THE TROPICAL FLORA REMAINS UNDERCOLLECTED[1]

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Abstract

Recent fieldwork of the Royal Botanic Gardens, Kew, in many parts of the tropics reveals the extent to which they are still undercollected and poorly studied. Recent studies of palms in Madagascar, Cameroon, Lao P.D.R., and Brunei Darussalam have produced many novelties, for example, in Madagascar, 3 new genera and 85 new species. Recent examples from Atlantic coastal Brazil, central Amazonia, and New Guinea are given. Even in apparently well collected areas such as the Ducke Forest Reserve near Manaus, Brazil, and in Brunei where detailed studies of small areas are made, many novelties are found. It is recommended that more such intensive studies of restricted areas are made. The rate of new species that are being described, an average of 2350 over the past nine years, and the rate of additions to *Flora Neotropica* suggest that the total number of angiosperms is currently being underestimated and that there are in fact between 300,000 and 320,000 species. In order to develop conservation and sustainable use of tropical ecosystems, it is essential that we continue to intensify the rate of collection before it is too late.

Key words: Amazonia, biodiversity, Brazil, Brunei Darussalam, Cameroon, conservation, field inventory, Lao P.D.R., Madagascar, New Guinea, palms, tropics.

The purpose of this paper is to show, with examples from a few places, that the tropical flora remains severely undercollected and that many new species of angiosperms continue to be discovered and described every year. The destruction of tropical habitats both in areas of rainforest and in savannas continues at an alarming rate and this before we have completed the inventory of what exists. As a result of the incomplete inventory, we seem to be underestimating the total number of seed plants in the world. We have identified a few areas of the world where further collecting is urgent and destruction of vegetation is continuing at alarming rates from a variety of causes. It is our hope that this will encourage greater efforts in both collection of material and habitat conservation before it is too late. The areas described are places in which the Royal Botanic Gardens, Kew, is involved, and they serve as examples of what is also occurring in many other places and in many different ecosystems, both tropical and temperate.

The Mata Atlantica of Brazil

We commence with this area because its destruction is now so well documented and only about 6% of the Atlantic coastal rainforest of Brazil remains intact. It has been devastated mainly by the establishment of cacao plantations and sugar cane fields as well as by other types of farming. Many studies have shown the high level of endemism in this area. For example, Mori et al. (1981) showed from a sample of 127 trees described in *Flora Neotropica* monographs that 53.5% were endemic to the Mata Atlantica. There is no doubt that some of these locally described species are now extinct. However, recent collecting in the remaining fragments of this ecosystem continues to turn up many new species and also interesting disjunct distributions. Two examples of this are *Brodriguesia santosii* R. S. Cowan and the new genus *Harleyodendron*, with its single species *H. unifoliatum* R. S. Cowan (Cowan, 1979, 1981). An interesting range extension is the recent first collection of *Anthodiscus* (Caryocaraceae) in the Mata Atlantica, a genus that was previously only known from the Guianas, western Amazonia, and the Chocó in Colombia. *Anthodiscus amazonicus* Gleason was found in the forests of Bahia (Prance & Mori, 1980) and added yet another Amazonian disjunct to the many cited by Lima (1953). If the remnants of the Mata Atlantica are yielding so many novelties, what have we lost in the 94% of the region that has been deforested? The conservation of the remnants, now declared a World Heritage site, is vital for the future reconstruction of this habitat.

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Table 1. New species found in the 100 km² Reserva Florestal Adolpho Ducke, Manaus, Brazil in the course of preparing a flora.

Family	No. of species
Lauraceae	11
Sapotaceae	10
Annonaceae	6
Araceae	6
Arecaceae	3
Lecythidaceae	3
Passifloraceae	3
Chrysobalanaceae	2
Rubiaceae	2
Other families	9
Total	55

The Reserva Florestal Adolfo Ducke, Amazonas, Brazil

This 100-km² forest reserve near Manaus in central Amazonia was believed to be one of the best-collected areas in Amazonia. In 1993, we set out to prepare a Flora and a field guide to the reserve and initiated intensive collecting. The preliminary list from the INPA herbarium database contained 825 species (Prance, 1990), and so we assumed we were working with a flora of about 1000 species. Five years later we now have 2175 species to be included in the Flora (M. Hopkins, pers. comm.). This includes over 50 new species (see Table 1). This work shows the value of the intensive study of a small area of tropical forest and the value of florulas. The recently published florula of the forest reserves around Iquitos, Peru, published by the Missouri Botanical Garden, is another good example of a local flora that has helped to improve the stocks of the botanical inventory of an area (Vásquez Martínez, 1997). In order to complete the inventory of the tropics, we need many more of these detailed floristic studies of small areas.

Madagascar

Madagascar is another place that is notable both for its high level of endemism of plants and animals and for the rapid destruction of the natural vegetation. It is also badly undercollected despite the recent efforts of both the Missouri and Kew gardens. The latter has made a recent study of the palms, which serve as an example of what remains to be done and what can be found when specialists concentrate on a particular group of plants.

Like many tropical countries with a half-finished flora, the families that have been treated in such floras are incomplete. The Palmae were written in 1945 for the *Flore de Madagascar et des Comores* by Jumelle and Perrier de la Bâthie, acknowledged experts on palm taxonomy. The volume described and keyed 115 species, but descriptions were often based on scrappy specimens and therefore the keys failed to work for most taxa. Consequently, palm information for Madagascar was confused, and this for a family in which many ethnobotanical uses were recorded: palms are used for food, construction, basketry, medicine, and many other items in Madagascar.

When Uhl and Dransfield (1987) published their monumental *Genera Palmarum*, their main problems with generic delimitation and tribal relationships were in Madagascar. Therefore Dransfield embarked on a series of field trips to the island, but soon started discovering so many new species and additional mysteries that he decided a special Madagascar project was needed. With funding from McDonald's Restaurants (UK) the project was set up, and Henk Beentje started working for it in 1991. He lived in Madagascar for a year and a half, traveling all over the east coast in search of palms.

The results of this fieldwork plus further visits by Dransfield showed how much we did not know: 3 new genera and 85 new species were discovered (Dransfield & Beentje, 1995). These included the world's smallest palm (*Dypsis tenuissima* Beentje, less than a foot high) but also 80-feet-high canopy palms such as *Voanioala*, *Lemurophoenix*, and *Orania ravaka* Beentje, and an amazing aquatic palm. The latter, *Ravenea musicalis* Beentje, has seeds that float on the water. A small bump splits the fleshy fruit wall, and releases the seed, which then sinks. The seed has already developed a half-inch-long hooked seed leaf within the fruit (a strategy analogous to several mangroves), and this hook catches on projections on the streambed, enabling the seedling to start rooting. The worrying thing is that this palm only seems to grow in a single river, in which 450 trees have been counted. Many of the newly discovered palms have very restricted distribution, and coupled to the threats to the vegetation where they occur, this emphasizes two things: the need to conserve, and the need to inventory such dwindling habitats.

Yet another new genus, *Satranala*, was known from a few tens of trees in a single reserve; on a recent trip, Dransfield visited a second newly discovered site, bringing the known numbers to the low hundreds. Why are such palms so rare? In the

case of *Satranala*, there is an intriguing hypothesis. The fruit endocarp is hard and shows strong flanges, unlike any other palm endocarp—apart from a few taxa from New Guinea, distributed by cassowaries. The hypothesis is that *Satranala* was distributed by the giant elephant bird, the roc of the Thousand and One Nights, the *Aepyornis* of science: a bird now extinct, though its subfossil eggs are still found on Madagascar. Therefore, because *Aepyornis* is extinct, long-distance dispersal of *Satranala* does not take place any more, and its area of distribution dwindles.

If the palm project had started 10 years later, several of the new species would not have been discovered, as they would have become extinct in the meantime. With information from projects such as these, focused conservation can take place next to general conservation, and save species. Without the inventory being completed, these rare species will just go extinct.

The Palms of Cameroon, Lao P.D.R., and Brunei Darussalam

Palms are one of the groups of plants that one might expect to be well known and well collected because they are often both large conspicuous plants and almost all are used in some way by local peoples. On the other hand, non-specialist collectors have tended either to avoid collecting palms or to make poor specimens because of the special difficulties of collecting such large-leaved and often spiny plants. A brief summary of three recent field projects involving John Dransfield shows what still remains to be done in the field to get even a basic catalogue of palms.

CAMEROON

With relatively few species (about 20 in all), the continent of Africa has a poor rattan flora when compared with Southeast Asia (Uhl & Dransfield, 1987). The rattans that do occur are certainly conspicuous and are sometimes visible in great thickets along roads in perhumid areas of equatorial Africa. They remain poorly understood, largely because they have rarely been adequately collected. For some time it has been assumed that in the genus *Laccosperma* (ca. 5 species) there was one large-diameter species, *Laccosperma secundiflorum* (P. Beauv.) Kuntze. Beccari had described a second large species, *L. acutiflorum* (Becc.) J. Dransfield (as *Ancistrophyllum acutiflorum* Becc.), based on very poor material. Subsequent workers have been content to include the latter as a synonym with *L. secundiflorum*. During fieldwork in December 1997 near Kribi in Cameroon, Terry Sunderland and John Dransfield found extensive populations along the main road of two clearly distinct, easily separable large-diameter rattans that match the two named taxa. They found it astonishing that two taxa so clearly distinct, could have been confused; no doubt the difficulty of collecting these spiny plants was responsible for their poor representation in herbaria. Terry Sunderland is now conducting a critical survey of all African rattans to put their taxonomy and economic development onto a firm basis.

LAO PEOPLES' DEMOCRATIC REPUBLIC

Lao represents one of the largest gaps in our knowledge of palms. Until two years ago, only three palms were recorded in the literature as occurring in Lao P.D.R. As a result of a preliminary survey of rattans by the Lao Forestry Department, funded by the International Development Research Centre and the International Network for Bamboo and Rattan, we know that there are at least 30 species of rattan in Lao P.D.R., but these have yet to be critically named. In order to provide a firm base for future rattan development in the country, the Lao Forest Department, together with Oxford Forestry Institute and Royal Botanic Gardens, Kew, has started a new critical survey of Lao rattans and ecological work aimed at understanding the demography of Lao rattans. This is funded by the UK Darwin Initiative. One of the first and most surprising results of the survey is that the premier large-diameter cane that is being harvested in huge quantities in Lao, much of it being shipped over the border to Vietnam, appears to be an undescribed taxon.

BRUNEI DARUSSALAM

Until the start in 1988 of Kew's project to prepare a checklist of the plants of Brunei, there were a mere 17 palms recorded for the country. Yet this small nation has one of the highest collecting indices for the whole of the *Flora Malesiana* region—just the sort of statistic that added to the difficulty in justifying further intensive work in the country. However, as in the case of the Reserva Ducke, intensive fieldwork in a relatively well collected area by specialists always yields results. By the end of the project in 1995 the palm list had risen from 17 to 140 different species, showing that almost half the Bornean palm flora occurs within the well protected forests of Brunei. During fieldwork several unusual new taxa were unearthed, including the smallest species of *Livistona*, *L. exigua* J. Dransfield, the handsome *Pinanga yassinii* J. Dransfield,

Table 2. Data from *Index Kewensis* on number of taxa.

Year	Genera		Species		Subspecific taxa subspecies and variety	
	New taxa only	All incl. new combinations & new names	New taxa only	All incl. new combinations & new names	New taxa only	All incl. new combinations & new names
1989			2752			
1990			2653			
1991			2220			
1992			1705			
1993	77	88	2049	3436	508	1663
1994	92	102	2126	3557	517	1398
1995	107	118	2413	4053	487	1400
1996	95	106	2409	4168	467	1493
1997	79	94	2770	4342	543	1586
5-Year total	450	508	11,767	19,556	2522	7540
9-Year total			21,097			

and, among the non-palms, the extraordinary *Orchidantha holttumii* K. Larsen (Lowiaceae).

New Guinea

Of all the places in the tropics, New Guinea probably remains the least known. This is certainly evident from the results of recent fieldwork organized by Kew in Irian Jaya, where a large number of the collections turn out to be new species. In Irian Jaya, collecting density estimates show that less than 25 specimens have been collected per 100 km^2, and there are only slightly under 140,000 collections from a territory with an estimated flora of 25,000 species. The neighboring Papua New Guinea has a collection index of well under 50 specimens per 100 km^2 and is also poorly known. New Guinea offers a particularly large range of habitats because of its rugged topography, where you can go from coastal mangrove to the glacier on Mount Jaya in a distance of only 110 km. The flora varies from tropical rainforest to high alpine. New Guinea is a center of diversity for many important tropical groups such as tree ferns (*Cyathea* and *Dicksonia*), Pandanaceae (a recently collected new species has thick fleshy, fruity smelling bracts that are eaten by bats, which are probably its pollinators), and Myristicaceae (for example, the recently described nutmeg species *Myristica inaequalis* W. J. de Wilde).

Fieldwork in Irian Jaya is also turning up many interesting new records such as the recent collection of *Ternstroemia magnifica* Stapf ex Ridley, which was thought to be distributed from the Malay Peninsula to Sulawesi. However, it has now been shown to occur in Irian Jaya.

The importance of collecting these basic data about the plants of New Guinea has been emphasized by the fact that Robert Johns has been able to prepare maps of proposed conservation areas for both Irian Jaya and Papua New Guinea. These maps are based largely on plant and vegetation data assembled as the result of Johns's collecting activities. This application to systematic data is a vital activity in an area where it is not too late to conserve large tracts of this highly endemic flora, which is now under severe pressure from both mining and timber extraction.

How Many Species to Go?

The most recent estimate of the number of species of angiosperms in the world is 250,000 and was originally based on a calculation by Stebbins (1974) and confirmed or cited by many other authors, including myself (Prance, 1977; Groombridge, 1992). These calculations were based on a family-by-family listing of species and provided a good estimate based on data of the 1970s. However, I am sure that this estimate must now be raised considerably. Data in Table 2 show the descriptive activity of botanists between 1989 and 1997, during which period 21,097 new species were described. Furthermore, the annual rate has not declined over the nine years involved. This is backed up by data from other sources: for example, 29% of the species treated in *Flora Neotropica* monographs are new (Wm. Wayte Thomas, pers. comm.).

These data show two interesting points. Firstly, there is obviously still a lot more collecting to be done, if an average of about 2350 species are being added each year; and secondly, despite the many claims that descriptive taxonomy is on the decline, we are still describing species at the same rate.

The fact that we have added 21,097 species over nine years, and also the comparison between 1970 and 1997 data for a few selected plant families, leads us to conclude that there are actually between 300,000 and 320,000 species of angiosperms.

Conclusion

Data from both the undercollected areas described here and the study of the rate of description of new taxa clearly demonstrate that the field inventory of the angiosperms is far from complete. It is necessary to continue to invest considerable resources into fieldwork and descriptive taxonomy and not be tempted to divert them all to the equally important and exciting new techniques of molecular systematics. More detailed studies of selected small areas in the tropics are likely to yield many more new species as well as most useful demographic data about those that are already described. The more complete the inventory is the better the data we will have to provide the rationale for conservation and for the sustainable use of ecosystems.

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