

Kew Scientist

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NEWS FROM THE LIVING COLLECTIONS, THE HERBARIUM AND THE LABORATORIES AT KEW & WAKEHURST PLACE

VEGETATION MAPPING

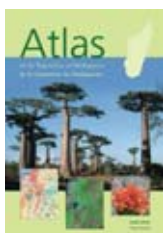
On 11 October 2007, an 'Atlas of the Vegetation of Madagascar' was launched in Antananarivo, Madagascar, in a ceremony attended by Tovondriaka Rakotobe (Secrétaire Général; Ministère de l'Environnement, des Eaux et Forêts, Madagascar) and Prof. Stephen Hopper (Director, RBG Kew). The Atlas, in both French and English, provides the most up to date and highest quality vegetation mapping available for Madagascar and represents a conservation tool that will help Madagascar's government and people plan a more sustainable future.

Madagascar is one of the world's most important biodiversity hotspots. About 90% of its 10,000 plant species are endemic, and natural vegetation ranges from rainforest to unique spiny forest. In common with many other tropical countries, the flora is extremely threatened not only by habitat destruction but also, for some species, by over-collection for the horticultural trade.

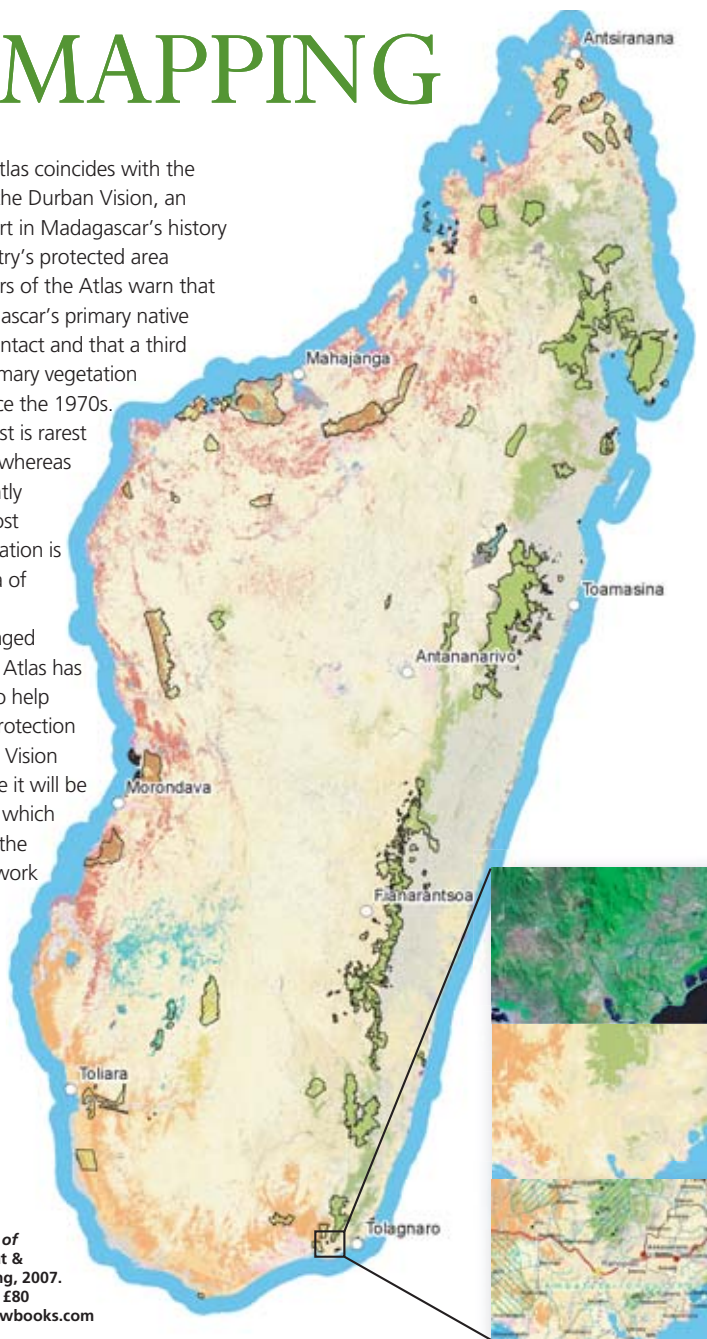
The Atlas is a product of a three-year Madagascar Vegetation Mapping project (www.vegmad.org), funded by the Critical Ecosystem Partnership Fund and managed by Kew, Missouri Botanical Garden and Conservation International's Centre for Applied Biodiversity Science. The project used remote-sensing technology together with data provided by specialists from a wide range of collaborating botanical and conservation institutions to produce the most thoroughly ground-truthed vegetation map ever compiled for Madagascar. Through a series of workshops with the conservation community, the project also ensured that the Atlas was of maximum relevance and utility to conservation planners and managers.

Publication of the Atlas coincides with the implementation of the Durban Vision, an unprecedented effort in Madagascar's history to expand the country's protected area network. The authors of the Atlas warn that only 18% of Madagascar's primary native vegetation remains intact and that a third of Madagascar's primary vegetation has disappeared since the 1970s. Western humid forest is rarest and least protected whereas tapia forest is currently disappearing the most rapidly. Such information is necessary if the flora of Madagascar is to be protected and managed sustainably, and the Atlas has already been used to help prioritise areas for protection through the Durban Vision Process. In the future it will be the baseline against which the effectiveness of the protected areas network will be measured.

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Atlas of the Vegetation of Madagascar (Eds J. Moat & P. Smith); Kew Publishing, 2007. ISBN 978 1 84246 198 3; £80 available from www.kewbooks.com



Montserrat Vegetation Map

The Caribbean island of Montserrat was devastated by a huge volcanic eruption in 1997. A new vegetation map has been completed as part of the Darwin Initiative project 'Enabling the People of Montserrat to Conserve the Centre Hills'. As a result of extensive fieldwork undertaken during this project, planners and conservationists now have an accurate vegetation map and tool to help guide the island's recovery. Species and habitat monitoring continues to identify the most important areas for plant diversity.

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Finalised vegetation map of Madagascar. Enlarged sections show the detail and progress of the map from satellite images (top) to classified image (centre) to final map (bottom).

Kew

PLANTS PEOPLE
POSSIBILITIES

DIRECTOR'S MESSAGE

Kew and Restoration Ecology



Plant-based solutions to mitigate the impact of climate change hold considerable promise and need urgent attention. They go well beyond the present focus on the use of biofuels

and plantation forestry. Caring for remaining wild vegetation is arguably critical in this context. Fully a fifth of present carbon emissions are due to ongoing deforestation and altered land use. Consequently, an improved understanding of remaining wild vegetation to enhance its conservation is the first aim of a new global plant conservation partnerships programme upon which the Royal Botanic Gardens, Kew, has embarked.

Recognising the importance of wild plant diversity and setting aside protected areas are two of the first steps possible from outputs of the plant-science powerhouse that Kew provides. The organisation recognises that it must get much better at repairing and restoring wild vegetation if persistence through climate change is to happen and biodiversity is to be conserved.

All wild vegetation faces the prospect of continuing decline due to human pressures on the landscape, directly or through climate change. It has become clear that we need a much-improved understanding of how plant communities may be repaired and restored when damaged if they are to remain the fundamentally important carbon sinks that help to moderate the worst aspects of climate change. This is a major new focus for RBG Kew, pushing its scientific direction into urgently needed but relatively uncharted research waters.

Successful repair and restoration relies fundamentally on a scientific understanding of the environments and requirements for plants to complete their life cycles in complex communities, from seed through seedling to adult plant and senescence. Botanic gardens are places already established with staff that have many of the requisite skills in hand.

If a world-class research programme of this kind is not pursued, ongoing attrition of wild vegetation will occur, even where it has been set aside in protected areas. The loss of the world's largest and most economical carbon sinks through this process will exacerbate the worst effects of climate change. We cannot afford to let this happen.

Prof. Stephen D. Hopper FLS, Director

SCIENCE-BASED CONSERVATION

Barcoding of Plants

The use of a standardised, short region of DNA (a DNA barcode) to identify unknown samples of animals, plants and fungi has received a great deal of attention in the past few years, and generated extensive controversy. In the last two years most of the controversies have been addressed, and several barcoding projects are now well-advanced and producing exciting results (e.g. in Canada; www.bolnet.ca).

Most of the activity has focused on animals; plant barcoding has lagged behind because the standard marker used in animals shows insufficient variation in plants and there has been a lack of clear vision about which alternative is best. Several projects have focused on this topic, including one led by RBG Kew involving 11 institutes. This group proposes the use of three regions of plastid DNA in land plants because no single region is variable enough to be successful across all taxa. *Taxon* 56, 295 (2007).

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Molecular Markers

Developing molecular markers for conservation genetic studies of threatened species is costly and time-consuming. Therefore conservation geneticists often attempt to use markers already available for related, better studied taxa. Three PhD students working at Kew have found that cross-species transferability of highly variable 'microsatellite' DNA markers is clearly greater in animals than in flowering plants and transfer success was greater in eudicots than monocots. Cross-species transferability appeared highest in species with long generation times and mixed or outcrossing breeding systems; success was also higher if genome size in the target species was small compared to the source. The results provide conservation geneticists with clues about whether cross-species transfer of genetic markers should be attempted for new species under study or whether novel markers will need to be developed. *Molecular Ecology* 16, 3759 (2007).

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Taxonomic Exaggeration and Orchid Conservation

Orchids are a key group in efforts to establish reserves in which many other species of less charismatic plants and animals are also protected. However, orchid conservation is beset by taxonomic problems, particularly in



Dactylorhiza lapponica, the subject of a UK government action plan until it was found to be indistinguishable from the more widespread *D. traunsteineri*.

Europe, where new species are still being described every year and taxonomic treatments vary drastically. By comparing a checklist of orchids from Europe and other areas and searching for geographical patterns, it was found that numbers of invalid, infraspecific and hybrid names are much higher in Europe. Recognition of numerous and poorly circumscribed orchid taxa is a serious obstacle to their conservation because rare, poorly defined species may be prioritized for conservation over taxonomically 'good' species. More taxonomic effort should be made in other areas of the world (e.g. the tropics), and European botanists should hesitate to describe new orchid taxa without conducting more thorough genetic investigations. *Conservation Biology* 21, 263 (2007).

Contact: Prof. Mark Chase (m.chase@kew.org)

Kew's new mission statement, 'to inspire and deliver science-based conservation worldwide, enhancing the quality of life,' emphasises the role that Kew's scientific research has to play in supporting conservation efforts.



Restoration Ecology

Southdown sheep grazing outside the Welcome Trust Millennium Building.

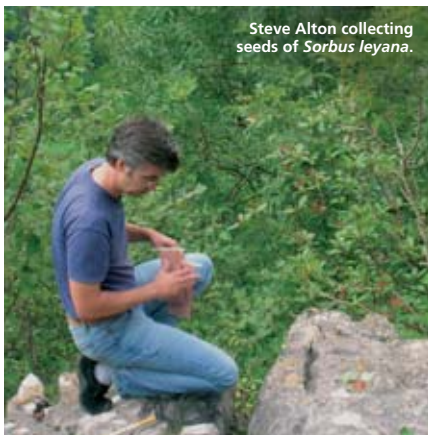
GSPC Under Review

The twelfth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the Convention on Biological Diversity (CBD) was held in Paris in July. During the meeting, members of Kew staff made presentations at a training day on the CBD. The meeting adopted eight recommendations covering a wide range of issues, including an in-depth review of the Global Strategy for Plant Conservation (GSPC). This review should consider the development of the GSPC beyond 2010, including the integration of targets relating to climate change and nutrient loading.

Plant Diversity Challenge: 3 Years – 16 Targets – 1 Challenge, an update on the UK response to the GSPC (co-produced by Plantlife International, the Joint Nature Conservation Committee and Kew), was launched at the SBSTTA meeting. For the first time it builds consideration of climate change into the UK response to the GSPC. The document makes ten recommendations, including focusing research on improving understanding of the importance of UK plants and fungi in a European context and supporting landscape-scale conservation initiatives that allow for the conservation of plants, fungi and their habitats in the face of climate change.

GSPC issues were also a focus of several papers presented by Kew scientists at the 3rd Global Botanic Gardens Congress (16-20 April 2007, Wuhan, China). Paul Smith moderated a session on Seed Science for Conservation, covering Target 8 issues, Alan Paton considered progress towards Target 1 and Colin Clubbe moderated a session on conservation training (Targets 15 and 16).

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Steve Alton collecting seeds of *Sorbus leyana*.

Conservation Grazing

After only two years of grazing the meadows at Wakehurst Place, the flock of Southdown sheep managed by Iain Parkinson are already having a positive effect on biodiversity. The floral richness of grassland at Wakehurst Place had been reduced by employing heavy mowing machinery, which removed shed seed and often could not be used at the best time of year. Continuous monitoring of Hanging Meadow in the Loder Valley Nature Reserve for almost 30 years shows a decline in species since the introduction of this equipment. The grassland is now cut by pedestrian machinery and the hay is left for several days before removal. The sheep then complete aftermath grazing, opening up bare areas of soil where wildflower seeds germinate in late autumn. Chris Clennett has been encouraged by the initial results, with the return of *Vicia tetrasperma* (smooth tare) and *Ophioglossum vulgatum* (adder's tongue) for the first time since 2000. This bodes well for the establishment of species rich grassland around the Welcome Trust Millennium Building, which is now under the same regime as Hanging Meadow.

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Seed Size Matters

Seed mass affects the production of soil seed-banks, germination and seedling survival. Consequently, seed mass differences may contribute to species coexistence, with large-seeded species exhibiting higher seedling survival but fewer seeds than small-seeded species. Recent publications have examined two aspects of seed mass variation that affect regeneration and use of seeds in restoration: why are seedlings from small seeds more likely to die, and how does seed size affect the suitability of micro-sites for germination and establishment? Across 19 tropical tree species, radicle growth of newly germinated seeds, and hence access to soil water in dry spells, was allometrically related to seed mass. As a result seedlings from large seeds establish better in dry environments (*Oecologia* doi: 10.1007/s00442-007-0848-2). For temperate forest herbs, seed mass has an impact on micro-site suitability for seedling establishment, which is also reflected in the threshold light quality (red:far red light ratio), and hence forest 'gap' size required for germination (*Functional Ecology* doi: 10.1111/j.1365-2435.2007.01328.x).

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Restoration Symposium

In April 2007, Tiziana Ulian and Hugh Pritchard gave invited presentations on seed conservation and ecology at the 2nd International Symposium on Ecological Restoration held in Santa Clara, Cuba. The symposium was organised by the National Organisation for the Protection of Flora and Fauna and was presided over by its director Comandante Guillermo Garcia Frias.

Contact: Prof. Hugh Pritchard (h.pritchard@kew.org)



Hugh Pritchard (left) meeting Guillermo Garcia Frias (right).

Sorbus Research

The parentage of polyploid *Sorbus* species in Britain and Ireland has been investigated using length-variable regions of plastid DNA. In research supported by the Thriplow Charitable Trust, more than 450 samples from 30 taxa were screened, and 28 haplotypes were identified. Hybridization events leading to formation of polyploids appear to be more or less unidirectional, with all samples of the *S. anglica* group (derived from *S. aria s.l.* and *S. aucuparia*) and the *S. latifolia* group (derived

from *S. aria s.l.* and *S. torminalis*) having *S. aria s.l.* as the pollen (paternal) parent. Multiple maternal lineages were identified for the polyploids *S. eminens*, *S. porrigentiformis* and *S. latifolia* and the primary diploid hybrids *S. x thuringiaca* and *S. x latifolia*. For each of the other polyploids screened, only one haplotype was recovered, indicating that each of these may be derived from a single maternal lineage. *Bot. J. Linn. Soc.* 154, 291 (2007).

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AFRICAN WORKSHOPS



R. Oubida

Difficult Seeds

Funded by DEFRA, a joint Kew-FAO initiative is underway to disseminate improved seed handling and storage technologies to gene banks in Africa. Focusing on species identified as 'difficult' (due to seed-storage behaviour, fruit or seed structure, seed-dormancy and/or inappropriate seed handling) the project has recently held training workshops in Kenya and Burkina Faso. The project is also facilitating gene banks to engage with farmers, community seed banks and small scale seed producers, with the aim of improving seed storage and seed security. A key feature of each training workshop was a 'workshop within a workshop' for farmers. Language was no barrier as gene bank staff and farmers shared experiences and answered each other's queries. Further workshops are planned in Botswana and Morocco.

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O. Grace

PROTA Workshops

PROTA (Plant Resources of Tropical Africa; www.prota.org) aims to ensure that botanical information is accessible in tropical Africa, and so encourage the sustainable use of plants for livelihoods in the region. At the second International Workshop for PROTA (24-26 September, Nairobi) representatives of stakeholders and project partners, including Kew, assessed achievements during the first project phase and planned future activities. Olwen Grace presented progress on collating the wealth of relevant information available at Kew. Over two thousand references about the uses and valuable properties of plants in Africa have been collected at Kew and other UK institutions since PROTA's inception in 2000.

Pesticidal Plants

Partners from the EU-SADC funded SAPP project (Southern African Pesticidal Plants) met in Lilongwe, Malawi, from 9-12 July 2007 to discuss progress and plan fieldwork. The collaboration, between the Universities of Greenwich, Zimbabwe and Mzuzu, the Malawi Department of Agriculture, the World Agroforestry Centre, the Southern Alliance for Indigenous Resources (Zimbabwe) and Kew, aims to increase the wealth of small-scale farmers in the region through sustainable pesticidal-plant use. This will be achieved by enhancing knowledge about distribution and habitats of the plants and optimising application techniques, harvesting, cultivation and health and safety. The meeting was followed by field trips to conduct farmer surveys and collect plant samples for analysis and biological activity testing in the UK.

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P. Stevenson

Madagascar has been a research focus at Kew since 1986, initially working on key families but more recently concentrating on conservation and sustainable utilisation of Madagascar's diversity. A new Accord de Siège with the Government of Madagascar, which continues Kew's status as a conservation NGO, was signed in January 2007.

Threatened Plants Appeal: Palm Update

There seems no end to the diversity of palms in Madagascar. Since the publication of *Palms of Madagascar* in 1995, six new species have been formally described. However, during fieldwork for his PhD, Kew student Mijoro (Joro) Rakotoarinivo, funded by the Kew's Friends and Foundation Threatened Plants Appeal project, has collected material representing at least 20 more undescribed taxa. These are currently being prepared for publication.

One of the palms included in the Threatened Plants Appeal, *Beccariophoenix madagascariensis*, has been the subject of a conservation genetics study, led by Alison Shapcott (University of the Sunshine Coast, Australia). This found that within the known, critically small populations there was considerable genetic variability and populations were genetically distinct, although gene flow was identified between populations within 3 km of each other. The study also confirmed the distinctness of the recently described *B. alfredii*. *Botanical Journal of the Linnean Society* 154, 589 (2007).

The level of variability found in *B. madagascariensis* gives hope that this species may have the potential for recovery. Recently, hopes were further boosted when Mijoro discovered a new population in the eastern rain forests. He visited the site in September 2007 with John Dransfield and they estimated the population to be over 1,000 individuals, making this the most significant population of the palm.

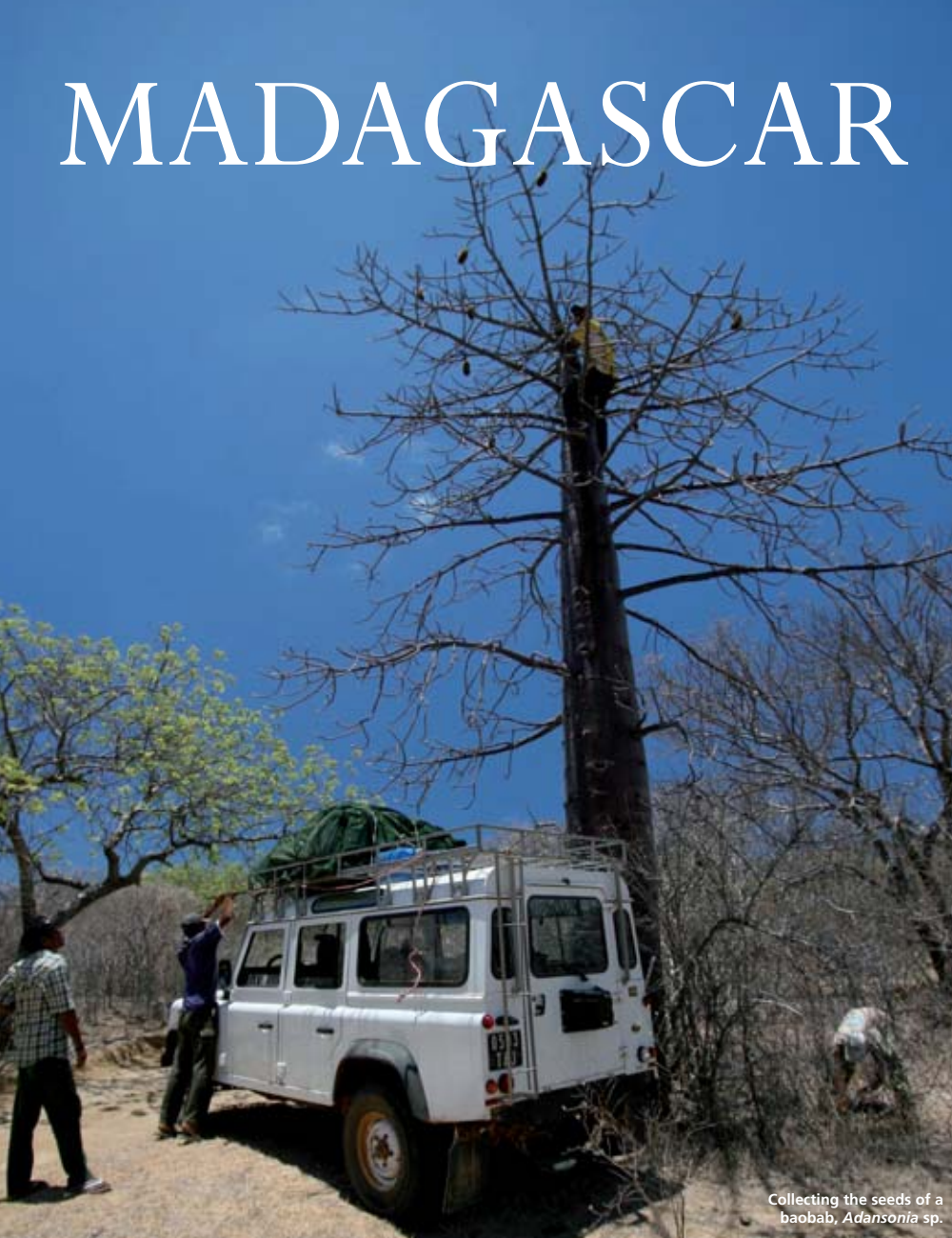
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Dr Mike Fay (m.fay@kew.org)



M. Rakotoarinivo

S. Cable

MADAGASCAR



Collecting the seeds of a baobab, *Adansonia* sp.

Madagascar Students Gain PhDs

The first two PhDs in plant systematics at the University of Antananarivo, Madagascar, both co-supervised by Kew staff, were awarded the highest distinction this summer. Hélène Ralimanana from the Kew office in Madagascar defended her thesis 'Systématique et Biogéographie du genre *Phyllanthus* L (Phyllanthaceae) de Madagascar' in which 55 species and five new subgenera of this giant genus are described. Franck Rakotonasolo of the Parc Botanique et Zoologique de Tsimbazaza defended his thesis entitled 'Revision taxonomique des espèces Malgaches de *Hyperacanthus* E.Mey. ex Bridson (Gardenieae-Rubiaceae).' This is a revision of 50 species of which 40 are new to science.

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Hélène Ralimanana (left) at her PhD viva.

S. Cable

More PhDs

Other research students, co-supervised by Kew staff, who have successfully defended their PhD theses recently include:

Desterio Nyamongo, 'Seed development and germination of *Vernonia galamensis* (Asteraceae): a potential oil crop' (January 2007).

Laura Butler, 'Seed development, rehydration, and variation in seed survival' (April 2007).

Kim Hamilton, 'Ex situ conservation of Australian *Citrus* species: investigations on seed biology, cryopreservation and in vitro culture' (April 2007).

Gunter Fischer, 'Evolution of the orchid genus *Bulbophyllum* in Madagascar' (June 2007).

Sutee Duangjai, 'Molecular Phylogenetics of Ebenaceae' (August 2007).

Yanis Bouchenak-Khelladi, 'Grass evolution and diversification: a phylogenetic approach' (August 2007).

Eve Lucas, 'Systematic studies in Neotropical Myrtaceae with an emphasis on *Myrcia* s.l. The evolution and biogeography of a large South American clade' (August 2007).

RBG Kew has become an Affiliated Research Centre (ARC) of the Open University (UK). This status has been granted to Kew as a result of an accreditation visit and enables Kew to continue offering a research degree programme validated by the Open University.

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New Genus

A distinctive new genus of Euphorbiaceae has been discovered in the remote western limestone karsts (tsingy) of Madagascar. It was first collected in 1992 and has been re-found twice since. The plant has large heart-shaped leaves and much-branched inflorescences of pink flowers. Molecular phylogenetic and pollen morphological studies showed that it belongs to subfamily Crotonoideae but has no close relatives within this group. The plant was described in a

collaboration between Kew and the Smithsonian Institution and published in *Kew Bulletin*. It is named *Radcliffea smithii* in honour of Alan Radcliffe-Smith (the former Head of Kew's Euphorbiaceae section and world expert on the family, especially in Africa), who died on 8 August 2007. *Kew Bull.* 61, 193 (2006).

Contact: Dr Petra Hoffmann (p.hoffmann@kew.org)

Seed Banking

The Millennium Seed Bank Project (MSBP) is working with Silo National des Graines Forestières (SNGF) to bank the seeds of 1,000 species over the 10 years of the project, which ends in 2009. This target represents 8-10% of the total flora of Madagascar and around 20% of the bankable dryland flora. The focus is on endemic, endangered and economic species. So far the project has collected over 5 million seeds representing around 850 species, including several that are new to science.

The MSBP is also enabling SNGF to improve their seed banking facilities with the establishment of a national seed collection that will include the full range of bankable species. This capacity building has included technical training, academic studies (support for two Masters degrees and two PhDs) and the provision of seed processing equipment and a Landrover. In 2004, Guy Rakotondranony, Director of SNGF, gained a PhD on the endemic palm *Ravenea rivularis*, before being promoted to Director General of the Direction Eau et Forêt.

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Radcliffea smithii, drawn by Lucy Smith



NEW BOOKS

The Genus Roscoea (J. Cowley; Kew Publishing; 2007) describes all 20 species of these striking orchid-like members of the ginger family.

Species of *Roscoea* are native to the Himalayas, Burma and China, and are of high horticultural merit. The book covers their structure, nomenclature, history,

synonyms, colour forms and cultivation, and is illustrated by 20 full-page paintings and 94 colour photographs. ISBN 9781842461341. £33.00 from www.kewbooks.com

The Genus Psychotria (Rubiaceae) in the Philippine Archipelago (S.H. Sohmer & A.P. Davis; Botanical Research Institute of Texas; 2007) recognises 112 species of *Psychotria* in the Philippines (29 new to science). *Psychotria* (Rubiaceae) is probably the world's largest predominately woody genus, with perhaps around 2,000

species, and is often an obvious component of humid tropical forests. This book presents a classical taxonomic revision with identification keys. ISBN 9781889878157; £34.50

Preliminary List of the Cyperaceae in Northeastern Brazil (A.C. Araujo, E. A. Cesar & D. Simpson; Kew Publishing; 2007) includes data from 1,392 Cyperaceae specimens and 191 species in 24 genera. £25 from www.kewbooks.com

A Checklist and Synopsis of American Species of Acacia (Leguminosae: Mimosoideae) (M. Rico-Arce; CONABIO; 2007) treats the 159 species of *Acacia* found in the Americas, plus 29 introduced taxa. Each species is described with notes on taxonomic relationships, geographical distribution, current conservation status, and complete synonymy. The introduction serves as a basic reference for anybody interested in the genus.



Kew Bulletin

Springer Verlag will be a publishing partner for *Kew Bulletin* from January 2008 for a five-year term. This will ensure state of the art publication online and in print within a portfolio of quality plant science publications, improve the visibility of the journal (particularly in the digital media) and provide a basis for future editorial development.

www.kew.org/publications/kewbulletin.html

Angiosperm Origins

Michael Frohlich (Natural History Museum London) and Mark Chase (Kew) have reviewed current knowledge on the phylogenetic relationships within the angiosperms and the evolution of flowers. These distinct topics are related, and an improved understanding of one provides insights into the other. Seed plant phylogenetics has allowed a better understanding of angiosperm character evolution and provides an increasingly detailed picture of early angiosperm diversity when coupled with discoveries of fossil flowers. The dominant concept of the 1980s and 90s, postulating Gnetales as the closest living relatives of the angiosperms, has been overturned; Gnetales have been demonstrated to be more closely related to conifers. Furthermore, monophyly of extant gymnosperms has been demonstrated, and this too challenges long-held ideas about their evolution. Finally, new theories of flower origins have been proposed based on gene function, duplication and loss, as well as on morphology. In spite of this progress, a great deal is still unclear, and identifying fossils with morphologies that convincingly place them close to angiosperms could revolutionize both the understanding of angiosperm origins and the evolution of flowers. *Nature* (in press).

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Pollen Clues

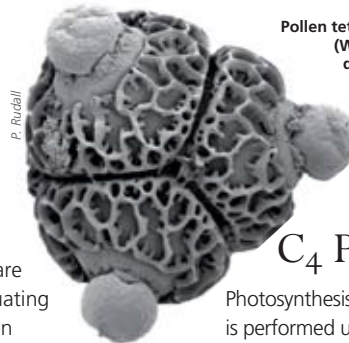
Rare examples of profound morphological transitions in the fossil record that can be linked convincingly to underlying developmental processes are especially valuable in evaluating seed-plant evolution. Pollen grains of angiosperms and derived gymnosperms differ from spores and pre-pollen of more primitive seed plants in that the apertures are located distally relative to the contact faces of the tetrad. In contrast, proximal apertures characterise extinct early-divergent gymnosperms and most pteridophytes. Paula Rudall and Richard Bateman have explored whether this and other deep transitions associated with the microgametophyte are developmentally related, including co-option of the pollen tube to a role in siphonogamy. They conclude that the proximal-to-distal transition in microspore polarity represents a 'fossil fingerprint' for an underlying series of radical developmental shifts involving microtubule organisation at meiosis and an asymmetric first mitotic division. This transition had important downstream effects, not only on aperture location and site of germination, but also on microgametophyte polarity and perhaps indirectly on sperm motility. *Trends in Plant Science* 12, 317 (2007).

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Hydatellaceae

The recent dramatic transfer of Hydatellaceae from the highly-derived monocot order Poales to one of the most ancient extant angiosperm lineages, the waterlily clade Nymphaeales, has prompted Paula Rudall (Kew) and a worldwide team of researchers from Australia, Canada, India, Russia, UK and USA to re-examine the morphology and taxonomy of this inconspicuous aquatic family. Comparison of Hydatellaceae with other early-divergent angiosperms and other seed plants has added new impetus to long-running debates on the evolutionary origin of angiosperms. As newly circumscribed (*Taxon*, in press), Hydatellaceae consist of a single genus, *Trithuria*, containing 12 species of minute ephemeral herbs, mostly confined to Australia. Reproductive units of Hydatellaceae, normally interpreted as inflorescences, share some developmental features in common with flowers of some of their closest extant relatives, Cabombaceae, but are much smaller and lack a showy perianth. Species of *Trithuria* with bisexual reproductive units show unusual organ arrangement; a single unit resembles an 'inside-out' flower, in which central early-formed stamens are surrounded by later-developing carpels. *American Journal of Botany* 94, 1073 (2007).

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Pollen tetrad of *Drimys winteri* (Winteraceae), an early-divergent angiosperm.

C₄ Plants

Photosynthesis in the vast majority of land plants is performed using the C₃ pathway, in which the enzyme RuBisCO fixes atmospheric carbon dioxide into a 3-carbon molecule. However, some flowering plants can use an alternative physiological pathway, C₄ photosynthesis, which outperforms C₃ photosynthesis in warm and dry environments. Many C₄ species are found in the grass family, but the genetic basis for the repeated evolution of this pathway has remained speculative. Researchers at the University of Lausanne, the Northern Illinois University and Kew have now reconstructed the evolutionary history of genes encoding phosphoenolpyruvate carboxylase (PEPC), a key enzyme of the C₄ pathway. A phylogenetic tree of these genes showed that one isomorph of PEPC evolved at least eight times independently from the same non-C₄ PEPC gene. The team also showed that many of the amino acids in the C₄ isomorph evolved under positive selection and converged on the same set of amino acids in most of the C₄ lineages. These results open new avenues for the engineering of the C₄ pathway in crops. *Current Biology* 17, 1241 (2007).

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Trithuria australis
(Hydatellaceae), longitudinal section
of female reproductive unit (x50).

Elemental Composition

Species-level variation in leaf nitrogen and phosphorus accumulation by living plants helps to drive the functioning of terrestrial ecosystems. In contrast, ancient evolutionary processes can influence the present-day composition of other elements in leaves. A collaboration between researchers from Japan and the UK has produced a comparative dataset of 42 elements from over 2,000 leaf samples, representing 670 species and 138 plant families. Analyses reveal that for 21 elements that are associated with structural (cell-wall) or osmotic (vacuolar) fractions of leaf tissues, over 25% of the total variation in leaf element concentration, including variation between sites, is at the family level and above. Knowledge of such phylogenetic variation of leaf elemental composition increases our understanding of terrestrial nutrient cycles and the transfer of toxic elements from soils to living organisms. Elucidating the mechanisms by which species of different plant families control their leaf elemental concentration remains the challenge ahead. *New Phytologist* 174, 516 (2007).

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Ant Dispersal

Félix Forest (newly appointed Head of Molecular Systematics at Kew) and colleagues from Kew, Reading University and Göteborg University have studied the evolution of elaiosomes (seed structures involved in dispersal by ants) in Polygalaceae and the biotic and abiotic factors that might be associated with their emergence. They showed that the appearance of these structures was broadly concomitant with global temperature increases in the early Tertiary (Paleocene-Eocene Thermal Maximum) rather than ant evolution. Although ants appeared long before Polygalaceae in the fossil record, their abundance in amber deposits increased drastically only in the mid-Eocene, long after the appearance of elaiosomes in Polygalaceae. These results suggest that the environmental advantages conferred by elaiosomes may have been an important innovation in elaiosome-bearing clades. *Evolution* 61, 1675 (2007).

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EVOLUTION

Genome Evolution

The genus *Nicotiana* includes approximately 40% of allopolyploids, and in a new study these allopolyploids were used to characterise the nature of sequence turnover across the whole genome in allopolyploids of different ages. Using molecular-clock analyses, the likely age of *Nicotiana* allopolyploids was estimated, and genomic in situ hybridization (GISH) and tandem repeat characterisation were used to determine how the parental genomic compartments have diverged over time. Within 1 million years of allopolyploid divergence there is considerable exchange of repeats between parental chromosome sets. After c. 5 million years of divergence GISH fails, possibly representing near-complete genome turnover, involving the replacement of nongenic sequences with new, or previously rare sequence types, all occurring within a conserved karyotype structure. This mode of evolution may influence or be influenced by long-term diploidization processes that characterise angiosperm polyploidy-diploid evolutionary cycles. *New Phytologist* 175, 756 (2007).

Contact: Prof. Mark Chase (m.chase@kew.org)

Most angiosperms possess small genomes, and those with enormous genomes (with 1C >35 pg) are phylogenetically restricted, occurring in a few families (mostly monocots), including Liliaceae. This family exhibits a wide range in genome size, with species possessing some of the largest genomes so far reported for any angiosperm and others possessing much smaller genomes. To gain insights into when and where genome size change/expansion took place during the evolution of Liliaceae and the mode and tempo of this change, data for 78 species were superimposed onto a phylogenetic tree and analysed. Results suggest genome size in Liliaceae followed a punctuated rather than gradual mode of evolution and that most of the diversification evolved recently rather than early in the evolution of the family. *Journal of Evolutionary Biology* 20, 2296 (2007).

Contact: Dr Ilija Leitch (i.leitch@kew.org)

These and other genome evolution studies were presented at Plant Genome Horizons: Vistas and Visions, a conference held at Kew in April 2007 to mark the retirement of Prof. Mike Bennett as Keeper of the Jodrell Laboratory. Papers from the conference will form a special issue of *Annals of Botany* in early 2008.

P. Ruedell

F. Forest



Polygala myrtifolia, a species
with ant-dispersed seeds.

Dormancy Release

Physiologically dormant seeds require exposure to dormancy releasing factors before germination can be completed. In imbibed seeds, exposure to environmental factors such as nitrate, low temperature and light can contribute to dormancy release. Imbibed dormant seeds require two of these factors, one of which needs to be light. Seeds exposed to only one factor remain at an intermediate level of dormancy without completing germination. A recent study investigated the expression patterns of two sets of genes associated with either germination or dormancy during dormancy release. Transcription of these gene sets responded in a quantitative way to these dormancy-releasing environmental signals, and resulted in intermediate gene-expression patterns. Nitrate, chilling and light treatments had a comparable quantitative effect. This study reveals how totally different environmental factors regulate the transcriptome in a similar way and initiate molecular changes that lead to seed dormancy release. *The Plant Journal* 51, 60 (2007).

Contact: Dr Peter Toorop (p.toorop@kew.org)

Gordon Brown Receives One Billionth Seed

On 26 April 2007, the Prime Minister Gordon Brown (then Chancellor) was presented with the billionth seed collected by the Millennium Seed Bank Project (MSBP). The seed was from an African bamboo, *Oxytenanthera abyssinica*, and was collected in Mali by the Institut d'Economie Rurale, an MSBP partner institution. This bamboo is valuable to local people but over-harvesting has led to the species becoming endangered in Mali. The seed was later banked on 22 May during a ceremony at the MSBP seed bank at Wakehurst Place.

AWARDS

At the Linnean Society of London Anniversary Meeting on 24 May 2007, Dr Phillip Cribb was awarded the Linnean Medal for Botany for 'his outstanding contribution to botany, in particular for his research and publications on orchids.'

Prof. Stephen Hopper and Dr Paula Rudall have been made Corresponding Members of the Botanical Society of America. Bernard Verdcourt has been made a Corresponding Member of the American Society of Plant Taxonomists.

The books *Seeds* (by Rob Kessler and Wolfgang Stuppy) and *Pollen* (by Rob Kessler and Madeline Harley) jointly won a gold medal at the 2007 Independent Publisher Book Awards in June.



NEW GRANTS

Botanical Healthcare

Kew scientists have been awarded a three-year grant of nearly £1 million from the Engineering and Physical Sciences Research Council to conduct research on the use of plant-derived extracts in the development of new skin and health-care products in collaboration with Proctor & Gamble. The study aims to characterise the mode-of-action of plant-derived compounds that can be obtained from sustainable sources. Kew is already investigating the quality of plant extracts entering the trade and a recent paper highlighted challenges in the analysis of saponins. *Journal of Chromatography A* 1148, 177 (2007).

Contact: Prof. Monique Simmonds (m.simmonds@kew.org)

Populus Evolutionary Genomics

A NERC standard grant has been awarded to Christian Lexer to investigate within-species variation for genomic isolation and transcriptome differentiation between two ecologically divergent hybridising European forest trees, *Populus alba* and *P. tremula*. The award is for £332K, approximately £280K of which go to Kew. The three-year grant includes funding for a postdoctoral researcher at Kew and a tied studentship in the laboratory of Prof. Gail Taylor at University of Southampton.

Contact: Dr Christian Lexer (c.lexer@kew.org)

Orchid Seed Stores

The threat of environmental change in regions of the world rich in orchid biodiversity is driving the need to develop appropriate conservation biotechnology strategies for this important plant family. In a new three-year Darwin Initiative project 'Orchid Seed Stores for Sustainable Use', Hugh Pritchard and Phil Seaton will coordinate studies on c. 300 orchid species, working with organisations in 16 countries in the Americas and Asia. The project will develop a database of in vitro germination requirements, deliver specialist research training at regional workshops in Chengdu (China) and Quito (Ecuador), and bank seed. Pedro León-Lobos of Chile made the first seed collection of this project, the high-elevation species, *Aa nervosa*.

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Collecting seed of *Aa nervosa* at over 4,400 m from the altiplano in Chile.

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