Oxford Plant Systematics

With news from Oxford University Herbaria (OXF and FHO), Department of Plant Sciences, Oxford

OPS 16 **May 2009**

Miscellaneous specimens of marine algae from the herbarium included in the exhibition at the Oxford University Museum of Natural History

Foreword

The big event for the Department of Plant Sciences in 2008 was its success in the UK Research Assessment Exercise; the Department was ranked 4th out of 52 Biological Sciences Research Institutions in the UK. *Oxford Plant Systematics* presents a glimpse of the range of systematic activities happening in the Department of Plant Sciences. This year we have research-based articles on the Darwin project based in Bolivia, the biogeography of the genus *Aglaia* and updates on recent developments in mapping diversity using BRAHMS. Reports by our D.Phil students cover plant diversification in Andean seasonally dry tropical forests and a new project on nickel hyperaccumulation in the Eurasian genus *Alyssum*. Marcelo Simon is to be congratulated on successfully defending his D.Phil. thesis on the biogeography of South American *Mimosa*. Wider collaborations across the university, especially with the Oxford University Libraries Service, are reflected in the articles on George Druce's Birthday Book and the watercolours of the amateur botanical artist Charlotte Trower. The herbaria have users other than researchers and students, and some of these uses are revealed by a collaborative exhibition of marine algae held at the University Museum of Natural History and the work of the artist Sarah Simblet. I hope you enjoy reading OPS 16.

Stephen A. Harris
Curator of Oxford University Herbaria

News items

We are delighted to announce that **Dr Colin Hughes** was appointed as Departmental Lecturer in Plant Sciences from October 2008. Colin was formerly a Royal Society University Research Fellow.

Colin Hughes attended the 12th International Lupin Conference in Fremantle, Western Australia in September where he presented a keynote talk entitled, *Diversity and evolutionary history of lupins – insights from new phylogenies*.

An exhibition of **marine algae** at the **Oxford University Museum of Natural History** was staged between 4 December 2008 and 4 February 2009 drawing on the collections of the herbarium. The aim of the exhibition was to heighten awareness of the importance and beauty of algae.

A new commentary on the Thornton's *Temple of Flora* was written by **Stephen Harris** and published by the Folio Society as part of a complete reprint of this famous illustrated book.

Contents

Foreword
Stephen A. Harris …… 2

News items …… 2

Publications 2008 …… 3

Abstract of systematic thesis submitted in 2008
Marcelo Simon …… 3

Student reports
Pattern and tempo of plant diversification in Andean seasonally dry tropical forests
Tiina Sarkinen …… 4

The evolutionary ecology of nickel hyperaccumulation in *Alyssum* L. and related species
Tom Flynn …… 5

Rock outcrops in the Cerrado biome – hotspots of endemism ?
John R.I. Wood …… 5

Evolution and biogeography of *Aglaia*
Caroline Pannell …… 7

The Trower sisters and George Claridge Druce
Stephen A. Harris …… 8

George Claridge Druce's Birthday Book
Oliver Bridle …… 10

News from the Herbaria
Visitors, Fielding-Druce (OXF) and Daubeny (FHO)
Serena Marner …… 12

Unstill lives. An artist working in the herbarium
Sarah Simblet …… 13

Mapping diversity using BRAHMS 6.5.
Denis Filer …… 16

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Oxford Plant Systematics Research Group website: http://herbaria.plants.ox.ac.uk

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Cover images : Marine algae - (top; left to right) *Caulerpa paspaloides* (Bory) Grev.; *Delesseria sanguinea* (Huds.) J.V.Lamouroux; *Padina pavonica* (L.) Thivy. (middle; left to right) *Calliblepharis ciliata* (Huds.) Kütz.; *Desmarestia ligulata* (Stackhouse) J.V.Lamouroux; *Calliblepharis jubata* (Gooden. & Woodward) Kütz. (bottom; left to right) *Caulerpa peltata* J.V.Lamouroux var. *macrodisca* (Decne.) Weber-van Bosse; *Rhodophyllis gunnii* (Harv.) Harv.; *Sargassum vulgare* C.Agardh.

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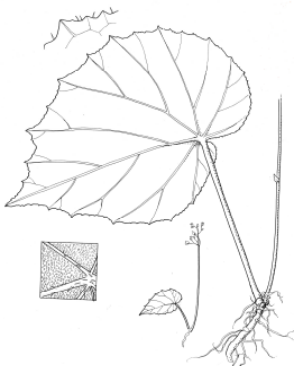

Begonia glandulifera drawn for the Checklist of Trinidad and Tobago by Rosemary Wise

Abstract of systematic thesis submitted in 2008

The following D.Phil. thesis was submitted in December 2008:

Systematics and evolution of *Mimosa* L. (Leguminosae) and the assembly of a Neotropical plant diversity hotspot

Marcelo Simon
Wolfson College

Supervisors: Drs Colin Hughes and Stephen Harris. Clarendon scholarship and Embrapa.

The causes of differences in species diversity across the globe and the processes prompting accumulation of hotspots of diversity remain poorly understood. The central objective of this thesis is to investigate macro-evolutionary processes involved in the historical assembly of species-rich biomes using the flora of the Cerrado as a study system. Specifically, the study aimed to test the hypothesis that the evolution of the Cerrado flora coincided with the emergence and dominance of flammable C4 grasses and the consequent appearance of fire as a natural element in this ecosystem. Time-calibrated phylogenies for a set of plant groups representing 3-4% of the flora of the Cerrado suggest that Cerrado lineages started to diversify less than 10 million years ago, with the majority of lineages younger than four million years, coinciding with dominance of flammable C4 grasses and expansion of the savanna biome worldwide. These phylogenies suggest that Cerrado lineages evolved from immediately adjacent, largely fire-free wet forest, seasonally dry forest, subtropical grassland, and wetlands, implying that the cerrado formed in situ via recent and frequent adaptive shifts to resist fire. The location of the cerrado, surrounded by a diverse array of biomes, and the apparently modest adaptive barrier posed by fire are likely to have contributed to its striking species richness. These findings add to growing evidence that the origins and historical assembly of species-rich biomes have been driven by unique features of regional and continental scale processes.

A new phylogenetic analysis of the legume family using *matK* gene sequences and a relaxed molecular clock approach including 839 terminals and 23 fossil constraints was undertaken to estimate ages of the legume groups used in this study. Analyses on this scale are methodologically challenging and computationally demanding. This is by far the most complete analysis of relationships and ages for the legume family and provides a solid comparative framework for future analyses aimed at understanding the

evolutionary success of this large plant family.

As part of this study the first substantial molecular phylogeny for the species-rich legume genus *Mimosa* was constructed using *trnD-trnT* plastid DNA sequences of 259 species (50% of the total). This new phylogeny was used to test the monophyly of *Mimosa*, evaluate the current infrageneric classification of the genus, investigate the evolution of a set of core morphological characters, and establish new biogeographic hypotheses about the temporal and geographic patterns of species diversification. One of the most striking findings is the high level of geographic structure found in the *Mimosa* phylogeny. The age and relationships of the Old World species of *Mimosa* are revealed for the first time and shown to be deeply nested within New World groups, suggesting recent long distance dispersal to account for the amphi-Atlantic distribution of *Mimosa*.

Four new species of *Mimosa* are described and illustrated, all of them apparently narrowly restricted endemics from the Chapada dos Veadeiros in Goiás, central Brazil. In addition, complete data and an illustration for the poorly understood *M. pycnocoma* Benth., previously incompletely known from only the type collection, is presented.

Fig. 1 A new *Mimosa* species from Jaén, northern Peru. This species is closely allied to another Marañon endemic, *M. weberbaueri* Harms.

Student reports

Tiina Särkinen (D.Phil., 3rd year). **Pattern and tempo of plant diversification in Andean seasonally dry tropical forests**

Supervised by Dr Colin Hughes (Oxford) and Dr Toby Pennington (Royal Botanic Garden Edinburgh). Osk.Huttusen Säätiö and Helsingin Sanomain 100-vuotisjuhlasäätiö scholarships.

The focus of my D.Phil. is on geographical and temporal patterns of plant diversification in Andean seasonally dry tropical forests (SDTF). These SDTFs, although not as species-rich as wet forests, are especially rich in narrowly-restricted endemics, and the origins of this high endemism remain poorly understood. The markedly disjunct distribution of SDTF with isolated patches scattered from northern Mexico to Argentina and Paraguay suggests that long-term isolation (dispersal limitation), or a more continuous distribution of these forests and their subsequent vicariant fragmentation, could have driven species diversification and high endemism. Distinguishing between these alternative hypotheses is the central aim of my research.

During the year, I have focussed on building species-level molecular phylogenies for *Tecoma* (Bignoniaceae) and *Mimosa* (Leguminosae). Both of these genera have been challenging to work with in their own ways. *Tecoma*, despite being a relatively small genus of ca. 11 species mainly restricted to the Andean SDTFs, is taxonomically difficult despite recent efforts to clarify species delimitation (Gentry, 1992; Wood, 2008). Some of the taxonomic difficulties are likely caused by hybridisation between species, and this is reflected in complex patterns of incongruence between gene trees constructed using chloroplast (cpDNA), nuclear ribosomal (nrDNA) and low-copy nuclear gene (nDNA) sequences.

Mimosa, on the other hand, has been challenging purely due to its size. With ca. 500 species, it is one of the largest legume genera and is very widely distributed across several different Neotropical biomes. In order to investigate the timing and diversification of *Mimosa* in the Andes, I have added DNA sequence data for 73 Andean accessions into the preliminary phylogeny recently constructed for the genus as a whole by Marcelo Simon in Oxford. Building on Marcelo's dataset, I have now sampled nearly all the Andean SDTF *Mimosa* taxa, most with multiple accessions, and aim to use this more densely sampled tree to estimate the ages and geographical structure of the Andean *Mimosa* lineages which comprise sets of narrow endemics restricted to single inter-Andean valleys.

Results for my third study group, *Amicia* (Leguminosae), have now been written as a draft monographic taxonomic account of the genus including descriptions of two new infraspecific taxa, an identification key to species, detailed distribution maps, botanical illustrations and a new, densely sampled phylogeny of the genus based on both nrDNA and cpDNA data. The biogeography of *Amicia* and the wider *Adesmia* clade, where *Amicia* belongs are discussed based on this new time-calibrated phylogeny.

One of the biggest surprises for me has been the very incomplete state of knowledge of plant species diversity in the Andean SDTFs. Based on only two field trips to the Marañon valley in northern Peru, we have discovered two new *Mimosa* species. The first was spotted close to the main road leading across the Andes from the

Fig. 2 One of the largest patches of dry forests in the northern part of the Marañon valley, at Gota de Aguas near the town of Jaén. This forest is a private nature reserve, protected by the passionate owner, Luciano Troyes Rivero. The forest is regenerating from selective logging and grazing disturbance during the 1960s.

PanAmerican Highway. The second was discovered and collected, along the roadside during field work in April-May 2008 involving a survey of tree diversity in vegetation plots in the same area (Fig. 1). It seems that although these SDTFs are now quite accessible, they still remain under-collected and poorly known botanically.

Data on amphibian, reptile, mammal and avian diversity for the Marañon valley and other Andean dry forests (Tumbes-Piura, Ecuadorian, Chiquitano and Bolivian montane dry forests), (World Wildlife Fund 2009) suggest that the Marañon valley is by far the most species- and endemic-rich of the Andean dry valleys with total endemism as high as 43%. Levels of endemism are especially high for reptiles (54%) and birds (58%) (WWF, 2009; Bird Life International, 2009). Unlike some other Andean SDTFs, there are no protected areas in the Marañon valley. The establishment of the Tabaconas-Namballe National Sanctuary (295 km^2) in 1988 by the Peruvian Government was a significant step forward, but the area still lacks formal protection or baseline studies of plant species diversity (WDPA, 2009). However, there is growing interest and awareness of the conservation importance of these dry forests within Peru. Some individual land owners around Jaén are protecting remaining areas of dry forest from grazing, fire and timber exploitation (Fig. 2). The Universidad Nacional Agraria La Molina herbarium has a strong research focus in the area, and José Luis Marcelo Peña is currently working on a much-needed plant checklist and field guide for the area.

In the coming months I plan to integrate and synthesize the growing set of plant phylogenies that include dense sampling of Andean SDTF species to shed light on the origins and historical assembly of the endemic plant diversity of these poorly known Andean dry forests.

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Tom Flynn (D.Phil., 1st year) **The evolutionary ecology of nickel hyperaccumulation in *Alyssum* L. and related species**

Supervised by Professor Andrew Smith and Dr Stephen Harris. NERC funded.

My research focuses on species within the tribe Alysseae (Brassicaceae), of which the majority belong to the large genus *Alyssum* (c. 200 species). Some of these plants have the ability to tolerate very high concentrations of soil nickel (up to 0.8% of dry mass), and about 50 species also have the remarkable ability to hyperaccumulate this element within their above-ground parts to concentrations as high as 2.4% of dry biomass. In many cases the species that exhibit these unusual traits appear to be endemic to relatively small areas of serpentine-derived soils, which are naturally ultramafic (metal-rich). Interest in plant species that can tolerate and hyper-accumulate heavy metals, such as nickel, stems partly from their potential use in the remediation of polluted industrial and mining sites, but also from the broader evolutionary question of how such traits evolved.

I am interested in identifying the mechanism of diversification within the Alysseae, and in particular, determining whether the large number of nickel tolerators and hyperaccumulators within the tribe result from multiple origins of these traits through local adaptation, or from the region-wide dispersal and subsequent differentiation of an initially small number of tolerator and hyperaccumulator species. I will be asking how many times the tolerance and hyperaccumulation traits evolved, and whether it is easier for nickel tolerators to evolve or to move.

My approach will be to construct a phylogeny that includes as many species from the tribe as possible, and then to attempt to determine the extent to which this phylogeny correlates with the geographic distribution of species and their status as nickel tolerators or hyperaccumulators.

This year I am concentrating on growing plants from the extensive seed bank built up by Prof. Andrew Smith and Prof. Alan Baker (formerly University of Melbourne), which will add to the tissue collection of Roger Reeves and Robert Brookes (both formerly Massey University, New Zealand) that was kindly provided by Roger last year. I am also constructing a chloroplast phylogeny using regions such as *ndh*F and *trn*L-F. I will set up a growth experiments to measure plant growth under a range of nickel concentrations, including those experienced by plants growing in normal and in ultramafic soils.

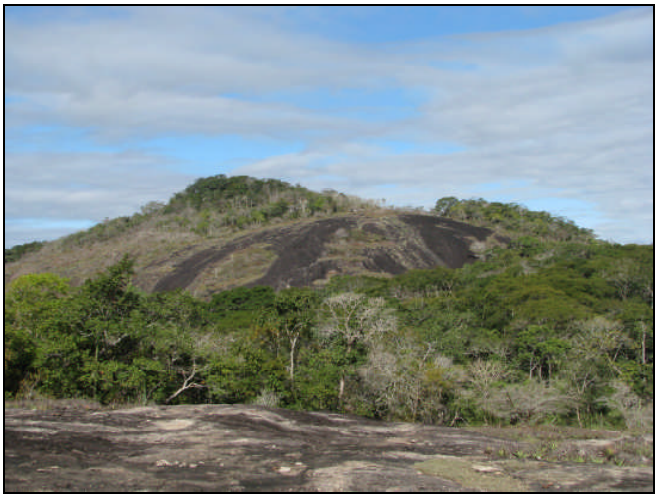
In the next year or so I will investigate suitable nuclear markers to include in my phylogenetic analysis, and I want to carry out field work in either southeast or southwest Europe, both of which are hotspots for *Alyssum* species.

Rock outcrops in the Cerrado biome – hotspots of endemism?

The Cerrado biome covers much of eastern Bolivia and central Brazil. It is a mosaic of savanna-type vegetation mixed with dry forest. From the air it appears to be a continuous plain covered by a patchwork of forest alternating with pasture and areas cleared for agriculture. The average atlas gives no more idea of the region's topographical diversity, suggesting it is one vast area of woodland and savannah broken only by the occasional low ridge. The reality is very different. There are indeed extensive undulating plains but these contain swampy hollows and small lakes alternating with steep-sided ridges and isolated mountain peaks, reaching heights equal to those of the highest mountains in Scotland. Some form extensive plateaux or mesetas like lost worlds isolated from the plains below. And wherever the land rises above the plains there are rocks.

At lower altitudes are huge flat or gently sloping rock slabs usually hidden by trees. In some areas granite domes rise like huge beached whales out of the plain. Then there are the escarpment slopes themselves, mostly steep sandstone cliffs largely devoid of vegetation except in steep gullies. Occasionally huge rock pillars separated by geological accident from their parent escarpment stand like isolated sentinels. And the mesetas are not flat grassy lawns but are capped with rock outcrops which form natural arches and small rock towers.

Although it has been known for some time from studies in Brazil (Coile & Jones, 1981, Simon & Proença, 2000) that the higher mountains of the cerrados are hotspots for rare and endemic plant species, it is becoming obvious from the work of the Darwin Initiative Project "Conservation of the cerrados of eastern Bolivia" that rock outcrops at lower altitudes are also important sites for rare and endemic species. The rock domes that dot the cerrados of eastern Bolivia are always fascinating to explore, at least after any period of rain. There is a very distinctive tree vegetation along the fringes commonly dominated by the only neotropical species of the common East African genus, *Commiphora*, *C. leptophloeos* (Mart.) J.B.Gillett. Isolated trees on the rock dome are often surrounded by a circle of viciously spiny bromeliads, most commonly *Deuterocohnia meziana* Kuntze ex Mez. or *Dykia leptostachya* Baker. These protect vulnerable plants from grazing animals and the occasional marauding botanist. Then in hollows in the rock there develops a curious ephemeral



Granite rock dome of El Cerrito in the Lomerio region

Meseta of the Serranía de Santiago de Chiquitos with rock pillars

Chaemaecrista chiquitana from El Cerrito

Hippeastrum starkiorum from Santiago de Chiquitos

Pink-flowered *Ipomoea* sp. growing at El Cerrito

Praxelis chiquitensis from Santiago de Chiquitos

All photos on this page courtesy of the Darwin Initiative Project 16-004

aquatic vegetation which includes several species of the insectivorous bladderworts, *Utricularia* and the rare Iris, *Onira unguiculata* (Baker) Rav., which is known only from a handful of collections from eastern Bolivia and Matto Grosso in Brazil.

One particular rock dome, named El Cerrito, in the Lomerio region has proved to be of particular interest as three species endemic to eastern Bolivia grow here, two of which occur apparently only on this rock. The dome itself is a steeply sloping rounded monster rising out of the surrounding cerradão vegetation. It is mostly smooth, bare rock but isolated small trees have established themselves in crevices. It is amongst the patches of spiny *Deuterocohnia meziana* that surround each tree that the endemic plants grow. At the very edge of the patch is *Chaemaecrista chiquitana* Barneby, representative of a very diverse genus of legumes in the cerrados but this species only known from this rock. In amongst the prickly *Deuterocohnia* grows another legume with curious pallid flowers and deeply lobed leaves. This is *Vigna sublobata* Verdc., found some 12 years ago on another granite dome a hundred kilometres to the north, growing in an almost identical habitat. Here at El Cerrito it is even more abundant. However, our most interesting discovery was a species of *Ipomoea*, or Morning Glory, with pink flowers. Its finely dissected leaves combined with an unusual calyx structure indicate that it is almost certainly a new species. This bare rock with its patches of vegetation, is therefore, home to at least three plants unknown outside Bolivia, two of which only grow here.

The summit of the escarpment at Santiago, variously known as "El Mirador" for its spectacular views or "El Organo" for its strange rock formations, is capped by a group of curious sandstone towers, whose bases lie in partial shade. The steep sides are deeply pockmarked with holes which provide ideal nesting places for hornets. It was on my first visit that I met the hornets. David Goyder and I spotted the strange Asclepiad illustrated in the previous edition of *Oxford Plant Systematics* (Wood, 2008) growing on the rock face. I climbed up to collect what would be the type collection of *Blepharodon crabronum* Goyder (Goyder, 2009) disturbing a hornets nest in the process. I returned to earth fast clutching the specimen in my hand while the hornets attacked the spectators below. These cliffs are the main site for a small composite, *Praxelis chiquitensis* (B.L.Rob.) R.M.King & H.Rob, which is common on the rock faces but only known from tiny populations on a few other nearby cliffs. In the shade at the foot of the rocks is the yellow-flowered bromeliad, *Pitcairnia mohammadii* Ibisch & R. Vasquez, while in rock crevices there grows the spectacular amaryllid *Hippeastrum starkiorum* (I.S.Nelson & Traub) Van Scheepen. More modest is a small herb with white flowers in the family Rubiaceae, *Galianthe chiquitosiana* E.L.Cabral. These five species only occur in a few similar places on the neighbouring hills but are unknown anywhere else in the world, and nowhere else, even in the near vicinity, do they all grow together. Nor are these the only plants of great interest. There are several others which we still cannot identify while other very rare species occur such as the tiny *Paepalanthus jahnii* Ruhland, which only grows in rock crevices here and in Matto Grosso.

What makes the rock outcrops so important as hotspots for endemic species? Certainly altitude is not the only factor. Clearly they provide a refuge from the burning which is a defining feature of the cerrado biome, in which they occur. Equally, they could have provided a rare open habitat in previous eras when moister forest covered what is now cerrado. Rare plants could have survived in these relatively unchanging rock habitats until today. And the future? The rocks may well provide a secure haven from anthropomorphic habitat change. Forests can be cleared, cerrados grubbed up and planted with exotic pasture grasses but the rock plants will probably remain safe until the danger from human interference recedes in the distant future.

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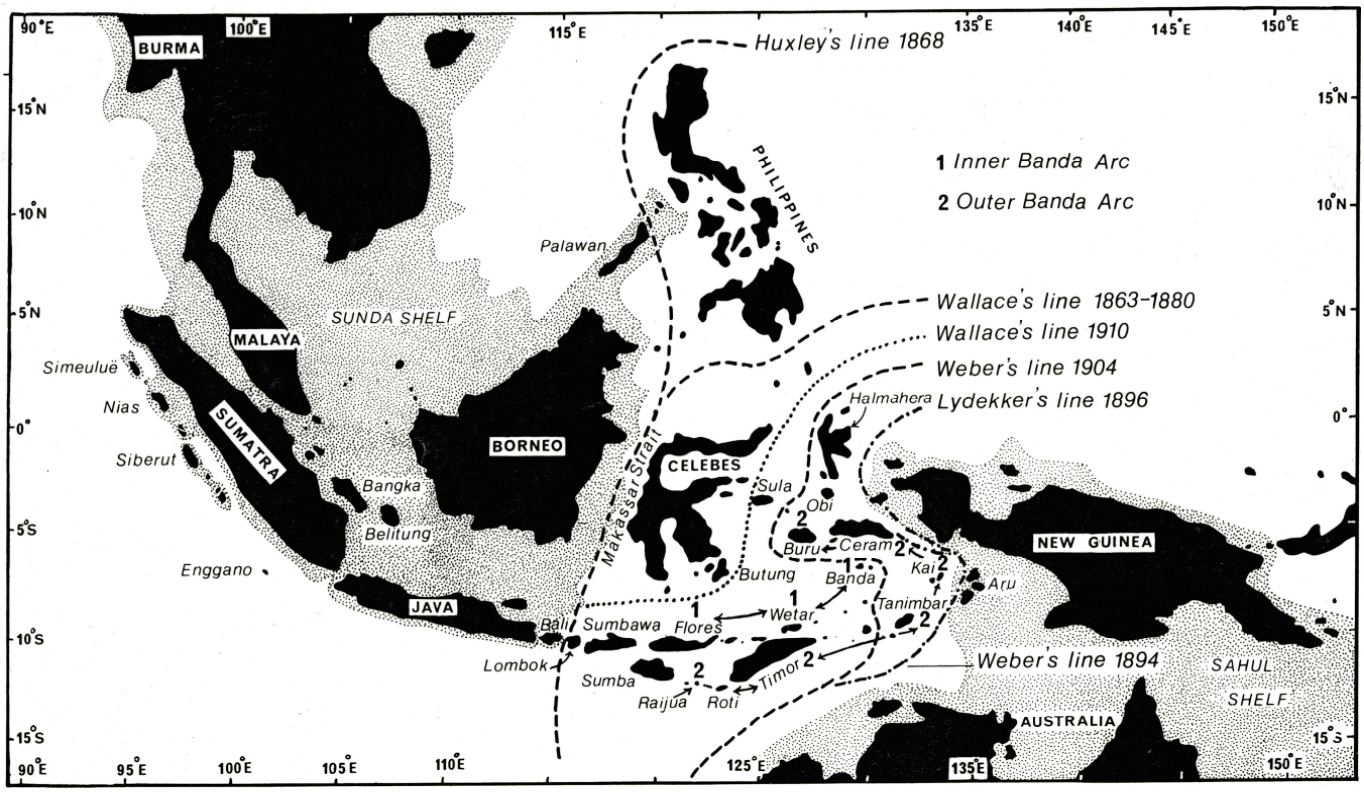
John R. I. Wood
Research Associate

Evolution and Biogeography of *Aglaia*

Two approaches, morphology and molecular phylogeny, have illuminated our understanding of the historical biogeography of the south east Asian genus *Aglaia* (Meliaceae). During preparation of the taxonomic monograph (Pannell, 1992), it became clear that Lydekker's line, which delimits the Sahul continental shelf, on which New Guinea and Australia sit, represents a boundary between predominantly west-Malesian species of *Aglaia* and the eastern species. Lydekker's line was originally based on a disjunction between animal groups. It is one of a series of lines, the first of which was Wallace's Line, located in the Strait of Lombok between Bali and Lombok. Wallace's line is one of the most distinct faunal boundaries in the world. Modified by Huxley (1868), it coincided with the eastern edge of the Sunda continental shelf, which bears the Malay Peninsula, Sumatra, Java, Borneo and the Philippine island of Palawan. Alfred Russell Wallace first mentioned his line in January 1858 in a letter to Henry Bates. This, incidentally, was during the month before the famous paper, authored by Wallace and Charles Darwin, entitled 'On the tendency of varieties to depart indefinitely from the original type' was read to the Linnean Society. The area between the lines is called 'Wallacea' which consists of a deep oceanic trench, from which emerge the islands of the Philippines (excluding Palawan), Sulawesi, the Lesser Sunda Islands (excluding Bali), and Maluku (excluding the Aru islands). These lines were traditionally thought to be more important for animals than for plants. They apply to animals at a higher taxonomic level than for plants, but similar patterns can be detected in plants within individual families and genera, such as the Dipterocarpaceae and *Aglaia* (Pannell & White 1988).

An analysis of the distribution of *Aglaia* species, defined by their morphology, showed that only 10 species occur on both sides of Wallacea, whilst 67 species occur only to the west of Lydekker's line and 37 species occur only to the east. The majority of species found in Wallacea are shared with Sundaland, four are endemic and three are shared with New Guinea. Of the 10 species found on both sides of Wallacea, all but one is either variable or complex in morphological characters. *Aglaia cucullata* (Roxb.) Pellegrin, the one non-variable species, grows in estuaries and mangrove-forest and is probably at least partly dispersed by water. It was therefore clear that, if the variable and complex species could be resolved, the species of *Aglaia* might prove to be almost entirely different on either side of Wallacea. There are two ways for this distinction to have arisen. Either, one species was dispersed across the seas between West Malesia and East Malesia and radiated independently on the two sides of Wallacea or several species crossed the 'barrier' and each was modified morphologically after establishment to the east of Lydekker's line. Seventeen years later, when a molecular phylogeny, built by Dr Alexandra Muellner, was published, evidence for both processes was found



Map showing the series of lines, based on distribution of animal taxa, related to the Sunda and Sahul shelves and Wallacea (from Pannell & White, 1988).

(Muellner et al., 2005). A distinct and derived clade of species in section *Aglaia* was confined to the east of Wallacea, but some widespread species remained nested in the 'Western Clade', even though they occurred as far east as Australia or New Caledonia. Building on this phylogeny, we performed a biogeographical analysis with the programme Dispersal Vicariance Analysis (DIVA). The phylogeny was calibrated using fossils of known age and identified as belonging to genera of Meliaceae. The biogeographical analysis demonstrated that the ancestral area for *Aglaia* encompasses the Malay Peninsula, Sumatra, Java, Borneo and Palawan and that the genus spread from there to the north, west and east (Muellner et al., 2008). Two of the three sections of *Aglaia* (section *Aglaia* and section *Amoora)* have colonised the east independently of one another. For section *Neoaglaia*, there is no DNA sequence available from the east of the range to test this hypothesis. Within section *Aglaia*, the youngest clade (3 MY old) consists of species endemic to Fiji and the next youngest (5 MY old) includes Australian species. Together, they form an 'Eastern Clade', the youngest clade in the genus, and made up of species confined to the east of Lydekker's line. No species from New Guinea or its satellite islands was included in this investigation. The Australian and Fiji clades include representatives of several of the 'morphological groups' into which the genus was informally divided by Pannell (1992, t.2; 2004, t.2). These had been based partly on the trichome structure and the density and distribution of the indumentum on the plant surface, characters that often provide reliable and easily observed delimitations between species in the genus. The Fiji endemics share a unique combination of leaf characters: a rounded leaf apex and divergence of the lateral veins from the midrib at a wide angle of more than 60º. What the molecular analysis has demonstrated is that these two character are not derived independently in each of the species exhibiting it, but that they first acquired the rounded apex and widely divergent veins characteristic of the clade and that the variation in indumentum within the clade has arisen since.

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Caroline Pannell
Research Associate

The Trower sisters and George Claridge Druce

The amateur naturalist has a special place in British botany. Much of the raw data that has contributed to our knowledge of the taxonomy, ecology and biogeography of the flora of the British Isles has been obtained through the exertions of the amateur. Yet amateur botany is often disparaged as 'natural history', and flower painting is dismissed as a social grace for fashionable, nineteenth - and early twentieth - century ladies.

The most prominent amateur botanist during the first three decades of the twentieth century was George Claridge

Druce (1850-1932). Druce was the illegitimate son of a Northamptonshire housekeeper, apprenticed to a wholesale and retail chemist, set-up his own retail pharmacy business in Oxford and retired a very wealthy bachelor about 1904. On his retirement, Druce devoted himself to his primary interest, botany. Reactions to Druce are often polarized; this was true during his lifetime and remains so to the present day. He was treated with a mixture of contempt for his methods and admiration for the means by which he successfully achieved his ends. Druce was essentially a collector of plants for his herbarium; he saw such collections as the gold-standard of scientific research. His first reaction to hearing about a rare plant in the British Isles was to go and collect it. However, Druce was protective of the rarities he discovered but readily supplied specimens of very rare plants, roots and all, for artists to paint.

One of the artists Druce eventually trusted implicitly was Charlotte Trower and her sister Alice. 'I shall be very grateful for any information that you can give me - every one who really cares for wild flowers is so kind in helping us'; so Alice ended her introductory letter to Druce in April 1907. These were well-chosen words, as they played to three of Druce's most prominent foibles; enjoyment of the reflected glory of the rich and influential and interest in promoting his own botanical reputation. Alice Trower's letter was to start a friendship and correspondence that would last until her death in 1929. Over this period they exchanged hundreds of letters.

The Trower sisters

Charlotte Georgina (1855-1928) and Alice Trower (1853-1929) were born into a wealthy Hertfordshire family. On the death of their father, their eldest brother, took on the responsibilities of the family estate and his two spinster sisters. However, when their brother died suddenly in 1914, the Trower sisters took on formal responsibilities for the management of the house and the estate. The two ladies divided these responsibilities. Charlotte was responsible for the running of the farm; Alice for keeping the house. However, it is clear from their correspondence with Druce that Charlotte and Alice were a formidable partnership. The sisters' strength of character is hardly surprising for a pair of women who successfully ran the family estate and were volunteer nurses during the First World War. The Trowers' letters reveal a lively humour. For example, they nicknamed themselves the 'chastened one' (Charlotte) and the 'unchastened one' (Alice) and referred to Druce as their 'beloved vagabond' - running jokes that were maintained to the end of their lives. The Trower sisters were upper-middle-class ladies who had taken to their affections a tradesman. Through him they got access to plants that would otherwise have remained unknown to them, Druce got social cachet and new, if reluctant, recruits to his Botanical Exchange Club empire. These two ladies of contrasting characters collaborated on a project; Alice did much of the field work and Charlotte the paintings.

The Trower Collection

Druce worked with Charlotte and Alice on the watercolour collection from 1907, and finally, in 1928, acquired the whole collection, which he, in turn, bequeathed to the University of Oxford in 1932. The three elements of the Trower Collection are unequal in size and importance. The general botanical watercolours comprise the most significant part of the collection (Trower Main Collection; 1,817 illustrations). The second element is the collection of bramble illustrations (Trower Bramble Collection; thirty-eight illustrations). The third element is the illustrations made specifically for Druce (Trower Druce Illustrations; nine illustrations) and is the least significant. A selection of her illustrations were shown at Royal Horticultural Society exhibitions in 1924 and 1926 for which Charlotte was awarded one Silver and two Silver-gilt Grenfell Medals.

Charlotte almost always worked, early in the morning, from fresh plants that she or her sister had collected from the wild, had collected from their garden (originally from seeds or plants transplanted from elsewhere) or were sent to them via their network of collaborators. The results are minutely observed watercolours of great delicacy, and importantly, they give an excellent impression of the plant's *Gestalt*. The Trower sisters were not particularly interested in dried plant collections, the focus of Druce's interest: 'we do not collect dried flowers. I think that we got thoroughly tired of them when we were young - some old Aunts used to show us very bad specimens whenever we went to see them giving us long histories of each flower. I have never seen a good Herbarium'.

Trower Main Collection

There are 1,817 illustrations in the Trower Main Collection. All illustrations are on white paper of a standard size and crudely mounted on brown paper. Each painting was annotated in pencil with the following: plant family name, scientific and vernacular names, collection location and date. Charlotte usually signed the bottom right-hand corner of the sheet. Each painting, even before she met Druce, usually comprised the plant's habit together with details of the flowers or fruits. After Druce had acquired the illustrations he made additional annotations in his usual scruffy hand. The annotations include the number associated with his *British Plant List* (1928) and indications of the plants that he supplied to Charlotte, when these details were missing.

Of the paintings in the Trower Main Collection, almost all bear year dates (1904-17; 1921-28), and nearly 29% were prepared before the Trower sisters made their first contact with Druce. The earliest painting in the collection is dated 2 February 1904 and is of Alder (*Alnus glutinosa* (L.) Gaertn.) collected from Amwell Marsh (Hertfordshire). The first painting that Charlotte made after her sister's first visit to Druce in Oxford was, appropriately, Oxford Ragwort (*Senecio squalidus* L.). The last painting,

Tetragonolobus maritimus (L.) Roth, watercolour by Charlotte Trower 1924 from material collected by George Druce at Henley, Berkshire in July.

dated 30 April 1928, seven months before Trower's death, was supplied by Druce and was of the sedge '*Carex oxoniensis* Druce' from Thame (Oxford-shire), one of Druce's last discoveries in the British flora.

There were two distinct periods of artistic activity, 1904-17 and 1921-28, associated with the Main Collection. On average, 82 watercolours were completed per year, although the number of watercolours varied between one (in 1917) and 211 (in 1905). The absence of activity between 1918 and 1920 is unexplained, but it does indicate that the sisters did not have the acquisitive passion of the obsessed collector. There is also a gap in the Trower's correspondence with Druce during this period.

Excluding Alice's own contribution, 76 people contributed plants for Charlotte to paint. By far the greatest contribution was made by Druce (272 plants) who regularly sent plants during two periods. The Trower sisters were widely travelled in the British Isles, especially Alice. The vast majority of plants in the Main Collection are from Britain and Ireland. The Main Collection contains watercolours of 1,467 taxa. In terms of the taxonomic representation of the collection, the top three families are the Cyperaceae (220), Asteraceae (160) and Fabaceae (101). There are some surprising omissions, for example only two grasses are represented. Inevitably, serendipity played an important part in the watercolours that Charlotte prepared. Very rare plants (e.g., *Carex microglochin* Wahlenb., *Cypripedium calceolus* L., *Epipogium aphyllum* Sw.) are found in the Collection, yet common species, such as Hemlock (*Conium maculatum* L.), Heather (*Erica tetralix* L.) and Sun Spurge (*Euphorbia helioscopia* L.) are absent. In 1935, 501 of Trower's watercolours were published in a disappointing volume (Skene, 1935).

Trower Bramble Collection

The Trower Bramble Collection comprises 38 watercolours and black ink drawings of British representatives of the genus *Rubus* (Rosaceae). Unlike the watercolours in the Main Collection, the brambles were illustrated on either heavy-duty white card or white paper. Each painting or line drawing was annotated in pencil with the following: scientific name, collection location and date. Charlotte usually placed a 'CGT' monogram on the sheet. The bramble illustrations are part of an aborted project devised by Druce to focus Charlotte's talents for botanical painting. Brambles are a notoriously complex group in the European flora, and she was advised that to make the collection representative of the British species, it would be necessary to paint 100 to 200 species. Charlotte needed the help of an expert on brambles; she found this in the aged Revd William Moyle Rogers (1835-1920), Britain's leading pre-First World War batologist. Rogers had enormous practical experience of bramble variation both in the field and the herbarium, and ensured that Charlotte's illustrations were representative of the *Rubus* species they depicted. Rogers described Charlotte as 'patient & enthusiastic & deserves any help that I can give her', yet he was highly critical of her work and only considered about one in four of her plates as characteristic. He also demanded that she prepare herbarium specimens for all of the illustrations since 'in painting your great difficulty is to be sure that your pieces are quite representation average ones'. Charlotte naturally turned to Druce for advice on how to prepare herbarium specimens of such difficult material, a fact which is ironic given that Rogers was critical of specimens that Druce had prepared for him. Trower appears to have been more realistic about the difficulties of this project than Druce. The illustrations were eventually published in 1929, as black-and-white relief halftones, with a subsidy from Charlotte's will (Watson, 1929).

Conclusions

Charlotte Trower's watercolours were the artistic product of one woman's collaboration with her sister, a team of enthusiastic collectors and a pre-eminent amateur botanist. The letters that exist between the Trower sisters and Druce reveal a collaborative network that extends across amateur and professional botanists, together with casual collectors interested in natural history and art. Charlotte is a forgotten illustrator of the British flora, the quality of whose illustrations is marred by indifferent reproduction of her published work. Through collaboration with her sister Alice, and a network of botanical contacts, Charlotte was able to draw a significant proportion of the British flora. Furthermore, her interactions with Druce gave her the constructive criticism of prominent botanists. Druce enabled her to gain access to some very rare plants. The corpus of Charlotte's work is a testament to her skill and tenacity.

This article is an abridged version of a more detailed analysis of the Trower collection (Harris, 2009). Images from the Trower collection are available at http://herbaria.plants.ox.ac.uk/bol/?Trower.

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Stephen A. Harris
Curator of Oxford University Herbaria

George Claridge Druce's Birthday Book

George Claridge Druce (1850–1932) was an influential, though not uncontroversial, botanist who had a long association with Oxford University, particularly with the Botany Department. Druce was heavily involved with developing and describing the University's herbarium collections (Allen, 2004; Black & Black, 2007). After his appointment as the special curator to the Fielding Herbarium in 1895 his efforts helped to restore the collection from the dilapidated state into which it had fallen. In addition to publishing detailed accounts of his work at the herbarium, Druce also authored substantial floras covering four counties and a range of other works appeared throughout his life.

Druce became the Honorary Secretary of the Botanical Exchange Club (BEC) in 1903 and considerably expanded both the size and activities of the organisation. This position brought him into contact with many fellow botanists and collectors around the globe. Involvement with local politics in Oxford and links with the pharmaceutical trade (Druce ran a pharmacy in Oxford from which much of his wealth was derived) further widened Druce's network of friends and colleagues.

In 1930 the BEC held a large party to celebrate the 80th birthday of their secretary (Foggit 1931). Prior to the festivities many of Druce's friends and contacts had been solicited to send birthday greetings, and, if possible, signed photographs of themselves. Items received were collected together into a handsomely bound scrap-book. The items cover a range of materials including photographs, letters, telegrams, cards and newspaper cuttings. This scrapbook became known as the 'Birthday Book'.

Druce passed away in February 1932 at his home in Oxford. His will left a large bequest to Oxford University, conditional upon the University overseeing the stewardship of Druce's personal documents, correspondence, herbarium specimens and manuscripts (Fig.1). Amongst this assortment was the Birthday Book, which is currently housed amongst the Special Collections of the Oxford Herbaria and Plant Sciences Library. The Birthday Book represents a fascinating historical document

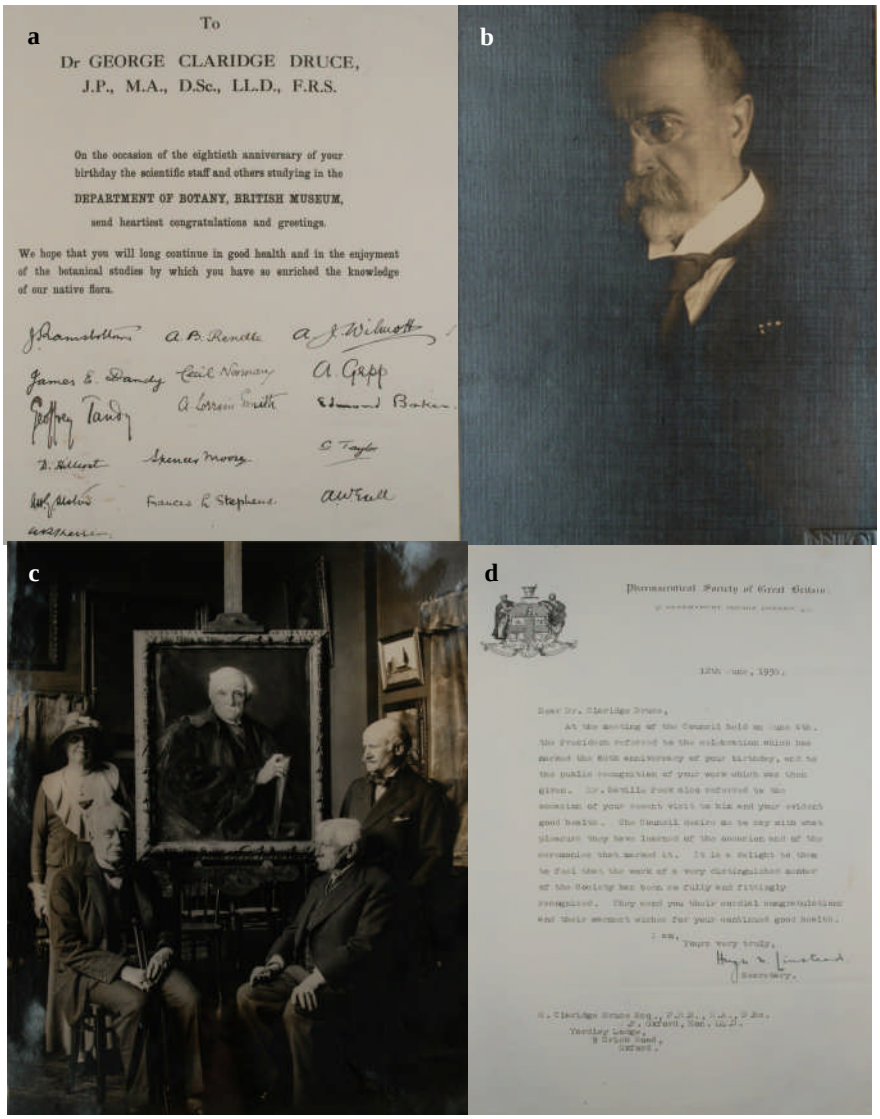

Fig. 1 A selection of items from the Birthday Book. *(a)* Letter from the British Museum. *(b)* Portrait photograph of the President of Czechoslovakia. *(c)* Druce (right, sitting) in the studio of a portrait artist. *(d)* Letter from the Pharmaceutical Society of Great Britain.

which, we believe, contains unique images of prominent botanists and scientists of the day. The contents are valuable to those who study the work of these individuals, as well as Druce himself. The book also serves as a testament to the wide scope of Druce's contacts and interests. A portrait photograph of Druce in his Mayoral regalia is juxtaposed with birthday greetings from the staff of the British Museum, the Pharmaceutical Society of Great Britain and a former President of Czechoslovakia!

Sadly, the existence of the Birthday Book is not widely known (it is not even listed on OLIS, the Oxford University public access electronic library catalogue) and accessibility is currently limited to a handful of researchers. Additionally, the book itself is in a fragile condition. Damage to the spine and binding has occurred and some items have come loose from the pages due to poor mounting. We have undertaken a project in the Plant Sciences Library to catalogue the contents of the Birthday Book and present the data as part of a searchable database to help tackle these problems. The project has three fundamental aims. Firstly, to provide a detailed catalogue of the Birthday Books contents. Secondly, to improve accessibility and awareness of the books contents. Thirdly, to aid conservation by using the database as a surrogate for the book itself, thus reducing unnecessary handling.

As preliminary steps in cataloguing the contents of the book we began by numbering each page and giving each item a unique catalogue number. The documents within the book were divided into 29 separate physical description categories. For example, telegrams, handwritten letters, typed letters and photographs with handwritten captions. A relational database was then constructed using Microsoft Access. This program was selected because it is a widely used and familiar package with sufficient functionality to allow construction of the Birthday Book database.

The database collects a variety of information about each item. The item's catalogue number, page number and physical description (picked from the 29 available categories) are mandatory and are always provided. Further information is optional depending on what is given on the item itself. Supplemental data collected includes dates, names, addresses and relevant notes about the condition of the item. Records of named individuals can be elaborated through incorporating details of job positions, memberships of learned societies, dates of birth/death and external web links to further biographical data where available. Finally, one or more photographs of the item are attached to each record. The data are stored in network of six linked tables (Fig. 2). Each table is dedicated to holding a particular set of information. For example, one table stores all the address information, another all the image data, and so forth. This structure allows separate sets of records of names, addresses and images to be maintained easily. In practice this allows us to append any number of names, addresses and images to an item's completed record without duplicating information within the database. This is important as some items in the Birthday Book have been signed by dozens of individuals. User-friendly data entry forms have been designed to simplify the process of adding records to the database (Fig. 2).

Even after only completing cataloguing around one third (115 separate items) of the Birthday Book contents, the details of 226 individuals have already been recorded. In order to make the large quantity of data manageable, search tools have been constructed. The database can be searched by a number of criteria including individual's names, locations and particular institutions. Searches can be limited to a particular type of material from one of the 29 categories. For example, we could search for all handwritten letters relating to John Smith. As the result of a search the database is able to list every item that satisfies the criteria specified and indicate there locations in the birthday book. Full records containing images of items of interest can then be accessed and viewed.

There is still significant work to be accomplished on the database. Tasks include the completion of data entry from the book, the development of more flexible searching and data reporting tools and completing appending digital to images to each of the records. There are two further objectives to the project. Firstly, at least a subset of the information in the database will be integrated with the herbarium database that uses BRAHMS. Secondly, it is hoped that the database can be made available to all researchers by distribution across the internet. There will be substantial technical challenges to overcome in accomplishing these objectives.

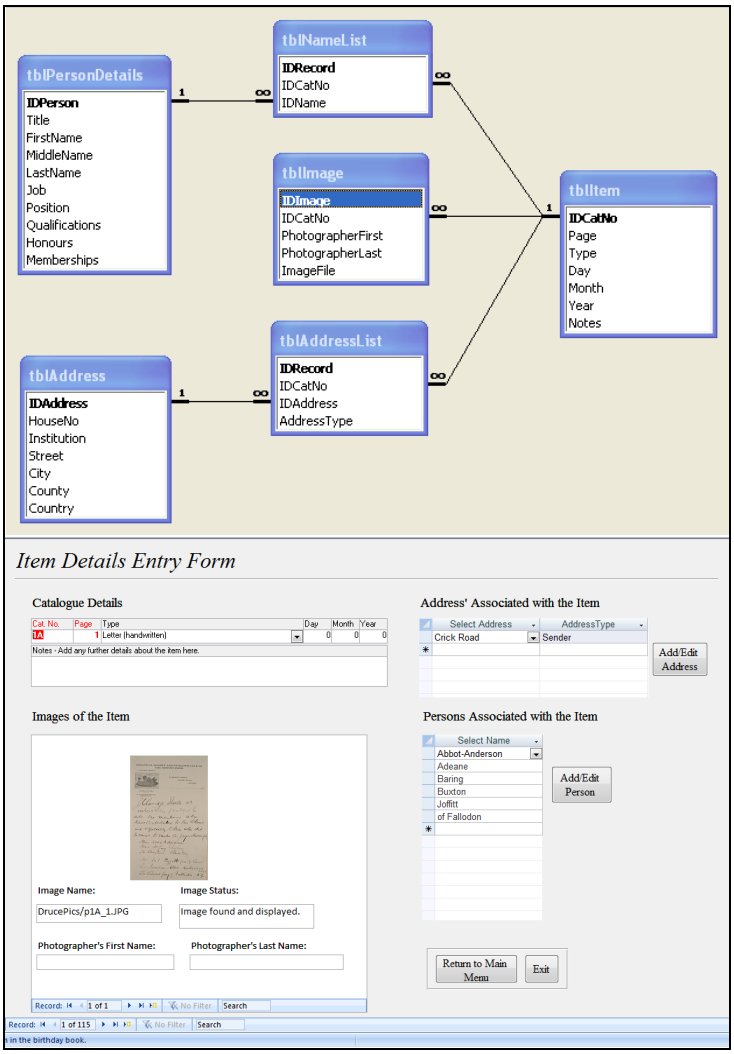

Fig. 2 The relational database is constructed from a set of six tables. However, from the user's perspective an item's details are entered using a single form.

However, the potential benefits of acquainting a wider audience with the contents of this remarkable document are certain to justify the time and effort involved.

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Oliver Bridle
Library Assistant

News from the Herbaria

2008 was a busy year for the herbaria in which we welcomed in the region of 150 visitors on various occasions. There was a steady flow of loan material being sent out from OXF and FHO, although we received a smaller amount of loan material than in previous years for staff and students as various research projects were coming to completion. Also a substantial number of specimen images were sent via the internet as electronic loans, this being an increasing trend. Work continued on databasing the collections and digitising type specimens.

Almost 90 specimens of miscellaneous taxa from OXF and FHO have been lent to the Oxford University Museum of Natural History for a new botanical display in the museum highlighting the range of plant diversity. This is the first time there has been a 'permanent' public display area for the collections from Oxford University Herbaria.

Visitors

Several group visits were organized during 2008 and we collaborated with Plant Sciences Library, especially with Anne Marie Townsend, Special Collections Librarian, to put on displays of herbarium specimens and associated literature unique to Oxford. The first of the group visits took place on 4th April when 48 members of the EBHL (European Botanical and Horticultural Libraries) Conference at Merton College, organized by Roger Mills (Biosciences and Environmental Sciences Librarian) came to the Department. Likewise on 16th June, 22 visitors from the Swedish Linnaeus Society were shown a display of herbarium specimens and associated literature with special reference to Carl Linnaeus and Johan Jacob Dillenius, Sherardian Professor of Botany at Oxford (1732-1747). They were also shown the *Flora Graeca*. We collaborated with the Linnean Society of London in arranging this trip for members of the Swedish Linnaeus Society to visit various venues in London and Oxford. A report of their excursion to the UK was published in *The Linnean* (Newsletter and Proceedings of the Linnean Society of London) 24: 9-11 (Oct. 2008). Another visit in collaboration with Plant Sciences Library took place on 14th July when 20 visitors attending the ALLCU (Association of Libraries in Land-based Colleges and Universities) Conference at Wadham College Oxford were also given a tour. The focus of the display for this group was an introduction to the herbarium collections over four centuries and included the herbaria's oldest 'Book Herbarium', that of *Gregorio da Reggio* dated 1606 (see *OPS* 13: 9-10), following right through to recent publications and specimens collected by research staff in the twenty-first century.

On 13th August 2008 we were pleased to welcome four staff from the Royal Botanic Gardens Kew and show them our methods of mounting and storing specimens and various examples from the collections of OXF and FHO. In November, four members of the Sheffield Botanic Garden Florilegium Society visited also to see how specimens are prepared and stored etc with a view to starting a herbarium at the Botanic Garden in Sheffield associated with their botanical paintings of plants. This was followed by a group visit in December by students studying for a Diploma in Environmental Conservation at the Department of Continuing Education, University of Oxford.

Several artists also visited to draw from herbarium specimens and carpological material (see article and drawings by Sarah Simblet on pages 13-15).

Fielding-Druce (OXF)

We are grateful to a number of people who have offered help in determining specimens in the collections, especially to Professor Dr

Paul Maas from the Netherlands who determined a batch of previously unnamed Robert Schomburgk collections from Guiana, also to Dr Bruno Ryves who is gallantly naming as many grasses as we can send him at Kew. We are also thankful to Julian Harber who made a return visit to re-sort the OXF *Berberis* specimens into a more logical order after studying them in connection with a Flora of China account. This material includes many type specimens of cultivated origin, cultivated and preserved by the Rev. Lesley Ahrendt.

New accessions to OXF included 320 miscellaneous specimens collected by Dr Caroline Pannell in Portugal on the undergraduate field course in 1988/89, with a few additional specimens collected by Professor David Mabberley and Mr Peter Placito. These are intended to be a source of reference material from the area in Portugal annually visited by second year students. A few specimens of Bromeliaceae from Venezuela, which had been presented in 1978, were also databased and incorporated. A few miscellaneous plants from the Shetland Islands, sent by Mr Walter Scott (co-author of the *Flora of the Shetland Islands*) were added to the Druce (British) Herbarium, plus a number of new lichen specimens presented by Professor Mark Seaward and collected mostly from the UK.

During the month of August, Cicely Marshall, an undergraduate, was employed to database and incorporate specimens and to help generally.

This year a greater number of specimen images were sent as internet loan material than specimens actually sent through the post in the traditional way. Specimen images sent included those of *Berberis*, Berberidaceae; *Corydalis*, Papaveraceae; *Erophila*, Brassicaceae; *Gentiana*, Gentianaceae; *Heiracium*, Asteraceae; *Linaria*, Scrophulariaceae; miscellaneous Lauraceae, miscellaneous Marcgraviaceae and *Xylaria*, Xylariaceae. Other loans requested comprised material of *Anthonotha*, Fabaceae; *Lonchocarpus*, Fabaceae; *Machaerium*, Fabaceae; *Koeleria*, Poaceae; miscellaneous Loranthaceae, Ochnaceae and *Passiflora*, Passifloraceae. 642 specimens were returned to OXF from loan and 10% of these were types.

The complete OXF holdings of marine algae were databased and a number of the specimens were exhibited in a temporary exhibition at the Oxford University Museum of Natural History from December 2008 to February 2009 (see front cover, caption and news item on page 2).

Daubeny (FHO)

During 2008 over 800 specimens were sent on loan to other herbaria from the FHO collections. The larger loans included material of *Anthonotha*, *Lonchocarpus*, *Maclearium*, *Macrolobium*, all Fabaceae; miscellaneous Meliaceae; miscellaneous Ochnaceae and *Passiflora*, Passifloraceae. All specimens are now databased before being sent out on loan and any name changes on return of the material can be added to the database (BRAHMS) quite easily. The complete 'determination' history of any specimen can be recorded.

Most of the material received on loan from other herbaria during the same period came for research studies by John Wood on the families Acanthaceae, Lamiaceae and Polygalaceae. A number of other specimens of *Tecoma* (Bignoniaceae) and *Mimosa* (Fabaceae) were received for study by Tiina Sarkinen. Miscellaneous specimens of plants from Trinidad and Tobago were received on loan for Rosemary Wise, Botanical Artist, to draw for a Trinidad and Tobago Checklist project funded by the Darwin Initiative [see *OPS* 13: 3 (2006) & *OPS* 14: 3 (2007)]. About 400 specimens previously sent to Oxford on loan for research studies were returned to other herbaria – this material mostly comprised specimens of *Agathis* (Araucariaceae) which had been sent for study by Timothy Waters, a former D.Phil. student in the Department.

Members of the systematics research group have donated many newly collected specimens gathered on fieldwork during 2008. New accessions to FHO comprised mixed specimens, especially legumes, collected from Peru and Bolivia by Colin Hughes, legumes collected in Brazil by Marcelo Simon, more legumes collected by Tiina Sarkinen and colleagues in Argentina, Peru and Bolivia. Other accessions included specimens of *Tecoma* (Bignoniaceae) collected by Tiina Sarkinen and a batch of *Tecoma* & *Delastoma* (Bignoniaceae) collected by Marcelo Simon. Gifts of material from other herbaria included specimens of Acanthaceae of the Flora of Myanmar presented by the Makino Botanical Garden of Japan. Other material was sent from Queensland, Australia, of *Toechima* (Sapindaceae) and material of *Aglaia* (Meliaceae) from the Australian Tropical Herbarium in Cairns Australia. Additional specimens collected by members of the systematics research group in South America were sent as gifts to various herbaria. This material included specimens of *Calceolaria* (Calceolariaceae) collected by Colin Hughes and sent to E, duplicates of *Adesmia* (Fabaceae) collected by Colin Hughes and Tiina Sarkinen sent to SI in Argentina and several of Tiina's South American duplicates were sent to UEC, Brazil, NY, AAU and E.

Serena Marner
Herbarium Manager

See Oxford University Herbaria database at:
http://herbaria.plants.ox.ac.uk/bol/?oxford

Back issues of OPS can be viewed at:
http://herbaria.plants.ox.ac.uk/OPS.html

Unstill lives. An artist working in the herbarium

For two years now, my studio door has only been visible as a brass handle poking out from between two pages of a book. Many visitors forget where it is, and so stand puzzling, often in front of the wrong wall, as they try to remember where and how they came in. I am an artist, and I write and illustrate books about my passion for drawing. Dorling Kindersley (DK) has commissioned three of these. Each one is filled with hundreds of images, and so is planned and made flat across the walls of my studio. Long rows of developing pages, taped edge to edge, cover every vertical surface, from ceiling to floor, including the door, so that all of the chapters are developed in unison, every page can be seen at once, and visitors may find it a little hard to leave.

The book that surrounds me now is an introduction to plant morphology for artists, a drawn and photographic journey into the wonder of plants. It features parts of around 500 species, ranging from enormous and gorgeously unfamiliar tropical flowers and fruits, to the beauty that is in the pavement milk thistle, colonies of down pipe liverworts, and tufts of city moss; always there to be discovered, if only we'd slow down and look. *Botany for the Artist* will be published by DK in the autumn and it has been made substantially possible by the generosity, support, and immensely rich resources of the University of Oxford Botanic Garden and University Herbaria.

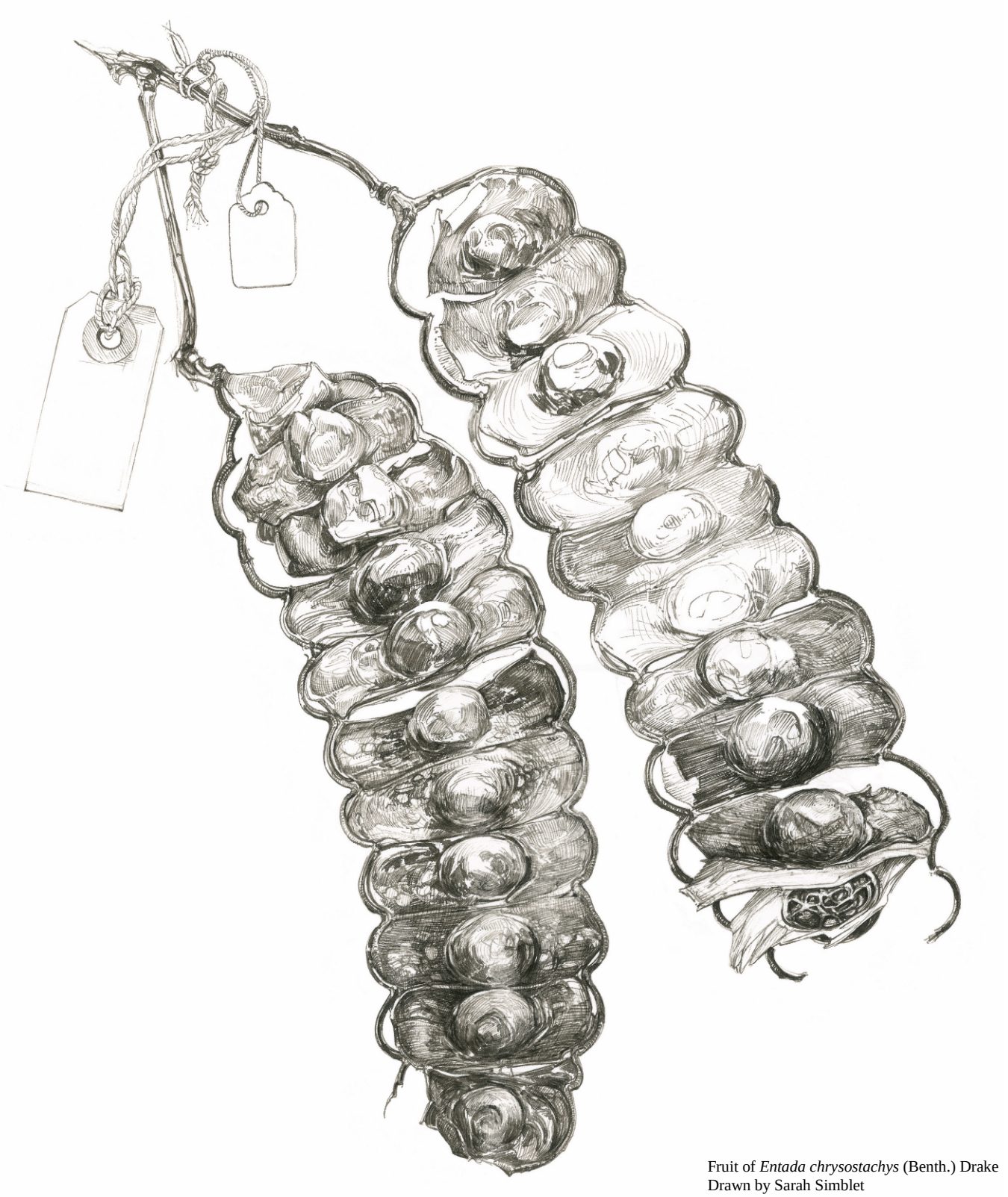
A herbarium is a treasure trove for an artist, a scientific and visual library that informs through touch and sight as much as by the written word. Unfamiliar things can be picked up and held in the hand; experienced in terms of their density, weight, surface and sculptural form. Dry fruits are all named, dated, filed and packed into a box or bag, with folded notes, hand written or typed by their collector. These detail plant habit and terrain, and every item holds the excitement of its find. Many dates are quiet reminders of wars and world events, and evoke thoughts of the experience of plant hunting in those times; risks and dangers faced; modes of transport taken. A herbarium preserves the united work of thousands of people, from ebullient adventurers who risked everything on expedition, to quieter lives lived nearby, and the infinity of their shared story spills out of every opened drawer.

When I first visited the Daubeny Herbarium, I knew tropical dry fruits would have an important place in my book, but I couldn't imagine what they looked like. Cupboards were soon opened and I was introduced. A tiny parachute made of beetles wings balanced on my palm. It was

an *Aristolochia* fruit, and I was told that despite its fragile beauty, its parent would have stunk like a rotting sheep. Something heavier, hairier, and the colour of mustard dust, was labelled *Sterculia oblonga*. Racks of pods in wriggly frames showed me the notion of a replum, followed quickly by visions of African *Entada* pods, two metres long, dropping shiny seeds, the size of piano wheel rests, into the east Atlantic ocean, where they become clues to the movement of global currents and can turn up on the west coast of Wales. Near to these, two tiny pairs of demonic looking rams horns lay on a windowsill, each one heavy as a pebble. More pods I was told, but these ones hook into bears.

The first time an artist visits a herbarium, and they are invited to open some of the cupboards and drawers, a new world rushes into their head, that is an utter feast for their imagination. I have since taken the liberty of bringing fellow artists, designers, writers, and students from the Ruskin School, to see the university herbaria, and to begin using this great resource for themselves. Every one of these guests has left the collection beaming, and with a plan for their imminent return.

Sarah Simblet
Ruskin School of Art



Fruit of *Entada chrysostachys* (Benth.) Drake
Drawn by Sarah Simblet

A selection of fruits drawn by Sarah Simblet : (top left) *Shorea macrophylla* (de Vriese) P.S. Ashton; (top right) *Aristolochia ringens* Vahl; (bottom left) *Proboscidea* sp.; (bottom right) *Enterolobium cyclocarpum* (Jacq.) Griseb.

Mapping diversity using BRAHMS 6.5

During the last year, functions have been added to BRAHMS to generate distribution summaries for taxa and based on these, to calculate diversity indices for the selected geographic scale. Results are displayed in spreadsheets and/or mapped to Google Earth, ArcView or another GIS.

For documentation on all procedures, see http://dps.plants.ox.ac.uk/bol/documentation/Default.aspx: *Mapping > Quick Links*.

Distribution calculations

By selecting a Taxa x Geographic combination on the distribution-diversity calculation form (see top right), the process creates a summary table based on the selected data sources. With Family x Country selected, the table would include one record per family-country combination together with totals and ranges for each combination (collection total, altitude range, lat/long boundaries, *etc.*). Similarly, the selection Species x Grid cell would create one record for each species-grid cell combination. Cell sizes can be defined.

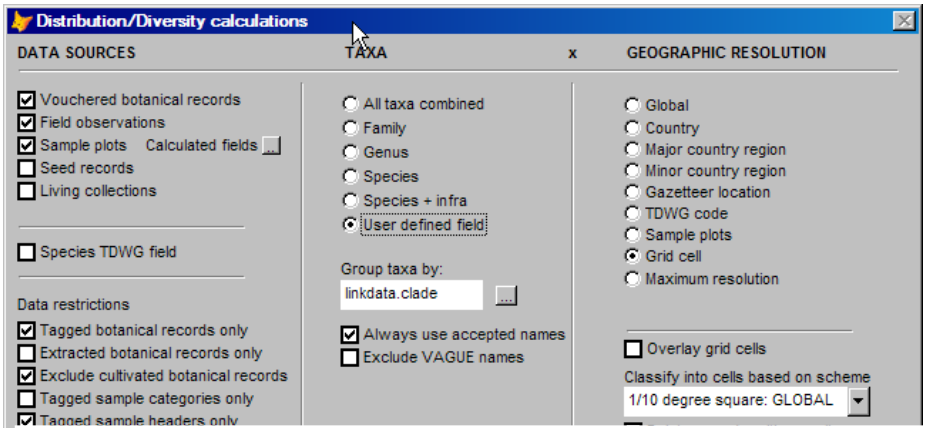
When mapping, lat/long range values can be adjusted to area centre, origin or average. Grid cells can be plotted as polygons. Summaries can be mapped directly from BRAHMS or exported elsewhere for further analysis. An explicit export link is provided for PC-ORD for multivariate analysis.

Diversity calculations

Distribution results are further processed into a separate 'diversity indicators' table with one record for each area or cell. Each record includes totals of families, genera, species, taxa and collections/plots.

Also calculated are a Chao2 species richness estimate, a Rarity Weighted Diversity (RWD) index and the Genetic Heat Index (GHI). Chao2 estimates species richness based on the number of species that are found once, twice, and more often than twice. This formula is important as it estimates the true number of species, not the number actually found, effective when mapping diversity for areas with different collection densities. The RWD calculation (grid cell calculations only) first calculates the number of cells each taxon in a given cell occurs in. Taxa that occur in fewer cells are assigned a higher value. Finally, values are summed for all species occurring in the cell to create a cell total.

GHI values are based on a weighted species scoring system devised by William Hawthorne. These are 'bioquality' scores that can be applied to samples of species at any scale, and show the degree of localness or edemicity of the species in the sample. Each species is assigned a Star value (black, gold, green, *etc.*), these representing global distribution, refined by local factors such as local distribution and taxonomic relatedness.



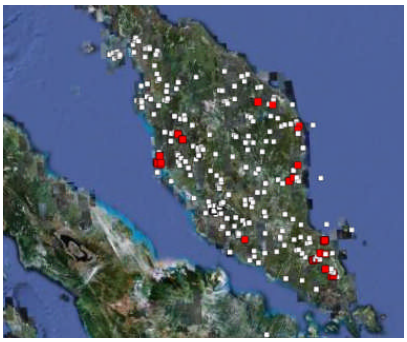
The upper part of the BRAHMS distribution-diversity calculation form.

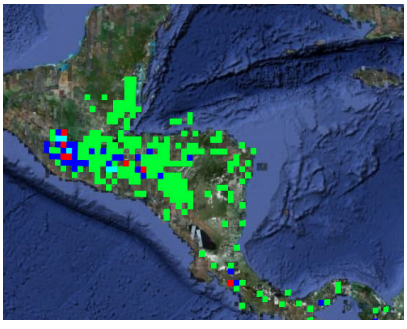
A separate BRAHMS table lists Stars and their adjustable numeric weights, which are determined by mean global range on a degree square resolution of the species of each Star. The GHI field in the diversity table sums the species x Star-weight value per selected area, divided by the species total. Areas with many species may have a lower GHI than areas with a small number of high scoring species. Hotspots can be detected at any scale.

Google Earth mapping

BRAHMS plots directly to Google Earth using individual points or polygons (grid cell boundaries). Colours, symbols, point size, text and labels are controlled within BRAHMS using map style setting options. Google Earth is ideal for displaying diversity analysis results at different scales.

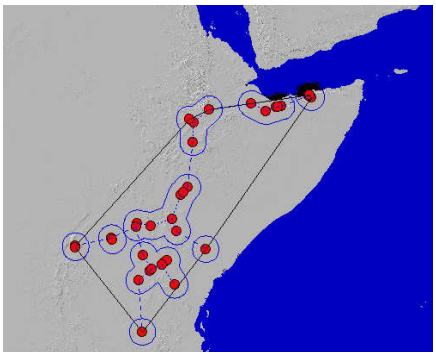
Displayed below, records of *Vatica* on the Malay Peninsula with *V. cimeria* in red; A 1/4 degree cell map of all conifer taxa in Mesoamerica plotted as polygons, style set on Rarity Weighted Diversity, red cells with highest index values. Data from FRIM, Malaysia and A. Farjon, Kew respectively.



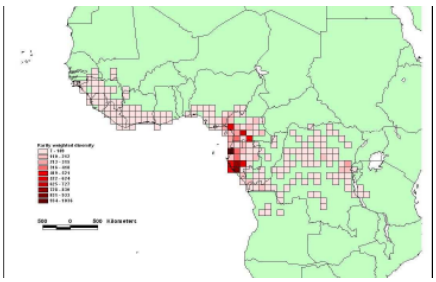


Two ArcView extensions

The Conservation Assessment Tool (CAT) ArcView extension developed by the GIS Unit, RBG Kew generates preliminary conservation assessments (IUCN Categories and Criteria) based on extent of occurrence (EOO), area of occupancy (AOO), number of sub-populations and number of locations. The species level results can be stored in a BRAHMS species link file.



Preliminary conservation assessment using CAT, for *Kalanchoe marmorata* from East Africa showing 9 sub-populations and the extent of occurrence (T. Pearce, Kew).



Anthonotha species per grid cell mapped using an ArcView extension developed at Wageningen University (J. Wieringa, Wag.)

ArcView extension download links are provided via the *Mapping > Quick Links* reference given in the introduction. The analysis functions discussed here have been developed in collaboration with W. Hawthorne (Oxford), J. Wieringa (Netherlands) and the GIS unit, RBG Kew.

***Denis Filer**, Research Associate*