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Kew Scientist

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News from The Living Collections, The Herbarium and The Laboratories at Kew & Wakehurst Place

RBG Kew

Michael Way (Head of Collecting and Network Support, MSB) on a species rich, track side verge at Beech Estate, East Sussex.

UK Native Seed Hub

On 17 August 2011, Kew launched the UK Native Seed Hub at the Millennium Seed Bank (MSB), Wakehurst Place. This initiative will support suppliers of UK native seed, conservation groups and other organisations in work to restore native plant species to the UK countryside by drawing on the extensive MSB collections and the horticultural and scientific expertise of staff. A gift of £750,000 from the Esmée Fairbairn Foundation, made as part of their 50th anniversary celebrations, will establish the project over four years.

The UK Native Seed Hub will comprise a dedicated seed store and approximately one hectare of seed production beds. The project will work with commercial companies and restoration practitioners to create seed stocks of selected UK species. Samples will then be bulked up by commercial suppliers for use by conservation organisations in landscape-scale restoration projects. The project also involves research and developmental studies aimed at improving the quality and genetic diversity of the seed stocks.

The UK Native Seed Hub will eventually support restoration efforts across the full spectrum of UK habitats. Initially the focus will be on plant species from lowland meadows (see Box), in partnership with The High Weald Landscape Trust's Weald Meadows Initiative, based in West Sussex.

Lowland meadows are a vanishing habitat in the UK. Fragments survive in areas that have not been ploughed, re-seeded or heavily fertilized. Compared to the 1930s, only 2% of species-rich grasslands remain, but there is potential to restore these habitats. This year, interim seed production beds were set up in the walled nursery at Wakehurst Place. These were open to the public until the end of September 2011 and contained ten native species, such as *Cardamine pratensis* and *Succisa pratensis*, that have been difficult to use in restoration projects.

The model established for lowland meadows will provide a blueprint for supporting restoration in another 40 priority habitats listed in the UK Biodiversity Action Plan, the UK Government's response to the Convention on Biological Diversity. The UK Native Seed Hub will also address concerns outlined in the Government's Natural Environment White Paper and respond to the challenge of the Lawton review, 'Making Space for Nature' (2010).

Contact: Michael Way (m.way@kew.org)

RBG Kew

Seed production beds being prepared for the UK Native Seed Hub.

RBG Kew

Cardamine pratensis

Species from lowland meadows are the initial focus of the UK Native Seed Hub and include:

Achillea ptarmica (sneezewort)
Ajuga reptans (bugle)
Betonica officinalis (purple betony)
Campanula rotundifolia (harebell)
Cardamine pratensis (cuckoo flower)
Centaurea nigra (common knapweed)
Genista tinctoria (dyer's greenweed)
Hypochaeris radicata (flatweed)
Leontodon autumnalis (autumn hawkbit)
Leucanthemum vulgare (oxeye daisy)
Lotus corniculatus (birdsfoot trefoil)
Primula veris (cowslip)
Pulsatilla vulgaris (pasque flower)
Rumex acetosa (common sorrel).
Serratula tinctoria (saw-wort)
Silene flos-cuculi (ragged robin)
Succisa pratensis (devil's-bit scabious)
Veronica agrestis (green field-speedwell)

RBG Kew

Wollemia nobilis (Wollemi pine)

Wollemi sets seed

Following the discovery of *Wollemia nobilis* (Wollemi pine) in 1994, Kew was given its first specimens of this 'living fossil' in 1997. Hardiness trials in 2005 found that plants performed best in acidic soil, and specimens started producing male and female cones three years ago. The first seed has now been obtained, from cones set in 2010, and a batch of nine seeds started germinating after 42 days. The bulk of the seed has been stored in the Millennium Seed Bank.

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Kew
ROYAL BOTANIC GARDENS

Direction

Kew's 2011 Science Review

The Department for Environment, Food and Rural Affairs (Defra) has commissioned a five-yearly independent review of Kew's science by a visiting group of distinguished colleagues, chaired by Professor Georgina Mace from Imperial College. We welcome this review, to be conducted in late November, and thank the members of the panel for volunteering their time to help Defra and Kew in this important task.

The principal aim of the Science Review is to provide the Chief Scientific Adviser of Defra with an independent, expert assessment of the quality, balance, scope and appropriateness of the scientific programmes being carried out by the Royal Botanic Gardens (RBG), Kew and those proposed under the Breathing Planet Programme for the next five years.

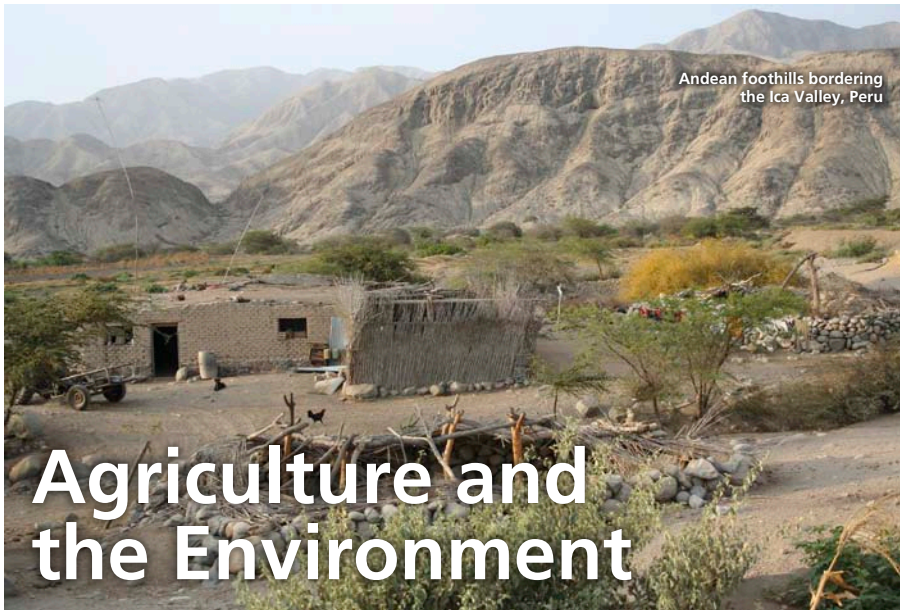
Kew has devoted a considerable effort over the past few years in firming up its corporate strategy under the aegis of the seven point Breathing Planet Programme, which draws its inspiration from international policy documents such as the Global Strategy for Plant Conservation. Thus, it is appropriate that the 2011 Science Review gives due attention to both a retrospective look at the past five years and a prospective examination of what is proposed for the next five years.

Most science at Kew is collections-based, and the expertise of Kew's staff is focussed in systematics, plant and fungal diversity, conservation, restoration and sustainable development. This combination of extensive collections, databases, scientific research and conservation/restoration is unique and gives Kew a leading role in facilitating greater access to basic plant information and improving conservation/restoration activity world-wide.

Over the past five years Kew has enhanced its collections and databases on time and budget. With prudent fiscal controls, Kew has also maintained its output of publications and achieved its science targets, including journal articles, floras and books, and has greatly increased output of papers in higher-impact journals. The Science Review will provide a timely assessment of this work and how Kew science proposes to advance over the next five years.

Professor Stephen D. Hopper FLS FTSE
Director (CEO & Chief Scientist)

Kew's directory of research projects and staff was updated in November 2011. The directory can be browsed at http://www.kew.org/science/directory/



O. Whaley

Agriculture and the Environment

Plant remains tell a two thousand year story of landscape change

Forest restoration for livelihoods in degraded areas is problematic without understanding their ecological history. By understanding the changing relationship of agriculture to natural resources in the past, we can inform our restoration activities in the present and bring an awareness of the lessons of history to local people.

In Peru's southern desert, scientists from Lima, Cambridge and Kew have been studying food and plant remains from ancient settlement sites, spanning roughly 750BC to 1000AD. The findings suggest that, over this time, changing farming techniques and production undermined the natural vegetation so badly that eventually much of the area had to be abandoned. Over some two millennia, the inhabitants of the lower Ica Valley shifted from subsistence on wild foods through a period of great agricultural production before returning again to a diet of largely gathered foodstuffs. This supports earlier interpretations, based on other lines of data, suggesting that farmers gradually exposed their land to flooding events and erosion by removing the natural dry forest vegetation (predominantly *Prosopis* and *Acacia*) to make way for crops. They inadvertently breached critical ecological thresholds beyond which farming was made impossible.

The study helps illustrate how bioarchaeology may assist restoration efforts, both by helping to determine natural vegetation history and by helping identify the links between sustainable crop production and native vegetation. *Veget. Hist. Archaeobot.* 20, 273 (2011).

Contact: Oliver Whaley (o.whaley@kew.org)

Adapting agriculture to climate change

Kew has embarked on a ten year project 'Adapting agriculture to climate change' in partnership with the Global Crop Diversity Trust. Adapting agriculture to climate change is one of the most urgent challenges of our time. The need for new crop varieties that can be productive in the climates of the future is now widely recognised. It is less well known that our ability to breed these new varieties cannot be taken for granted. The greatest source of untapped diversity, and in particular the richest source of diversity for adaptive characteristics needed to confront the challenges of climate change, is found in the wild relatives of our crops. Over the coming year Kew will use data from its herbarium and seed bank holdings to contribute to a gap analysis of crop wild relatives. It will then, through the Millennium Seed Bank Partnership, collect these species and pass them to specialist pre-breeders.

The project focuses on the wild relatives of 26 crops covered by Annex 1 of the International Treaty of Plant Genetic Resources for Food and Agriculture. The crops are alfalfa, apple, bambara groundnut, banana, barley, bean, carrot, chickpea, cowpea, eggplant, faba bean, finger millet, grasspea, lentil, oat, pea, pearl millet, pigeon pea, potato, rice, rye, sorghum, sunflower, sweet potato, vetch and wheat.

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A.McRobb/RBG Kew

Pests and Invasives

New quarantine facility

On 14 September 2011 a new plant quarantine facility opened at Kew, replacing the existing Quarantine House built in 1979. Funded by Defra, the Plant Reception and Quarantine Unit is critical to Kew's international conservation and scientific programmes. Initially the unit will quarantine plants entering or leaving Kew, but in the future it is planned to provide a service to other organisations. The facility was designed and built by Unigro, based on the requirements and outline design provided by Kew's project team. Containment and biosecurity are top priorities, with features including separate environmentally-controlled growing areas, the ability to fumigate isolated areas, sterilisation of drainage and filtering of air prior to release to the outside, and a sealed containment area operating under negative air pressure.

Contact: Sara Redstone (s.redstone@kew.org)

The new Plant Reception and Quarantine Unit at Kew.

A. McRobb/RBG Kew

Pine pests on Turks and Caicos Islands

The pine trees of the Turks and Caicos Islands (TCI) are under threat from environmental stresses that include disturbance, water shortage and invasive insect pests. The most serious of these is the scale insect known as pine tortoise scale, *Toumeyella parvicornis*. In many areas, mature trees are absent as they have been killed by the insect pests. The pines of the Bahamas also suffer environmental stresses due to human activity but are relatively healthy compared to the trees in TCI. Although *T. parvicornis* has not yet been detected in the Bahamas, several other pests, including scale insects, are known to be attacking the pines.

Collecting and cataloguing pine samples in the Turks and Caicos Islands

During fieldwork (8–22 May 2011), supported by the Bentham-Moxon Trust and Kew Guild, Martin Hamilton, Paul Green and Marcella Corcoran collected samples of insect pests from Abaco and New Providence (Bahamas) and North Caicos, Middle Caicos and Pine Cay (TCI) for identification. The team also collected samples of *Pinus caribaea* var. *bahamensis* from the Bahamas and TCI and these were extracted in solvent so their chemical composition could be compared. By cataloguing the occurrence and distribution of pests it is hoped that early warning of invasive insects can be given. Preliminary data suggest that the chemical fingerprints of healthy and unhealthy trees are different, which may be due to more significant environmental upheaval in TCI. Differences in the chemistry of healthy and unhealthy pines could identify compounds that protect healthy Bahaman trees from insect attack.

Contact: Martin Hamilton (m.hamilton@kew.org)

Invasive *Rubus*

Rubus niveus, native to Asia, is a morphologically-diverse and invasive species which has become an aggressive coloniser in areas of the world outside its native range. The fragile biodiversity of islands, such as the Galápagos archipelago and Hawaii, is especially threatened by this plant. As part of a larger study aimed at developing biological control for invasive *Rubus* in the Galápagos, researchers at Birkbeck (University of London) and Kew have used genetic and morphological studies to establish the homogeneity of *R. niveus* populations in the Galápagos and clarify their relationship to plants in Asia. The genetic studies demonstrated that *R. niveus* from the Galápagos is genetically closer to samples from India than to samples from Nepal and China, and this will help narrow down the search for suitable biocontrol organisms.

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

Rubus niveus in the Galápagos

J. Squirton

Flower of *Crotalaria capensis* showing 'silvering' on petal surfaces and viral damage on leaves, both the result of an infestation of western flower thrips

A. Scott-Brown

African anti-thrips plant

Thrips are serious economic pests on a wide range of crops, causing damage to plants and fruit through feeding, reproduction and the transmission of plant tospoviruses. Rapid increase in the global distribution of some species has expanded plant host records at a rate which exceeds both the accumulation of knowledge on host selection and the development of control agents or control strategies. Western flower thrips (*Frankliniella occidentalis*) and glasshouse thrips (*Heliothrips haemorrhoidalis*) are key species that continue to elude the controls available for use on protected crops in North America, Europe, Australia, Asia and Africa. Both are frequently found causing damage among their numerous host plants located in the glasshouse collections at Kew.

A study at Kew has recorded the morphological and chemical characteristics of plants in the Temperate House that remained free from thrips attack. The foliage of one species, *Sclerochiton harveyanus* (Acanthaceae), an evergreen shrub native to south eastern Africa, appeared to be toxic to thrips. Analysis of leaf extracts revealed the presence of iridoids, including four new compounds of this group. Bioassays indicated that some of these were toxic to *Frankliniella occidentalis* and deterred *Heliothrips haemorrhoidalis* from feeding. Understanding the mechanisms involved in plant resistance to thrips can serve to increase the possibilities of controlling thrips in environments where current techniques have limited success. *J. Chem. Ecol.* 37, 301 (2011).

Contact: Dr Alison Scott-Brown (a.scott-brown@kew.org)

Chemical Analysis

in Systematics, Conservation and Use

Painting no. 110 'Night Flowering Lily and Ferns, Jamaica' in which the blue pigment was identified as indigo.

Carbon isotope analysis in *Cyperus*

Scientists from Ghent University, KU Leuven (Belguim), University of Cape Town (S. Africa) and Kew have combined the results of carbon isotope analyses and DNA sequence analyses to reveal the affinities of lineages in *Cyperus*. The results revealed six well-supported clades, one of which exclusively contained all the species studied that employ C4 photosynthesis rather than C3, as indicated by carbon isotope ratios. Some former sections of the genus which were heterogeneous for photosynthesis type were not supported, with C4 and C3 members being split among the C4 clade and C3 clades, respectively, in the new analysis. The study enhances the long-held view that photosynthetic type, linked with distinct types of anatomy, is an important character in classifying taxa within the *Cyperus* clade. *Bot. J. Linn*. Soc. 167, 19 (2011).

Contact: Dr David Simpson (d.simpson@kew.org)

Conserving Marianne North paintings

Kew's Marianne North oil paintings (on paper) underwent conservation between 2008 and 2011 in a purpose built on-site conservation studio, located in the Herbarium. The conservation also involved research to identify the pigments, binding oils and varnishes that had been used. As many components of paint are derived from plant material, some of the research could be performed using the analytical facilities at Kew.

Very small paint samples were taken either from the edges of the painting or from paint that had become detached. The samples were analysed by liquid chromatography-mass spectrometry (LC-MS) and compared with reference material of dye-based pigments that were likely to have been used, such as madder (*Rubia*) and indigo (*Indigofera*), obtained from Kew's Economic Botany Collection. Oils and varnishes were analysed both by LC-MS and gas chromatography-mass spectrometry.

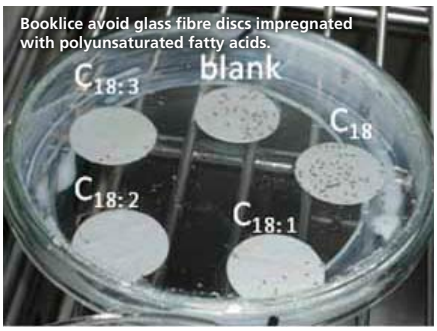
Several successful identifications were obtained. Poppy seed oil was found as a component of the oil media, mastic resin with Venice turpentine was detected in the varnish, and indigo (indigotin) was found in samples of a deep blue pigment from one painting (number 110). The analyses informed conservation decisions as knowledge of the materials is important in selecting appropriate treatments. The work has also enhanced understanding and awareness of the collection and Marianne North's working methods. The positive results are encouraging for potential future use of on-site facilities in the analysis of Kew's art materials.

Contact: Emma Le Cornu (e.lecornu@kew.org)

'Polyunsaturates' not good for booklice

Booklice (*Liposcelis bostrychophila*), despite their name, neither feed entirely on books, nor are they lice. These insects do cause damage to museum, library and herbarium collections by their feeding activity. Work is ongoing to better understand their settling behaviour and chemical ecology. The aim is to identify compounds from the insects or in their environment that can act as deterrents, to protect artefacts or museum collections or as attractant compounds for use in traps or lures. The mixture of compounds extracted from booklice can repel other members of the same colony. The insect-derived extracts contain fatty acids and fatty acid methyl esters, among other compounds. Booklice are able to discriminate between fatty acids with different numbers of double bonds, and are repelled by fatty acids with one double bond (C18:1) or more (C18:2 and C18:3). These results present the possibility that volatile fatty acids, or other compounds with similar properties, could be used in the vicinity of collections to deter booklice. *J. Stored Prod. Res*. 47, 262 (2011).

Contact: Dr Paul Green (paul.green@kew.org)



Booklice avoid glass fibre discs impregnated with polyunsaturated fatty acids.

P. Green

Flavonoid analysis

Geoffrey Kite and Nigel Veitch have improved the analysis of flavonoid glycosides. These widespread plant chemicals with claimed health benefits are often difficult to identify exactly when in mixtures (as in plant extracts) due to their structural variety, especially of the sugar ('glycoside') part. The Kew scientists found they could identify all of the simpler sugars involved in common flavonoid glycosides by tuning the analytical technique of liquid chromatography-mass spectrometry to record sodium ion mass spectra. The method is now used in Kew's work in systematic chemistry and herbal extract authentication. In a systematic legume project, 18 simple flavonoid glycosides were completely identified in leaf extracts of Kew's specimens of *Cladrastis kentukea* (Kentucky yellow-wood). Another 34 more complex flavonoid glycosides were partially identified by the method and 12 were found to be new-to-science after they had been purified by 'sandwich' student Emily Rowe and characterised by other methods. *Rapid Commun. Mass Spectrom*. 25, 2579 (2011); *Phytochemistry* 72, 372 (2011).

Contact: Dr Geoffrey Kite (g.kite@kew.org)

Nepeta cataria inhibits calcineurin

T. Prescott

Mechanistic insights into Old English plants

Often lacking in natural product drug discovery are 'mechanistic insights'; that is, insights into the events at the molecular level that are behind any effects shown by plant compounds on cells or organisms. With this in mind, Tom Prescott screened 250 plants from the Queen's Garden at Kew (containing species grown in England before 1800) to search for compounds that inhibit the human enzyme calcineurin. Calcineurin plays an important role in regulating human T-cell activation, and inhibition of this process is beneficial in certain auto-immune diseases. *Nepeta cataria* and *Teucrium chamaedrys* showed promise in the assay, and further investigation revealed phenylpropanoid glycosides to be responsible. These compounds potently inhibit the enzyme in its basal un-activated state but are less effective against the fully activated state. Whilst such selectivity could make them a useful 'chemical probe' with which to study calcineurin, efforts are underway to identify more active compounds using a yeast calcineurin gene expression assay. *J. Ethnopharm*., in press, doi:10.1016/j.jep.2011.07.063.

Contact: Dr Tom Prescott (t.prescott@kew.org)

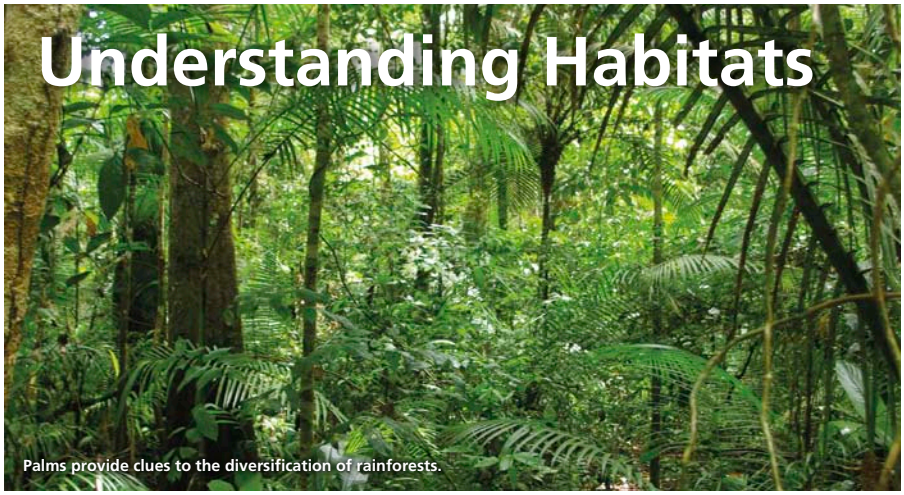
Understanding Habitats

Palms as a model for rainforest evolution

Understanding how biodiversity is shaped through time is a fundamental question in biology. Even though tropical rainforests represent the most diverse terrestrial biomes, the timing, location and mechanisms of their diversification remain poorly understood. In a recent paper, scientists from Institut de Recherche pour le Développement (Montpellier), the New York Botanical Garden and Kew address these issues by constructing the first complete genus-level dated phylogeny of a largely rainforest-restricted plant family, the palms (Arecaceae or Palmae).

Their results indicate that diversification of extant lineages of palms started about 100 million years ago during the mid-Cretaceous period. Using a range of diversification analyses, the authors inferred that palms diversified in a rainforest-like environment at northern latitudes and have conformed to a constant diversification model (the 'museum' model or Yule process), at least until the Neogene. These results imply the presence of a rainforest-like biome in the mid-Cretaceous period of Laurasia, considerably earlier than the first reliable fossil evidence for rainforests in the early Tertiary. Controversially, the results also suggest that ancient and steady evolutionary processes dating back to the mid-Cretaceous period can contribute, at least in part, to present day species richness in rainforest, perhaps due to the persistence of refugia during climatically unfavourable periods. *BMC Biology* 9, 44 (2011).

Contact: Dr Bill Baker (b.baker@kew.org)



Palms provide clues to the diversification of rainforests.

T. Couvreur

A study has revealed the richness and importance of the coastal dry forests in Mozambique.

J. Timberlake

Coastal dry forests of Mozambique

A recent paper in *Plant Ecology & Evolution* presents botanical results from two large expeditions and other recent trips to the little-studied coastal dry forests of Cabo Delgado Province, northern Mozambique. Using satellite imagery, the extent of dense vegetation across the area was estimated at 1,182 km^2, down from a suggested extent of almost 6,100 km^2 a century ago – a loss of 80.6%. Of this remaining dense vegetation, around 400 km^2 is believed to be dry forest, the rest being mostly dense miombo woodland. Over 3,000 plant collections have been made, with a total of 738 plant taxa recorded. Of these 36 are believed to be new or undescribed with an additional 68 being new records for Mozambique, confirming links with the much better studied dry forests in south-east Tanzania. Conservation assessments have been made for seven restricted-range species, and 14 areas of conservation interest were identified based on the uniqueness of their flora or vegetation type. This study has brought the richness and importance of coastal dry forests to the attention of the Mozambique authorities, and a project addressing their conservation is now being developed. *Plant Ecol. Evol.* 144, 126 (2011).

Contact: Jonathan Timberlake (j.timberlake@kew.org)

Wet grassland in Lunda Norte, NE Angola – a habitat found to contain rare or endemic species.

D. Goyder

Botanical survey doubles the known flora of Lunda Norte, Angola

In late April and early May 2011, Kew's Drylands Africa team was invited to make a rapid botanical survey of the remote Lagoa Carumbo region of Lunda Norte Province, NE Angola, in collaboration with staff from the Agostinho Neto University, Luanda and the Angolan Ministério do Ambiente. Expedition collections and historic specimen data from the Kew herbarium revealed 537 species, subspecies and varieties, more than doubling the known flora of the region. The three river valleys surveyed have largely intact ecosystems undamaged by commercial diamond extraction, with plateau grasslands on deep, heavily leached Kalahari sand deposits interdigitating with Guineo-Congolian riverine forests, where the rivers have cut through to the base of the Kalahari sands. Both these habitats, together with seasonally wet grasslands surrounding the lake contain many species restricted in Angola to this region and several rare or endemic species of very restricted range.

Data from this survey, together with reports on bird and animal diversity, were compiled to provide evidence for the formal designation of these river catchments under the Angolan Protected Areas Expansion Strategy, which was ratified by the Council of Ministers during the team's visit. Other sites across the country will be surveyed over the next few years.

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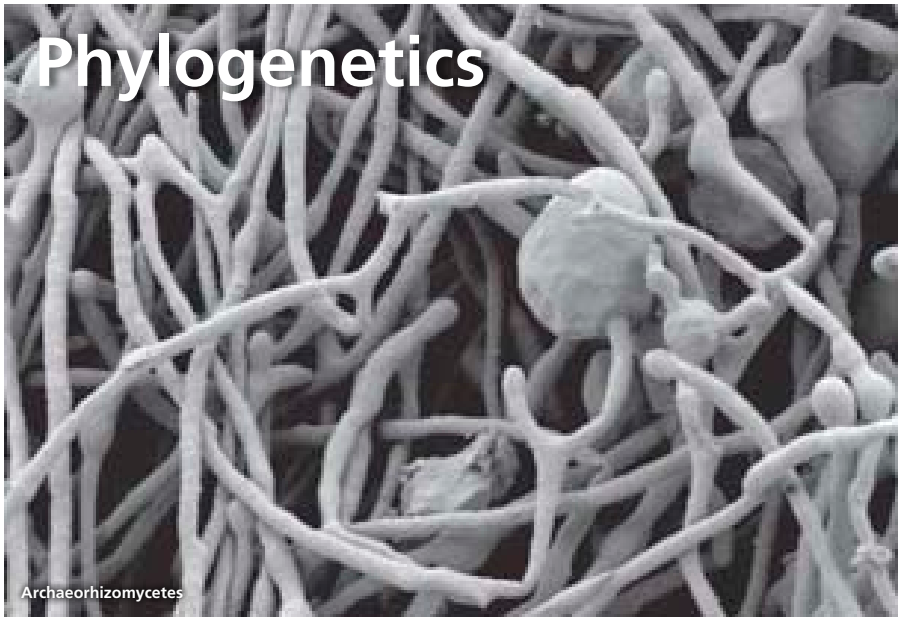
Phylogenetics



A. Rosling

Discovering common fungi

Fungi are among the most diverse and understudied organisms, so major evolutionary branches composed of hundreds of species are still being discovered. In the course of her PhD studies on environmental change in Europe's forests supported by the Natural Environment Research Council, Filipa Cox (Kew/Imperial) detected fungi in pine roots using DNA that were also being detected in other continents by other molecular ecologists. An international team led by Anna Rosling (Uppsala BioCentre/Indiana University) has now been successful in culturing these fungi in vitro and have shown them to form a diverse, ancient and previously unknown group, the class Archaeorhizomycetes. *Science* 333, 876 (2011).

Contact: Dr Martin Bidartondo (m.bidartondo@kew.org)

Predicting medicinal use

The study of traditional knowledge of medicinal plants has led to discoveries that have helped combat diseases and improve healthcare. However, the development of quantitative measures that can assist our quest for new medicinal plants has not greatly advanced in recent years. Phylogenetic tools have entered many scientific fields in the last two decades to provide explanatory power, but they are often overlooked in ethnomedicinal studies. PhD student Haris Saslis-Lagoudakis, co-supervised by Julie Hawkins (University of Reading) and Vincent Savolainen (Kew/Imperial), has compared medicinal use in various floras and looked at the phylogenetic patterns in a few case studies, including the legume *Pterocarpus*. The study showed that species used to treat certain conditions, such as malaria, are significantly clumped phylogenetically, highlighting the predictive power of phylogenetic trees in studying the medicinal uses of plants. *J. Ethnopharmacol.* 135, 476 (2011); *PLoS ONE* 6, e22275 (2011).

Contact: Prof. Vincent Savolainen (v.savolainen@kew.org)

A. Calvente

Epiphytic cacti

Tribe Rhipsalideae is composed of unusual epiphytic or lithophytic cacti that inhabit humid tropical and subtropical forests. Collaboration between researchers at the University of São Paulo and Kew has recently resulted on the publication of two papers on the phylogenetics, evolution and biogeography of this group of cacti, based on molecular data. The first paper focuses on the relationships within the tribe and showed that this group comprises four main clades supporting the recognition of genera *Lepismium, Rhipsalis, Hatiora* and *Schlumbergera*. It also presents evidence that genus *Schlumbergera* should be expanded to including *Hatiora* subg. *Rhipsalidopsis*. The second publication explores in more details the relationships within genus *Rhipsalis*, its biogeographical history and morphological evolution. The authors showed that coastal Brazil is the ancestral area of several lineages within *Rhipsalis* and that these further dispersed recently to other tropical forests in South America, North America, Africa, and Asia. *Mol. Phylogenet. Evol.* 58, 456 (2011); *Int. J. Plant Sci.* 172, 902 (2011).

Contact: Dr Felix Forest (f.forest@kew.org)

Araceae

An international team, including Simon Mayo from Kew, have produced the most complete molecular phylogeneny of Araceae to date, analysing 113 genera, and compared it with morphological and anatomical patterns in the family. The analysis resolved 44 larger clades, 16 of which were newly circumscribed and informally named. Most clades were well supported and also had morphological or anatomical synapomorphies as well as ecological or geographic cohesion. Some relationships within the subfamily Aroideae remained poorly supported. The most problematic placement was *Calla* within Aroideae, which conflicts with non-molecular characters. The study provides a basis for a new formal classification of Araceae. *Am. J. Bot.* 98, 654 (2011).

Contact: Dr Simon Mayo (s.mayo@kew.org)

Myrcia

Myrcia s.l. is the most species-rich tree genus in the Brazilian cerrado and Atlantic forest. Scientists from Kew, São Paulo and Oxford have reconstructed the phylogenetic relationships of the genus using DNA sequences of four plastid regions and the external and internal transcribed spacer regions of nuclear ribosomal DNA. The results supported some lineages identified by previous classifications, but others lineages with morphological and/or ecological correspondence are recognised for the first time. The previously recognised genera *Calyptranthes* and *Gomidesia* are shown to be monophyletic, whereas *Marlierea* is shown not to be. All are nested within paraphyletic *Myrcia* so a new subgeneric classification is required. *Int. J. Plant Sci.* 172, 915 (2011).

Contact: Dr Eve Lucas (e.lucas@kew.org)

Metals and seeds

Environmental pollution with metals is an increasing problem. Certain metals are toxic, whilst some essential plant nutrients are damaging at high concentrations. Metals can cause reactive oxygen species formation, leading to oxidative damage. In seeds, this compromises germination and seedling establishment, and can have potentially mutagenic effects on the next plant generation. Ilse Kranner and Louise Colville have critically reviewed the effects of metals on seed development and germination and the implications of metal toxicity at the biochemical and molecular level. The strategies for avoiding metal stress in seeds are discussed along with applied aspects such as the use of seeds for soil and water purification and in phytoremediation programmes. *Environ. Exp. Bot.* 72, 93 (2011).

Contact: Dr Louise Colville (l.colville@kew.org)

Seeds of *Tamarindus indica* have potential as a low-cost adsorbing agent to remove chromium from polluted water.

W. Suddy

Origins and Extinctions

Proliferated cone of *Cunninghamia lanceolata*. Conifer cone abnormalities provide insights into the origin of flower-like structures.

Origin of flower-like structures

Scientists from Kew, the University of Birmingham and Universidad Nacional Autónoma de México have considered how two categories of spontaneous developmental abnormalities in conifer cones, together with emerging developmental genetic data, provide insights into our understanding of the origin of flower-like structures. Typical conifer cones have restricted growth and exclusively bear either pollen or ovules. Common abnormalities result in the cone apex growing vegetatively (proliferated cones) or cones that bear both male and female structures (bisexual cones). Most functionally bisexual cones appear to be modified seed cones, therefore favouring the view that hermaphrodite flowers could have evolved from a gymnosperm seed cone by ectopic expression of B-function MADS-box genes in the proximal regions. *Trends Plant Sci.* 16, 151 (2010); *Flowers on the Tree of Life*, 8 (2011).

Contact: Dr Paula Rudall (p.rudall@kew.org)

Origin of apocarpy in palms

Recent phylogenetic evidence suggests that the apocarpous (free-carpellate) condition that occurs in mature gynoecia of some palm species represents a derived condition, in contrast with traditional views. Paula Rudall, Ruth Ryder and Bill Baker (Kew) have tested this hypothesis by comparing the morphology and ontogeny of several palm genera representing a broad phylogenetic range within the diverse subfamily Coryphoideae. The researchers optimized their observations onto a recent supertree phylogeny to clarify the evolutionary history of gynoecial characters within the subfamily. This indicated three evolutionary transitions to apocarpy within Coryphoideae and supported it being a derived state. Taking into account the genus *Nypa* (subfamily Nypoideae), apocarpy appears to have been independently derived four times within palms. *Int. J. Plant Sci.* 172, 674 (2011).

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Causes of plant extinctions

Biodiversity loss is the most significant ecological challenge we face. In groups that are well known, such as mammals, the risk of extinction has been related to biology, with the most vulnerable species tending to be large, slow breeding and narrowly distributed. For plants, however, our knowledge of the drivers of plant extinctions is still is poor. Research in the Cape region of South Africa by a team of scientists from Imperial College London, Kew and McGill University showed that the most vulnerable plant species were found within young and fast-evolving lineages, opposite to patterns in vertebrates. The study illustrates the intricate link between the processes of speciation and extinction. Critically, the research also showed that the most threatened species in the Cape are marching towards extinction at faster rates, but surprisingly, the risk appears independent of human effects. *PLoS Biol.* 9, e1000620 (2011).

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How plants conquered land

Since the 1970s scientists have widely agreed that the fungi that today form the most common nutritional symbiosis with plants, namely arbuscular mycorrhiza, were also the ones that allowed early rootless plants to colonise our planet's poor primeval soils over 400 million years ago. New evidence from a project led by Martin Bidartondo (Kew/Imperial) examining ancient plant lineages using DNA analyses and electron microscopy indicates that more likely candidates are an unexpected and overlooked group of fungi, the pea truffles (*Endogone*). The researchers found that *Endogone*-like fungi are widely associated with land plants that form the earliest lineages in phylogenetic analyses, and arbuscular mycorrhizas only take over in later lineages. This raises the new hyphothesis that *Endogone*-like fungi may have facilitated the greening of the Earth. *Biol. Lett.* 7, 574 (2011).

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Neotropical resources

Two new internet resources for Latin American plants were launched in August 2011.

The Neotropical Plant Image Database contained, at its launch, over 4,500 photos of Latin American plants taken by Kew's botanists. Each is accompanied by location data and, where appropriate, details of accompanying herbarium collections (vouchers), making this an important resource for plant identification and the development of field guides.

http://www.kew.org/science/tropamerica/imagedatabase.html

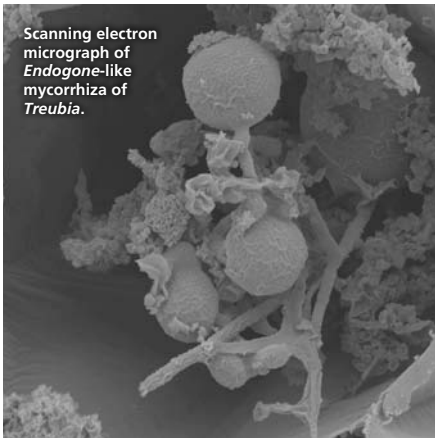
The Neotropical Vegetation Data Website makes published and unpublished inventory and vegetation survey data for Latin America readily accessible on a geographical basis. The rapid access to location-specific data informs decision-making and facilitates the application of existing scientific data to conservation management.

http://www.kew.org/science/tropamerica/vegetation/index.htm

OpenUp!

Kew has embarked on a collaborative project 'OpenUp!' which will enable the sharing of digitized natural history multimedia collections through the Europeana portal (http://europeana.eu). Europeana provides an interface to millions of books, paintings, films, museum objects and archival records that have been digitized by Europe's heritage institutions. A consortium of 23 European research institutes, led by Freie Universitaet Berlin, has been co-funded by the European Commission to deliver OpenUp! and expand the coverage of Europeana for the natural history domain. Kew's aims are to provide access to herbarium specimen images, IPR support and a data quality service for botanical names for all partners.

Visit: http://open-up.eu



Scanning electron micrograph of *Endogone*-like mycorrhiza of *Treubia*.

Speciation and Diversification

V. Savolainen

Cape Eland amidst the diverse Fynbos vegetation at Cape Point, South Africa

Plant diversification in the Cape of South Africa

The Cape region of South Africa is one of the most remarkable hotspots of biodiversity. Much of the diversity is due to an exceptionally large contribution of just a few plant lineages that radiated substantially within this region, but little is known about the causes of these radiations.

Research led by scientists from Kew and Imperial College London (Vincent Savolainen, Tim Barraclough, Jan Schnitzler and Martyn Powell), with South African colleagues (John Manning, James Boatright and Tony Rebello) and Peter Goldblatt (Missouri), present one of the most comprehensive analyses of plant speciation in the region. By combining near complete species-level phylogenies of four major Cape clades (more than 470 species) – the genus *Protea*, a tribe of legumes (Podalyrieae) and two speciose genera within the iris family (*Babiana* and *Moraea*) – with ecological and biogeographical information, the researchers tested hypotheses that have been proposed to explain the radiation of the Cape flora.

The results show that these radiations started throughout the Oligocene and Miocene and that net diversification rates have remained constant over time. Furthermore, by using sister-species comparisons to assess the impact of different factors on speciation, the researchers identified soil type shifts as the most important cause of speciation in *Babiana, Moraea* and *Protea*, while shifts in fire-survival strategy is the most important factor for Podalyrieae. Contrary to previous findings in other groups, such as orchids, pollination syndromes show a high degree of phylogenetic conservatism, including groups with a large number of specialised pollination syndromes like *Moraea*.

The study concludes that the combination of complex environmental conditions together with relative climatic stability promoted high speciation and/or low extinction rates as the most likely scenario leading to present-day patterns of hyper-diversity in the Cape. *Syst. Biol.* 60:343 (2011).

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AWARDS

In June 2011, Mark Chase was awarded the Orchid Digest Medal for contributions to orchid science/horticulture.

In July 2011, John Dransfield was awarded a corresponding membership of the Botanical Society of America in recognition of his outstanding contributions to plant science.

In September 2011, David Mabberley was presented with the National Tropical Botanical Garden (Hawaii) Robert Allerton Award for Excellence in Tropical Botany or Horticulture.

In September 2011, Phil Stevenson was awarded the title of Professor of Plant Chemistry by the Univeristy of Greenwich.

PhDs

The following PhD students co-supervised by Kew staff successfully passed their vivas:

Alex Papadopulos, 'Plant speciation on Lord Howe Island' (June 2011).

Haris Saslis-Lagoudakis, 'Evolutionary perspectives on medicinal plant use' (October 2011).

Sympatric speciation contributes to island biodiversity

How does a single species divide into two new species? For decades, the pervasive idea among evolutionary biologists was that geographic barriers (e.g. a river or mountain range) must be present between populations of a species for speciation to occur (a process known as allopatric speciation). Geographic barriers prevent reproduction between populations, allowing them to evolve independently and, given enough time, to become genetically and ecologically distinct from each other. The last ten years have seen a slow increase in examples of an alternative speciation process which does not require a geographic barrier (sympatric speciation) and is driven instead by natural selection and biological reproductive barriers (e.g. mate choice or variation in flowering time). However, sympatric speciation is often considered as a very rare, freak event that is unlikely to have made a significant impact on current patterns of biodiversity.

Research led by a team of scientists at Kew and Imperial College (Alex Papadopulos, Vincent Savolainen, William Baker and Ralf Kynast), in collaboration with colleagues in the UK and Australia, has challenged the status quo by demonstrating that sympatric speciation may be relatively common in some instances. Using genetic and ecological information for endemic plant species on a tiny, subtropical, Pacific island (Lord Howe Island, Australia) the researchers discovered at least eleven new instances of sympatric speciation and suggest that as many as one in five species on the island may be the products of sympatric speciation. *Proc. Natl Acad. Sci. USA* 108, 13188 (2011).

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W. Baker

***Howea* palms on Lord Howe Island**

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