera Galeras.

Ecuador is famous for many things: the Galapagos, the massive volcano Cotopaxi, the Yasuni National Park, etc. In addition, Ecuador stands out as one of the countries best explored botanically in South America (Schulman et al. 2007). However, a few regions are so remote that they remain hard to access and thus relatively unknown botanically. Such is the case of the Cordillera Galeras (Fig. 1), situated some 130 km south-east from the capital, Quito. The Cordillera is part of the Sumaco Napo-Galeras National Park. This park was classified by the UNESCO in 2000 as a World Biosphere Reserve, becoming the third such reserve in Ecuador after the iconic Galapagos Islands and the Yasuni National Park. The whole Sumaco Napo-Galeras National Park totals about 202,300 hectares with the largest area found around the impressive and largely isolated Sumaco volcano standing at 3900 m

1. View from the Galeras Cordillera. The crown of *Dictyocaryum lamarckianum* is visible.

above sea level (Fig. 2). The Cordillera Galeras is in fact separate and situated about 20 km south of the volcano covering a smaller area of about 11,800 hectares (Fig. 1). The Cordillera emerges abruptly from the lowland Amazonian rain forest to an altitude of 1700 m and represents the first ripple of the Andes, when coming from the Amazon basin. It is part of the smaller, third cordillera of the sub-Andean region, which also includes other mountainous chains such as the Cordillera de Cutucù and Cordillera del Condor further to the south (Neill 1999). Galeras is covered with dense primary premontane tropical rain forest with precipitation around 3000–3500 mm per year and temperatures between 18° and 24°C. The soil of the Cordillera formed from a Cretaceous limestone formation (Neill 1999). Limestone substrates, which are rich in calcite, are known to support a distinct type of flora with



2. Terrain map of the Sumaco Napo-Galeras region showing the Sumaco volcano and the Galeras Cordillera, as well as the route taken to reach the southern part of the mountain range.

numerous endemic species (Neill 1999). The forest is accessible only after one to three days' walking, depending if one wants to reach the north or south sides, respectively.

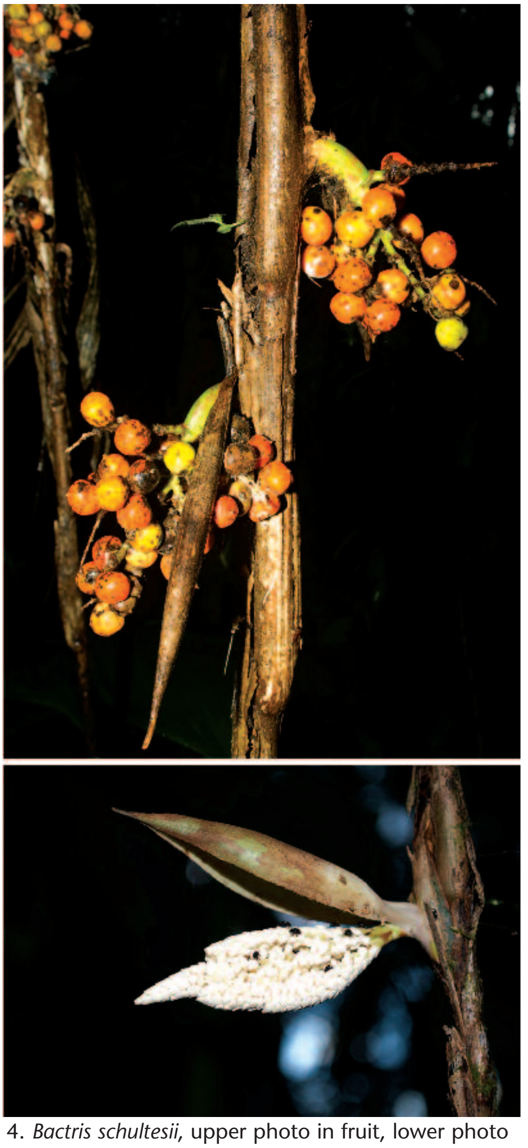
Palm research in Ecuador has been continuing for many years and has led to important publications such as "Manual to the Palms of Ecuador" (Borchsenius et al. 1998) or the online catalogue of herbarium collections from Aarhus (Denmark, AAU), www.palmbase.org. Because palms are rarely collected by the non-specialist, palm collections from the heart of Galeras are scarce. The main goal of this expedition was to document the palm diversity of the south-west part of the Galeras Cordillera. This field trip was funded in part by the International Palm Society.

The expedition departed from the small town of Archidona located near the city of Tena, ca. 5 hours by bus from Quito (Fig. 1). The team consisted of Thomas Couvreur and Marc Jeanson from the New York Botanical Garden, Juan Ernesto Guevara, a research associate at the Universidad Central in Quito, and Nelson

3. The Pusuno river at the base of the Galeras Cordillera, with *Wettinia maynensis* and *Iriartea deltoidea.*

Mamallacta, a local guide and community leader in Archidona and two of his relatives. After a short sleep in Archidona, a taxi dropped us off at the end of the road at around 6 a.m. We then started the long walk towards our final destination, the Pusuno River, which originates in the middle of Cordillera and then flows south along the east flank of Galeras. We expected to arrive there before nightfall of the same day. However, at noon, we were merely one quarter of the way. We were moving very slowly because of extremely muddy paths, heavy backpacks and asphyxiating heat, which took Marc and me by surprise. We thus spent the first night in a temporarily abandoned Quichua Indian house a little less than half way. The occupants of the house had gone to town to vote a few days earlier. After walking all the next day, we again failed to reach the river before dusk. One problem was that the guides had not returned to the Pusuno River for one year, and parts of the trail were untraceable. We walked in circles for a few hours under pounding rain. Just before sunset, we arrived at our second "hut," which was in a state of total decomposition. The rain forest is quick to eat away any trace of human settlements! Luckily, we brought large plastic tarps and were able to make the place very comfortable (at least by jungle standards). In the end, it took us over two days to reach our destination. Our final camp site was situated at about 1000 m above sea level along the beautiful Pusuno River (Fig. 3). In general, the weather was mostly rainy and the nights were pretty cold, but the day temperatures were extremely pleasant, and the relatively high altitude limited mosquitoes to a minimum. For the next three days we collected palms in the region of the Pusuno River.

The forest on the east side of the river was dominated by two lovely medium-sized palm species, *Wettinia maynensis* and *Iriartea deltoidea* (Fig. 3). The number of *Iriartea deltoidea* seedlings covering the forest floor with their simple eophylls was, in some places, impressive. This species is dominant along the Andean foothills from Ecuador to Bolivia below 1200 m, but in Galeras Cordillera it holds the record for stems per hectare. In a one-hectare plot established to evaluate the tree flora on the west side of Galeras, 323 individuals were counted with dbh ≥10 cm, representing 38% of the plot stems (Mogollón & Guevara 2003; Pitman et al. 2002). On the west side of the river, the dominance of these



4. *Bactris schultesii*, upper photo in fruit, lower photo in flower with weevil beetles feeding on the pollen.

palms continued, but we also noted a strong presence of another medium-sized palm, *Socratea exorrhiza*, not encountered, however, on the other side.

In addition, the understory was dominated by *Bactris schultesii* (Fig. 4), and several forms of *Geonoma stricta* and *G. macrostachys*.

A fruiting specimen of *Geonoma hollinensis* (Fig. 5) was also collected, making it just the third collection of this recently described palm (Henderson et al. 2008). This is one of the two *Geonoma* species with three stamens, the other one being *G. triandra* (Henderson et al. 2008).

Geonoma stricta is a common, widespread and very variable species, occurring throughout the Amazon region, with outliers in the Andes and Chocó (Henderson & Martins 2002). Because of its variability, it is better considered a species complex (Henderson 1995) – a widespread species with one or more forms at one locality but with intermediates or slightly different forms at other localities. On the eastern Andean slopes, where there are many isolated mountains and valleys, there are many local forms of *G. stricta*. Three quite different forms were collected during our trip to Galeras which we consider important to describe here briefly. The first form (Fig. 6, top middle) has undivided leaves and short, often recurved and densely flowered inflorescences. In addition, we also collected a specimen very similar to the

5. *Geonoma hollinensis*. Top: whole plant with infructescence; bottom: detail of infructescence.

6. Different forms of *Geonoma stricta* found in the cordillera Galeras region. Top left: *densely flowered thick inflorescence/pinnate leaf* form; Top middle: *densely flowered thin inflorescence/simple bifid leaf* form; top right: *densely flowered thin inflorescence/simple bifid leaf* form, smaller leaf form; bottom left: inflorescence detail of the *sparsely flowered thin inflorescence/pinnate leaf* form; bottom middle: *sparsely flowered thin inflorescence/pinnate leaf* form). Arrows indicate position of inflorescence/infructescence.

above but with considerably smaller leaves and inflorescences (Fig. 6, top right). This latter form was frequent in the understory, more so than the larger version. It could be a smaller version of the first form, or something new. The second form (Fig. 6, top left) is intermediate between the varieties *pycnostachys* and *trailii* (Henderson 1995). It has the non-raised veins of the former and pinnate leaves of the latter. It also has densely flowered, longer, erect inflorescences. Finally, the last form has pinnate leaves with long but sparsely flowered, recurved inflorescences (Fig. 6, bottom).

There was also a more limited presence of two wonderful *Chamaedorea* species, *C. pinnatifrons* and *C. pauciflora* (Fig. 7), as well as several *Oenocarpus bataua* individuals restricted mainly to the banks of the river.

On the fifth day we set out to climb the western flank of the Cordillera. As we climbed steadily upwards, we saw a spectacular emergent palm, *Dictyocaryum lamarckianum*, which gradually replaces the lower elevation *Iriartea deltoidea*. This palm is endemic to the Andes above 1000 m and generally grows on steep slopes (Henderson 1990). Although there were several individuals seen along this crest, it did not form a conspicuous component of the forest canopy, as has been reported from other localities. Indeed, *D. lamarckianum* can

7. Top photos: *Chamaedorea pinnatifrons*. Left: whole infructescence; right detail of infructescence. Bottom photos: *Chamaedorea pauciflora*. Left: whole plant; right detail of infructescence.

become very abundant within a narrow altitudinal range of 1500–1800 m, forming dense patches in the premontane forest canopy of the eastern flanks of Ecuadorian Andes (Borchsenius et al. 1998; Mogollón & Guevara 2003). As we arrived towards the summit, after five hours of steep climbing, the understory of the crest became dominated by *Prestoea* and *Pholidostachys synanthera* (Fig. 8). The yellow-orange light of the late afternoon provided a paradisiacal scene well worth the effort of the climb. *Pholidostachys synanthera* had already been spotted a few times at lower altitudes near the river, but became dominant above about 1300 m. The *Prestoea*, although as abundant as *Pholidostachys*, was never found in flower or fruit. It is hard to know precisely which species this is, but it could be juveniles of *P. acuminata*, a species we had seen at lower altitudes and along the river.

8. Understory forest of the Galeras Cordillera at ca. 1400 m, dominated by *Pholidostachys synanthera* (with wide pinnae) and *Prestoea* sp. (with narrow pinnae).

Table 1. List of species collected in the Galeras Cordillera, Ecuador, with their respective biogeographical element (Montufar & Pintaud 2005) in brackets. An=Andean; WA=Western Amazonian; N=Neotropical; Am=Pan-Amazonian; SA=South American.

Aiphanes ulei (Dammer) Burret [WA]

Bactris schultesii (L.H. Bailey) Glassman [WA]

Chamaedorea pauciflora Mart. [An]

Chamaedorea pinnatifrons (Jacq.) Oerst. [N]

Desmoncus polyacanthos Mart. [Am]

Dictyocaryum lamarckianum (Mart.) H. Wendl. [An]

Geonoma hollinensis A.J. Hend., Borchsenius & Balslev [An]

Geonoma macrostachys Mart. var. *macrostachys* [WA]

Geonoma stricta (Poit.) Kunth complex (three forms) [Am]

Geonoma supracostata Svenning [WA]

Geonoma triglochin Burret [An]

Iriartea deltoidea Ruiz & Pav. [N]

Oenocarpus bataua Mart. [SA]

Pholidostachys synanthera (Mart.) H.E. Moore [SA]

Prestoea acuminata (Willd.) H.E. Moore var. *acuminata* [An]

Prestoea schultzeana (Burret) H.E. Moore [An]

Socratea exorrhiza (Mart.) H. Wendl. [N]

Wettinia maynensis Spruce [An]

The next day it rained continuously, the sort of downpour that does not allow you to do much collecting. Because the rivers had swollen and changed from translucent to light brown (not really a good sign), we filled our water tanks with rainwater, which was pleasantly tasty (a bit like Evian™ water).

On the following day we headed back to Archidona, and this time we did reach the road in one day thanks to lighter backpacks and a cleaned trail. The last bit was the worst part (secondary forests near villages), because the trail was very muddy and quite dirty. The local inhabitants lay logs on the ground to help, but one has to use one's acrobatic skills to get by. The hardest part is to stay focused especially after a 10-hour non-stop hike. One mistake, and you fall flat in the mud, which can be potentially hazardous. Luckily all went well, and we returned safely to Archidona.

For the four days spent at the Pusuno River, we collected a total of 18 species and 12 genera (Table 1). All specimens are deposited at the NY and QCA (Pontificia Universidad Catolica del Ecuador, Quito, Ecuador) herbaria. Following definitions in Montufar and Pintaud (2005) and without having undertaken any detailed ecological studies, we believe the west side of the cordillera has a strong Andean component with 1/3 of species belonging to this biogeographical group (Table 1). This is, of course, not surprising given the cordillera's proximity to the Andes. The rest of the species belong to other groups such as western Amazonian, Neotropical or South American elements (Table 1). Although no new species were collected, we were able to cover only a small area of this mountain range. The east side of the cordillera is a steep slope down to the Amazon plain. This side might be of interest, as well as the lower east side, where lowland Amazonian elements meet montane rain forests. To date, the presence of ca. 60 tree species has been confirmed to occur within the cordillera (Mogollón & Guevara 2003). Moreover two new species of *Brownea* (Fabaceae) and *Guatteria* (Annonaceae) have been discovered in the west side of Galeras from previous collections (B.B. Klitgaard & P. Maas, pers. comm.). In this sense, the potential for finding a new palm species is high, particularly for genera such as *Geonoma*, if more extensive collections are made in this area. Our trip might be viewed as preliminary, and further trips could possibly provide a better overall knowledge of palm diversity in this small but fascinating region of eastern Ecuador.

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LITERATURE CITED

BORCHSENIUS, F., H.B. PEDERSEN and H. BALSLEV. 1998. Manual to the Palms of Ecuador. AAU Reports 37. Aarhus, Denmark.

HENDERSON, A. 1990. Arecaceae Part 1. Introduction and Iriarteinae. Flora Neotropica Monograph 53. New York Botanical Garden, New York.

HENDERSON, A. 1995. Palms of the Amazon. Oxford University Press, New York.

HENDERSON, A., F. BORCHSENIUS and H. BALSLEV. 2008. New species of *Geonoma* (Palmae) from Ecuador. Brittonia 60: 190–201.

HENDERSON, A. and R. MARTINS. 2002. Classification of specimens in the *Geonoma stricta* (Palmae) complex: the problem of leaf size and shape. Brittonia 54: 202–212.

MOGOLLÓN, H. and J.E. GUEVARA. 2003. Caracterización Vegetal de la Bioreserva del Cóndor. Informe Final. Quito: Fundación Numashir para la Conservación de Ecosistemas Amenazados/EcoCiencia.

MONTUFAR, R. and J.-C. PINTAUD. 2005. Variation in species composition, abundance and microhabitat preferences among western Amazonian *terra firme* palm communities. Bot. Jour. Linnean Soc. 151: 127–140.

NEILL, D.A. 1999. Geology, *in* Catalogue of the Vascular Plants of Ecuador, eds. P.M. JORGENSEN, AND S. LEON-YANEZ. Missouri Botanical Garden Press, St. Louis, Missouri.

PITMAN, N.C.A.P., J. TERBORGH, M.R. SILMAN, P. NUÑEZ, D.A. NEILL, C. CERÓN, W. PALACIOS and M. AULESTIA. 2002. Comparison of tree species diversity in two upper Amazonian forests. Ecology 83: 3210–3224.

SCHULMAN, L., T. TOIVONEN and K. RUOKOLAINEN. 2007. Analysing botanical collecting effort in Amazonia and correcting for it in species range estimation. Jour. Biogeography 34: 1388–1399.