Oxford Plant Systematics

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

OPS 24 **June 2018**

Foreword

Herbaria are slices through plant diversity in time and space, and long-term scientific investments with unexpected cultural value. Until recently in Oxford University Herbaria that slice was about 400 years. Through his research on a collection of specimens overlooked for over a century, Sandy Hetherington has extended that slice to about 400 million years. Using the earliest-known Polynesian sweet potato specimen (housed in the Natural History Museum London), Pablo Muñoz Rodríguez and colleagues have determined the likely age of this important crop plant and reopened discussion of human migration patterns around the Pacific.

George Claridge Druce, the Oxford-based pharmacist, politician and natural historian, amassed a herbarium of several hundred thousand specimens; a snapshot of British plant diversity before 1930. Serena Marner presents an outline of this controversial figure's contribution to British field botany. His specimens contribute to baseline date upon which change in the British flora can be investigated, as outlined by Keith Kirby.

For herbaria to be records of current plant diversity in the future, new specimens must be acquired. High-quality plant collections, such as those made by John Wood during exploration of Bolivia, are essential. In the seventeenth century, the first keepers of the Oxford Botanic Garden made herbarium specimens to support the lists of the plants they were growing; greatly increasing the scientific value of their lists. Voucher specimens remain vital in modern plant sciences research if data are to be objectively assessed by future researchers.

Researchers applying modern technologies to address specimen-based questions need ready access to both herbarium specimens and their associated metadata. Denis Filer and Andrew Liddell explain how BRAHMS v8 integrates all types of natural history collections to enhance data accessibility.

Application of advanced technologies means pigments used in one of the University's greatest botanical treasures, Ferdinand Bauer's *Flora Graeca* watercolours, can be investigated. Rosemary Wise describes her role in this research, together with the methods Bauer probably used to create his botanical masterpieces in eighteenth-century Oxford.

Collectors who contribute specimens to herbaria have many different reasons for doing so. Yet once their specimens are accessible within collections they start to be used in manners far removed from what original donors envisaged. As many of the articles in this year's edition of *Oxford Plant Systematics* show, the importance of an individual specimen may only become apparent decades after it was originally collected.

Stephen A. Harris
Curator of Oxford University Herbaria

Contents

Department of Plant Sciences, University of oxford, South Parks Road, Oxford, OX1 3RB, U.K. Tel. +44 (0) 1865 275000

Oxford Plant Diversity Research Group website: http://herbaria.plants.ox.ac.uk
Oxford University Herbaria database at: http://herbaria.plants.ox.ac.uk/bol/oxford

News

Awards and appointments

Many congratulations are due to the following:

Pablo Muñoz Rodríguez, D.Phil. student, has received this year's Social Impact Award from Oxford Interdisciplinary Bioscience, Doctoral Training Partnership, for the publication of his recent paper on the origin of the sweet potato:
Muñoz-Rodríguez, P., Carruthers, T., Wood, J.R.I., Williams, B.R.M., Weitemier, K., Kronmiller, B., Ellis, D., Anglin, N.L., Longway, L., Harris, S.A., Rausher, M.D., Kelly, S., Liston, A., Scotland, R.W. (2018). Reconciling conflicting phylogenies in origin of sweet potato and dispersal to Polynesia. *Current Biology* 28 (8): 1246-1256.

Alexander (Sandy) J. Hetherington has been presented with the Irene Manton Prize from the Linnean Society of London for the best Ph.D. thesis in botany examined in a UK institution for an academic year. His thesis was entitled 'Evolution and morphology of lycophyte root systems'. He studied under the supervision of Professor Liam Dolan, Sherardian Professor of Botany in the Department of Plant Sciences. His research involved studying fossil lycophyte (club-moss) roots in collections, including those found in Oxford University Herbaria (see the article on pages 4-5). Sandy is currently a "Fellow by Examination" at Magdalen College, Oxford.

On successfully completing her D.Phil. thesis, **Cicely Marshall**, has been appointed to a Junior Research Fellowship at King's College, Cambridge. This will be taken up at the Cambridge Conservation Initiative, starting in October 2018. Cicely will be testing evolutionary theories used to explain plant endemism hotspots in tropical Africa, for example by testing whether extinction and speciation happened at different rates, or at different periods, inside and outside hotspots.

Stephen Harris, Curator of Oxford University Herbaria, has been awarded the title of Associate Professor in the Department of Plant Sciences.

Front cover image:
Watercolour of *Fritillaria meleagris* L. painted by Rosemary Wise using a colour-code system, and pigments identified in Bauer's watercolours and recreated according to traditional eighteenth-century recipes.

Typesetting and layout of OPS by Serena Marner

Staff retirement

Anne Marie Catterall retired in September 2017, after 35 years as the Librarian of the Sherardian Library of Plant Taxonomy. Soon after her arrival in Oxford Anne Marie recognised the intimate link between the library collection and specimens housed in Oxford University Herbaria, yet the library was on long-term loan to the Bodleian Library, following decisions taken in the 1950s. Anne Marie's considerable work to reunite the library and plant specimens transformed the value of both collections to visitors; researchers could have the personal herbaria and libraries of some of Oxford's most illustrious botanists side by side. Among the manuscripts in the library were those of Professor John Sibthorp (1758-96), third Sherardian Professor of Botany, and the watercolours of Ferdinand Bauer (1760-1826), which were used to produce the *Flora Graeca* (1806-1840). The *Flora* is the University's botanical treasure, and one of the world's rarest botanical books. Anne Marie has been instrumental in making this work more widely available to people than ever before. In 1999, she organised a Bodleian Library Exhibition on the *Flora* that transformed our perceptions of this work, and ensured the collections were digitised and made available on the web. Through her concerns about access and accessibility, Anne Marie transformed the Sherardian Library from a relatively poorly known collection to an internationally important research library. Academic researchers have benefited from Anne Marie's detailed knowledge of the collection, whilst students and visitors have been able to glimpse some of the University's botanical riches through exhibitions organised by Anne Marie. Anne Marie's dedication and knowledge of the Sherardian Library shows the University's specialist librarians at their very best. We wish Anne Marie all the best for her retirement.

Blue Plaque unveiled to George Claridge Druce

The Oxfordshire Blue Plaques Board promotes recognition and awareness of people, places and events that have been of lasting significance, especially in the life of Oxfordshire, with eminence in the wider public domain. The botanist, pharmacist and Mayor of Oxford, George Claridge Druce (1850-1932) was chosen for this honour. A plaque was unveiled to him on 28th April 2018 at 118 High Street, Oxford, on the wall of his former chemists shop. George Claridge Druce has especial significance for Oxford University Herbaria and the University, not least for the bequest of his herbarium and library collections as well as funds for curation and research on the collections. See article on pages 8-9 which was based on a speech made by Serena Marner at the Blue Plaque ceremony.

Publications 2017

Biju, P., Josekutty, E.J., Rekha D., **Wood, J.R.I.** (2017). *Strobilanthes jomyi* (Acanthaceae), a remarkable new species from South India. *Phytotaxa* **332**(1): 075-080.

Harris, S.A. (2017). *Oxford Botanic Garden & Arboretum. A brief history.* Oxford: Bodleian Library.

Muñoz-Rodríguez, P., Draper Munt, D., Moreno Saiz, J.C. (2017). Global strategy for plant conservation: inadequate in situ conservation of threatened flora in Spain. *Israel Journal of Plant Sciences.* Special Issue: New Thinking and Conceptual Advances in Plant Conservation **63**(4): 297-308.

Pennington, T.D. & **Wise, R.** (2017). The genus *Sloanea* (Elaeocarpaceae) in America. 432pp. David Hunt.

Wood, J.R.I., Vasconcelos, L.V., Simão-Bianchini, R., **Scotland, R.W.** (2017). New species of *Ipomoea* (Convolvulaceae) from Bahia. *Kew Bulletin* **72**(8): 1–20.

Wood, J.R.I. & Scotland, R.W. (2017.) Misapplied names, synonyms and new species of *Ipomoea* (Convolvulaceae) from South America. *Kew Bulletin* **72**(9): 1–26.

Wood, J.R.I. & Scotland, R.W. (2017). Notes on *Ipomoea* (Convolvulaceae) from the Amazonian periphery. *Kew Bulletin* **72**(10): 1–18.

Wood, J.R.I., Nuraliev, M.S., Kuznetzov, A.N., Kuznetzova, S.P., **Scotland, R.W.** (2017). *Strobilanthes barbigera* (Acanthaceae), a new species from Vietnam. *Kew Bulletin* **72**(28): 1–5.

Wood, J.R.I. & Scotland, R.W. (2017). A new species of *Strobilanthes* (Acanthaceae) from western Thailand. *The Natural History Bulletin of the Siam Society* **62**(1): 29–34. http://www.siam-society.org/pub_NHB/download_062_1f.html

Wood, J.R.I., Buril, M.T., **Scotland, R.W.** (2017). Remarkable Disjunctions in *Ipomoea* species (Convolvulaceae) from NE Brazil and Central America and their taxonomic implications. *Kew Bulletin* **72**(44): 1–10.

Wood, J.R.I. & Scotland, R.W. (2017.) Notes on *Ipomoea* L. (Convolvulaceae) in Cuba and neighbouring islands with a checklist of species found in Cuba. *Kew Bulletin* **72**(45): 1–16.

Wood, J.R.I., Degen de Arrua, R., **Scotland, R.W.** (2017). El género *Ipomoea* L. (Convolvulaceae) en Paraguay. *Rojasia* **16**: 9–22.

Wood, J.R.I., Muñoz-Rodríguez, P., Degen, R., **Scotland, R.W.** (2017). New species of *Ipomoea* (Convolvulaceae) from South America. *Phytokeys* **88**: 1–38.

Expeditions and visits

John Wood made a two-day visit to the Paris Natural History Museum in March 2017 to see type specimens in the Lamarck herbarium. He also made a one-month visit to Bolivia in June-July 2017 to collect Convolvulaceae and report on *Ipomoea* research to counterparts in Bolivia.

Caroline Pannell's visits last year were to Java, Thailand, Edinburgh and Leiden. She gave a presentation at the Third South East Asian Gateway Evolution meeting, 28th August to 1st September 2017, and visited Kebun Raya, Bogor Botanic Gardens and Kebun Raya, Cibodas, to see their living collections of Meliaceae. A field trip to Mount Gedeh was followed by four days at Bogor herbarium to work on determination of their holdings of *Aglaia.* She made a preliminary exploration into resolving the complex species, *Aglaia elaeagnoidea* (A.Juss.) Benth., a project in which she is collaborating with Ph.D. student, Lizzy Joyce, from James Cook University, Cairns, Queensland. From 10th September to 7th October, Caroline determined the entire holdings of *Aglaia* in Bangkok herbarium and continued working on the account of the genus for the *Flora of Thailand*. This visit included field trips to Khao Khieo Wildlife Sanctuary, Khao Ang Rua Wildlife Conservation Area, Khao Soi Dao and Kang Krachan National Park. She gave the Biology Week lecture for Royal Society of Biology and County Armagh Wildlife Society, entitled 'Wallace's Line and the bio-geographical contrasts between SE Asia and Australasian rainforests'. She visited RBG Edinburgh herbarium from 30th October to 4th November, to commence work on the remainder of the Meliaceae for the *Flora of Thailand*. From 30th November to 9th December, she visited the Naturalis herb-arium in Leiden, the Netherlands, to begin to resolve complex species of *Aglaia* from Indonesia and to search for additional material of new species that are known only from single collections or from sterile specimens. This is for a project in collaboration with Professor Alexandra Muellner-Riehl and Dr Jan Schnitzler of Leipzig University.

Rosemary Wise was invited to be the annual guest on a contemporary art residency in Mexico, spending one week in Tlayacapan and a second week in Oaxaca city

Roots in the Palaeobotanical Collection

The oldest plant specimens in the University of Oxford Herbaria are over 400 million years old, much older than any of the specimens collected during the 400 years of botanical research and teaching at the University. These ancient plants form the Palaeobotanical Collection, housed in the Fielding-Druce Herbarium (OXF; Fig. 1). The collection consists of 115 palaeo-botanical thin sections, originally purchased in the early twentieth century as a teaching collection for botany students, but can accessed by anybody through the Oxford Herbaria database (https://herbaria.plants.ox.ac.uk/bol/palaeobotox).

Figure 1. The Palaeobotanical collection housed in the Fielding-Druce Herbarium (OXF). Photograph © John Baker.

The majority of the thin sections in the collection were made by two of the leading palaeobotanical thin section manufacturers of the late nineteenth and early twentieth century J. Lomax and W. Hemingway. The sections contain fossil plants from the Paleozoic Era (540-250 million years ago). This was the stage in Earth history when land plants first colonised the continental surface. Within 100 million years extensive forest ecosystems had developed. The thin sections were made primarily from two-world famous British fossil localities: 1) the earliest preserved terrestrial ecosystem, the 407 million year old Rhynie chert; and 2) the Lancashire and Yorkshire Carboniferous coal field that preserves a record of the tropical coal swamp forests that clothed Britain just over 300 million years ago. These two very different fossil assemblages are separated by almost 100 million years but have one striking thing in common. Plant fossils are preserved with exceptional cellular preservation in both the silica-rich Rhynie chert and the calcite-rich nodules "coal balls" from the Lancashire and Yorkshire coalfield. This exceptional preservation provides a unique window into plant life in the Palaeozoic and allows us to ask research questions that would not be possible from any other early fossil locality.

In our research we aim to characterise the key steps during the evolution of rooting systems. Rooting systems were one of a suite of key adaptions that diversified enormously during the Palaeozoic, allowing early land plants to explode in size and colonise drier regions of the continental surface. The 115 thin sections in the Palaeobotanical Collection became the backbone of the work of AJH's D.Phil. under the supervision of LD, and are now proving to be a central resource for AJH's Fellowship by Examination at Magdalen College, hosted in LD's lab. The exceptional preservation of plants preserved in the thin sections have allowed us to identify defining features of rooting systems from the Palaeozoic.

Despite rooting systems being frequently preserved in the fossil record the poor preservation of the vast majority of fossils obscures the identification of the sole defining feature of roots, the development of a root meristem with a root cap. Rooting systems had been described for well over 100 years from the coal balls of the Lancashire and Yorkshire coalfield but a root meristem had never been found. During AJH's D.Phil. he discovered the first fossilised root meristem – preserved on thin section 81 (OXF). This root meristem (Fig. 2), provided the first opportunity to compare a fossil root meristem with the root meristems of extant plants. By comparing the structure of this meristem with the root meristems of extant plants we discovered that this 310 million year-old root meristem was distinct from all known root meristems of extant plants (Hetherington et al. 2016). Our findings therefore revealed previously unknown diversity of roots in the Carboniferous period.

Alongside work on the plants from the Carboniferous we have also been studying rooting structures from the Devonian Period by examining the thin sections of the 407 million year old Rhynie chert. The Rhynie chert is the oldest preserved terrestrial ecosystem and the thin sections in the collection provide a glimpse onto the structure of early vascular plants prior to the evolution of leaves or roots. Despite lacking roots, all plants in the Rhynie chert developed some form of rooting system. The rooting systems of the majority of plants consisted of masses of hair-like cells termed rhizoids that increased the surface area for water and nutrient uptake and anchored the plants to the sediment. Despite these rooting cells being tiny in size the exceptional preservation allows us to examine these rhizoids and the regions of the axes from where they developed. By examining these rhizoid-based rooting systems we identified shared features common between all species. In rhizoid-based rooting systems the development of rhizoids led to a modification of the cylindrical axis leading to the formation of an axis with bilateral symmetry (Hetherington and Dolan 2018). This break in symmetry of the rooting regions had not been identified as a unifying feature of early

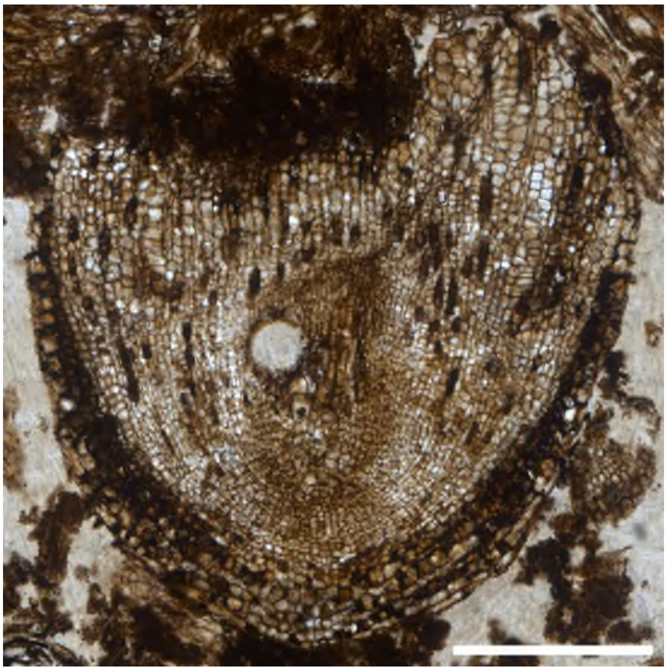


Figure 2.
310 million year-old fossilised root meristem discovered on thin section 81 of the OXF Palaeobotanical Collection.
Photo © Oxford University Herbaria

rooting systems before. The Rhynie chert thin sections in OXF were essential for drawing this new conclusion.

Collectively studying thin sections from the Carboniferous coal balls and the Devonian Rhynie chert we are gradually building up a clearer picture of the early steps involved during the evolution of rooting structures. There is however a sobering lesson to be learned from the Palaeobotany Collection in OXF. The entire collection was almost lost when the collection was assigned to the skip. Fortunately, Professor Stephen Harris was able to rescue the box of thin sections preserving this exquisite collection. We hope the work described here acts as a testament to the importance of conserving natural history collections. Many new insights and discoveries can be gained from asking new research questions from old collections and we hope that continued work with the Palaeobotany Collection will produce new insights into the evolution of roots.

References

Hetherington, A.J., Dubrovsky, J.G., Dolan, L. (2016). Unique cellular organization in the oldest root meristem. *Current Biology* 26: 1629–1633. (doi:10.1016/j.cub.2016.04.072)

Hetherington, A.J. & Dolan, L. (2018). Bilaterally symmetric axes with rhizoids composed the rooting structure of the common ancestor of vascular plants. *Philosophical Transactions of the Royal Society B Biological Sciences* 373: 20170042. (doi:10.1098/rstb.2017.0042)

***Alexander J. Hetherington**, Post Doctoral Researcher & **Liam Dolan**, Sherardian Professor of Botany*

What did the Garden grow?

Our desire to understand plant diversity is driven by curiosity but often justified in terms of the economic, social and environmental benefits we derive from plants. Biological collections, amassed by networks of individuals connected by mutual interests, correspondence and specimen exchange, are central to understanding biological diversity. In sixteenth-century Europe, as global exploration increased and humanist ideas took root, collections of living and preserved plants evolved from being pleasure gardens and cabinets of expensive curiosities into today's scientific collections (Morton, 1981; Ogilvie, 2006).

Collectors of living or preserved plants who wished others to know what they possessed published and circulated lists of names. Some lists were illustrated but most were unadorned, e.g. Robert Morison's *Hortus Regius Blesensis* (1669), James Sutherland's *Hortus Medicus Edinburgensis* (1683) and Simon Warton's *Schola Botanica* (1689).

Names, as flags, confer identity that enables information to be catalogued, stored and transmitted in time and space. However, for maximum use a name should be applied unambiguously so that it means the same to everyone. The correct application of plant names therefore has direct scientific, economic and social consequences.

Correctly naming a living or preserved plant is a complex process dependent on the quality of the specimens being named and the comparative material available, together with an individual's experience of, and competency at, naming plants. Furthermore, groups of plants vary in the features that are important for their identification. For example, the genus *Rosa* is distinct within the British flora and can be readily identified from even fragmentary botanical specimens or crude drawings but separating *Rosa canina* from its close relatives requires a specialist botanist and carefully collected specimens.

Natural history collections are known to be replete with misidentifications (Goodwin et al., 2015). Plant lists are likely to suffer similar problems since there is no reason to suppose identifications based on herbarium specimens are poorer than those based on living plants. Herbarium specimens therefore become essential for interpreting plant lists, and making objective comparisons among such lists. Ultimately, plant identifications are hypotheses refuted by examining specimens named by the person responsible for putting together a species list. Identifications based solely on lists of names, and lacking voucher specimens, rely wholly on the authority of the list compiler.

Early modern plant lists complemented by herbarium specimens are very rare, whilst identification based on pre-Linnaean polynomials has been characterised as 'interpretation rather than an equation' (Harvey, 1972). In the case of the seventeenth-century Oxford Physic Garden, a collection of plant lists and specimens is available (Harris, 2018).


CATOLOGUS PLANTARUM
Horti Medici
OXONIENSIS
Sc. Latino Anglicus, & Anglico Latinus.
Eas Alphebetico ordine accurate Exhibens.
Excudebat
HENRICUS HALL Typographus Academiæ OXONIENSIS. 1648.

Title page of the first catalogue of plants growing in the Oxford Botanic Garden, and published in 1648. Photo © Sherardian Library

Planting started in the Oxford Physic Garden in the 1642 following the appointment of Jacob Bobart the Elder as Keeper (Harris, 2017). Building the Garden's plant collection continued under Bobart's son, also called Jacob. Together these men contributed to three plant lists of the Garden in the seventeenth century. In 1648, an anonymous catalogue, *Catologus Plantarum Horti Medici Oxoniensis*, was published; traditionally, the author is identified as Jacob Bobart the Elder. In 1658, the Oxford-based academics Philip Stephens and William Browne wrote a second edition of the *Catologus*. A manuscript list of plants growing in the Botanic Garden, dated 1676, in Jacob Bobart the Younger's hand, appears to be a draft for another edition of the *Catologus*. There are 4,369 polynomials in the three Garden lists.

Specimen of the medicinal plant *Digitalis purpurea* L. collected by Bobart the Younger in the mid seventeenth century (Acc. No.: BJr-04-021). Photo © Oxford University Herbaria

Objective interpretation and comparison of the polynomials in the lists was only possible because three, mid- to late-seventeenth-century herbarium collections, directly associated with the Bobarts, have been preserved: Bobart the Younger's *Hortus Siccus*; Bobart the Elder's Herbarium; and the Morisonian Herbarium. Bobart the Younger also contributed large numbers of specimens, and annotations, to the herbaria gathered by the diplomat William Sherard and the East Indian Company cashier-general Charles Dubois. Together these pre-Linnaean collections comprise approximately 49,000 specimens (Clokie, 1964).

Matching between polynomial list names and modern Linnean names was done using a laborious comparison process. All polynomials were compared with herbarium specimens labelled by either of the Bobarts, most usually Jacob Bobart the Younger. Published classification systems (those of Robert Morison and John Ray), directly or indirectly associated with the Bobarts, and the unpublished manuscript of William Sherard's *Pinax* helped establish likely polynomial synonyms. Standard, early modern illustrated works from the Bobarts' personal library, e.g., Gerard's *Herball* (1633) and Parkinson's *Paradisi in Sole Paradisus Terrestris* (1629) and *Theatrum Botanicum: The Theater of Plants* (1640), were resorted to when herbarium specimens proved insufficient. As identifications became more remote from the Bobarts, or relied on descriptions or illustrations in the early modern literature, confidence in the association between Linnean bionomials and Bobartian polynomials declined.

In total, 2,435 polynomial names, representing at least 1,311 Linnaean taxa, were reported from Oxford Physic Garden between 1648 and 1676. However, approximately a fifth of the polynomials remain unidentified to species rank. There are numerous reasons for this including loss or destruction of specimens, essential parts for reliable identification being absent or perhaps specimens were never collected.

When Henry Danvers established the Physic Garden in 1621 his intention was that it should grow and display medicinal plants for teaching purposes. In practice, only about a quarter of the plants growing in the Garden were medicinal. Necessity meant the Bobarts had to concentrate on horticultural productivity. Consequently, favourite ornamentals of the period, e.g., *Anemone hortensis* (at least 36 types) and *Narcissus* (at least 32 types), and food plants, e.g., *Brassica oleracea* (at least nine types) and *Lactuca sativa* (at least five types), were well represented in the Garden's stock. However, most plants in the Garden could not be conveniently grouped as medicinal, ornamental or culinary; they appear to have been grown for their curiosity value, e.g., sensitive and variegated plants.

Most of the species in the seventeenth-century Garden were Eurasian introductions. However, among the 526 native British species, 436 were Oxfordshire natives, which is over half the native flowering plants recognised in Oxfordshire today (Killick *et al*., 1998).

As might be expected for a fledgling garden in an academic institution the garden's contents changed between 1648 and 1676. The living collection increased through the acquisition of species not previously grown or new forms of species already growing. The collection decreased when species died because of pest and diseases or the discovery that conditions were inappropriate for them to flourish. Approximately six years after Jacob Bobart the Elder took charge, over 890 species were growing. A decade later, there were over 1,100 species but nearly twenty years after that, Bobart the Young recorded fewer than 800 species. Throughout this period, 513 species were grown continuously, which included 208 medicinal plants. Surprisingly, *Viscum album* was reported in 1648 but not later lists, whilst among the more unusual, and less surprising, 1658-list species that did not survive were the African/Indian *Tamarindus indica* and the North American *Toxicodendron radicans*.

With limited resources to run the Garden, the Bobarts had to be content with modest collection expeditions and enlisting personal contacts across Europe to fill it. However, they undertook collecting trips in Oxfordshire and surrounding English counties. For example, Bobart the Younger grew a white-fruited bramble he had spotted near Oxford, and a specimen of *Cynoglossum germanicum* was grown which was 'bought from Reading, where it was shewed us by Mr Watlington'. Internationally, the Bobarts were in contact with Pierre Magnol in Montpellier, Paulo Boccone in Sicily and Guy-Crescent Fagon in Paris. Eventually, Jacob Bobart the Younger was able to call upon the extensive botanical network of the law student he mentored in Oxford, William Sherard.

Using herbarium specimens labelled by the Bobarts it has been possible to match rigorously polynomials with Linnaean binomials, and reinterpret plant lists from the seventeenth-century Oxford Physic Garden. The Garden the Bobarts filled was closer to John Evelyn's concept of a 'Philosophico-Medical Garden' than a collection of plants focused on medical training (Ingram, 2001). The vast majority of the plants were of botanical interest only. They show some of the plant diversity imported into seventeenth-century Britain and were the raw material for research into plant classification, cultivation and physiology.

Specimens of *Primula auricula* L. cultivars raised by Bobart the Younger and grown in the Botanic Garden in the mid seventeenth century (Acc. No.: BJr-05-214-1). Photo © Oxford University Herbaria

References

Clokie, H.N. (1964). An account of the Herbaria of the Department of Botany in the University of Oxford. Oxford University Press, London.

Variegated *Solanum dulcamara* L., labelled by Bobart the Younger and probably collected from the Garden in the 1680s
(Acc. No.: BSn-D06r-02).
Photo © Oxford University Herbaria

Goodwin, Z.A., Harris, D.J., Filer, D., Wood, J.R.I. and Scotland, R.W. (2015). Widespread mistaken identity in tropical plant collections. *Current Biology* 25: 1066-1067.

Harris, S.A. (2017). *Oxford Botanic Garden & Arboretum. A brief history*. Bodleian Library Publications: Oxford.

Harris, S.A. (2018). Seventeenth-century plant lists and herbarium collections: a case study from the Oxford Physic Garden. *Journal of the History of Collections* 30: 1-14.

Harvey, J. (1972). *Early gardening catalogues: with complete reprints of lists and accounts of the 16th-19th centuries*. Phillimore, London.

Ingram, J.E. (2001). *Elysium Britannicum, or the Royal Gardens*. University of Pennsylvania Press, Philadelphia.

Killick, J., Perry, R. and Woodell, S. (1998). *The Flora of Oxfordshire*. Pisces Publications, Newbury.

Morton, A.G. (1981). *History of botanical science: an account of the development of botany from ancient times to the present day*. Academic Press, London.

Ogilvie, B.W. (2006). *The science of describing. Natural history in Renaissance Europe*. University of Chicago Press, Chicago.

Stephen A. Harris
Curator of Oxford University Herbaria

Painting by numbers

Imagine a botanical artist being invited to accompany an academic from this University to record the plants overseas. In my long career as the botanical artist in the Department of Plant Sciences (I started in 1965) this has fortunately happened to me on many occasions. Besides the usual travel requisites, I pack my pad of watercolour paper, my compact box of Winsor and Newton paints, a notebook, my hand lens and and a small pouch containing pencils, rubber and ruler and sometimes a plant press. I get the airport bus from Oxford and then a flight to the chosen destination. I can be working in places as far away as Papua New Guinea within two days of leaving home, well-rested after a comfortable flight.

But think back to 1780s Oxford. John Sibthorp had by then succeeded his father Humphrey to the Sherardian chair of botany. En route to study the little-known flora of the eastern Mediterranean, he stopped off in Vienna. Here he was able to study a copy of Dioscorides' *Codex Vindobonensis*, a first-century account of plants from the central and eastern Mediterranean. But, more important, he was introduced to the botanical artist Ferdinand Bauer (1760–1826) and invited him to accompany him. They left Vienna on March 6th 1786. Poor guy, his relationship with Sibthorp was certainly not good, he was treated as a servant and he had little or no command of the Greek or English languages. Travel would have been long and arduous, by coach from Vienna to Trieste and then onwards into Italy most probably on horseback. They also had stormy seas to cope with. During their exploration over the following 21 months, visiting Sicily, western Crete, some of the Aegean islands, Turkey and eventually Greece, Bauer produced very detailed pencil drawings of almost 1,000 plant species and colour-coded them. But with so little known of the Mediterranean flora, they soon found that summer was not the best time for plant collecting, most of the plants at low altitude would have long since finished flowering. The majority of Bauer's exquisite masterpieces feature mountain plants.

By this time Winsor and Newton were producing pans of paint but a classically trained artist such as Bauer was almost certainly still grinding his own pigments. The actual paintings were executed back in Oxford several years later and Stephen Harris has suggested that each painting took Bauer on average a day and a half to complete. Bauer was able to compare his colour-coded sketches with the pressed material from the trip and he also had access to plants grown from seed in the botanic garden. I think he had to have had a remarkable memory of colours and textures besides his code, which sadly no longer exists.

It seems obvious to me why Bauer declined an offer to accompany John Sibthorp on his second trip from March 1794 to May 1795! The professor's health was failing by then and he died in 1796, leaving a considerable fortune and instructions that the paintings should be published in ten folio albums and entitled *Florae Graeca*. James Sowerby, assisted by family and friends, produced copper plate engravings of the paintings and 30 sets were printed and carefully hand-coloured. Only 25 copies of the *Flora Graeca Sibthorpiana* were published, it remains to this day one of the most expensive Floras ever produced. Bauer's sketchbooks from this first expedition, the herbarium specimens and the original paintings comprise some of the greatest botanical treasures of Oxford University.

Dr Richard Mulholland has spent several years researching the pigments that Bauer used for these wonderful paintings. Using the latest techniques of Raman spectroscopy and hyperspectral imaging, paintings have been examined and pigments have been recognised. Bauer seems to have had a limited palate, using possibly no more than a dozen colours. An exhibition in the Weston Library in summer 2017 highlighted the result of this research.

My work is always varied and exciting but never had I been asked to produce an illustration demonstrating Bauer's method of working. Richard appeared in my studio in the Department of Plant Sciences one morning with a large selection of ground-up pigments, all mixed with supermarket runny honey, decanted into mussel shells and left for a week to solidify. With the help of a sealant gun, we attached these shells to a square of plywood and the strange new paint box was ready for use. My idea was to show several stages in just one illustration, my own colour code, a detailed pencil drawing with numbers relating to the code and parts of the illustration painted. Deciding on a suitable plant took a while but the obvious choice was snake's head fritillary (*Fritillaria meleagris* L.), the designated flower for Oxfordshire and, with grateful thanks, obtained from the Oxford Botanic Garden.

Then my attention turned to the paints. I was fascinated with the names, the ingredients and even more so, the historic aspects. Madder, a red dye made from boiling the roots of *Rubia tinctorum* L., has been detected in linens found in the tomb of Tutankhamun and in Norse burials. Another red, vermillion, was originally produced by grinding the mercury-rich mineral cinnabar to a powder. An alternative 'Dutch method' was formulated in the seventeenth century when mercury and melted sulphur were mixed and heated, resulting in crystals of mercuric sulphide being formed by condensation. Washing these crystals in a strong alkali, prior to grinding, removed the sulphur content. Both methods produced an extremely poisonous pigment. A rich reddish brown dye produced by boiling up the heartwood of various species of *Caesalpinia* from the East Indies has the intriguing name Brazilwood. Early Portuguese explorers also found this genus growing in South America and named the country after it. Ancient Britons made use of a native plant, *Isatis tinctoria* L., to produce their own blue dye, the legendary woad. We can see that Bauer frequently made use of white, contemporary botanical artists shy away from the more dense, body-colours, preferring the transparency of watercolours. He would have had access to both barium white and the very poisonous lead white, which was only banned and taken off sale in the UK in 1994. Formerly used not only in paints but also cosmetics, this pigment caused many deaths.

Gamboge is obtained by grinding the orange-brown resin tapped from the bark of trees in the family Clusiaceae, mainly *Garcinia* from the Far East. Indigo is extracted from another plant source, the legume genus *Indigofera*. The earliest recorded use of this dark greenish-blue dye dates back to Peru in 4,000 B.C. The name indigo is thought to have originated from the Bronze Age Indus Valley Civilization, an area stretching across modern-day north east Afghanistan, Pakistan and northern India.

Cochineal dye is insect based. Last summer I was very fortunate to be on a working trip to Mexico and had the opportunity to visit a cochineal farm. Cladodes (pads) of species of the prickly pear cactus (*Opuntia*) are cut off and placed upright in large trays of moist sand in long, light sheds. The aphid-related *Dactylopus coccus* insects, are introduced to little woven baskets, commonly called Zapotec nests, which are wired to the pads. After fertilisation, the wingless females leave the baskets and sink their mouthparts into the fleshy pad, cover themselves in a powdery coating – and never move again (the winged males die after a few days). After 90 days, these 'scale insects' are gently brushed off the pads, dried in the sun and ground to form the dye.

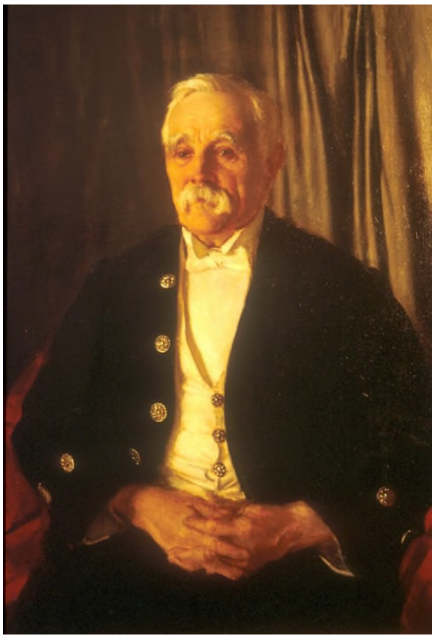
I must admit I was very surprised when I found that I could do the whole *Fritillaria* painting using only three colours: gamboge (yellow); indigo (dark blue); and cochineal (red). Bauer certainly used these. All the greens were possible using different combinations of yellow and blue with touches of red to tone down where necessary. The maroon colour was obtained perfectly using indigo and cochineal and all the soft grey tones for the shadows on the white fritillary were a combination of all three. Of course, with this very limited choice it would not have been possible to recreate violets, mauves or purples, had I chosen a different species. On a technical note I found the pigments easier to use than I had expected but had to be aware of one little thing. Botanical illustrators build up colours with a series of washes and I was aware that the drying times were slightly slower than when using my usual paints. The difference was probably not more than two seconds, but enough to make me hesitate before applying another layer of colour. We had hoped to obtain a sheet of paper similar to that which Bauer would have used but this proved difficult and I resorted to my preferred surface, the French "Arches" (grain satiné).

This exercise gave me a far greater understanding and total admiration of the work of my predecessor, Ferdinand Bauer, very possibly the greatest botanical illustrator ever (certainly so in my estimation).

Rosemary Wise
Botanical Artist

A palette made by Richard Mulholland using eighteenth-century recipes and traditionally presented in mussel shells.

George Claridge Druce's career as a botanist



Portrait of G.C. Druce © Department of Plant Sciences

George Claridge Druce (1850-1932) was a self-taught botanist but a pharmacist by trade. He was able to recognise 400 species of plants by the time he was 16, though he did not know their names. He was further inspired in botany as it was one of the subjects he took in his final pharmaceutical exams in 1872. It was at the age of 22 (in the middle of a night when he could not sleep) he made the decision to collect plants he found on his rambles and form a herbarium, so he could name the plants and record their distributions. He had the intention of writing a Flora of his native county Northamptonshire. His first publication was on Northamptonshire plants published in the *Journal of Botany* in 1877, followed by another in the *Botanical Exchange Club Report* for 1878; forerunners to the Flora he later compiled. Frank Bellamy, the Oxford astronomer, was a friend of Druce and said he was 'a man of energy' when he arrived in Oxford in 1879 and already experienced in field work in natural history. He was eager to acquire knowledge, make friends and publicise the botanical information he had learnt. Oxford was a good place to access libraries, mix with people from the academic scientific community and within easy access of the countryside.

These early beginnings led to Druce becoming the most prominent British amateur botanist of the first three decades of the twentieth century. He had an enormous influence on a large number of amateur botanists. He had ambition. Druce is well known for almost single-handedly running the Botanical Exchange Club of the British Isles from 1903. This was the forerunner to the present day Botanical Society of Britain and Ireland (BSBI). He increased membership considerably. One of the ways he did this was to write to people - amateurs, professional botanists, the 'great and the good' - inviting them to join. However sometimes he did this a little too often and received rather curt responses, as seen in a few letters in the Druce archives in the Department of Plant Sciences (University of Oxford)! One of the people he invited to join the Northamptonshire Natural History Society was Charles Darwin from whom he received a courteous letter declining the invitation. On field excursions with other people Druce provided abundant and valuable botanical information and this was enriched by his 'cheery mood' which made the 'walk a pleasant one', as Bellamy records. In this way he kept up the profile of field botany. He was always enthusiastic in helping and encouraging young people.

Apart from writing most of the yearly accounts for the Botanical Exchange Club reports, which were very voluminous, and papers and notes, Druce published several county Floras, those of Oxfordshire (1886), Berkshire (1897), Buckinghamshire (1926), Northamptonshire (1930), Zetland (Shetland) (1922) and West Ross (1929) along with three other books. He added a historical dimension to his accounts. These books were very well received and they provided him with much desired acclaim in the academic world.

In 1895 Druce was appointed as Special Curator of the Fielding Herbarium in the Department of Botany in the University of Oxford, which was then housed within the Botanic Gardens. As a botanist he was the first person to take curation of the herbarium collections seriously in the University. During his curatorship, Druce carried out the re-arrangement of about a quarter of a million specimens including naming, at least to genera, those undetermined plants and those from the pre-Linnean collections. Today the collections would not be in the orderly state they are but for him. The Fielding Herbarium of worldwide plants is still in the general arrangement Druce placed it in, which made the collections useable by researchers. He also had a great interest in the holdings of historic collections. Together with Professor Vines (the Sherardian Professor of Botany from 1888 to 1919), he published two books, one on the herbaria of Johann Jacob Dillenius (1907) and one on Robert Morison's collections (1914), both of whom were former Professors of Botany in the University. On his death Druce left his own herbarium and library to the University and a bequest of money, the bulk of his fortune, for curation and research on the collections. This bequest continues to make a contribution to the maintenance of the Herbaria. The herbarium bequeathed by Druce, consisting mostly of British plants, comprises 200,000 specimens and is one fifth of Oxford University Herbaria's entire collection.

For his botanical work and publications Druce received an Honorary doctorate from St Andrews University in 1919, he was made an Honorary Fellow of Magdalen College and received a D.Sc. on his publications and by examination from the University of Oxford in 1924. Druce also became a Fellow of the Royal Society (FRS) in 1927; an amazing achievement for an amateur.

Druce's desire to find new plants to add to the list of British plants was something that was the driving force in his field work for his entire life. One of his most exceptional finds was a grass which had been sitting in the herbarium of Dillenius for almost 200 years unnamed and unknown in Britain. He visited the locality in Somerset where Dillenius had collected it and found spikes of it, also in other localities nearby at Brean Down. He proceeded to name the species *Koeleria splendens* (Pourr.) Druce (now called *K. vallesiana* (Honck.) Bertol. ex Schult.). Other discoveries of his included the grass *Bromus interruptus* (Hack.) Druce, a British endemic which is now extinct in the wild, a pondweed in the River Loddon that was named by Alfred Fryer as *Potamogeton drucei* Fryer (now recognised as *P. nodosus* Poir.), and the common spotted orchid *Orchis fuchsia* Druce, which is now *Dactylorhiza fuchsia* (Druce) Soó. Druce was the first person in Britain to discover and recognise the very rare thistle broomrape, *Orobanche reticulata* Wallr. This he found in north-east Craven in 1908. He loved to be able to discover and name new varieties of plants but unfortunately most of the new names he described are not valid or current today, although it did highlight many taxa of ecological or geographical interest. His methods of the naming of new species were thought controversial by his 'intellectual superiors'; he did not always adhere to the generally accepted rules! He had a long-running feud with James Britten, who worked at the Natural History Museum in London, as some of his new finds had been attributed to others by Britten who also had criticized Druce over his *Flora of Berkshire*. Even after the death of Britten, Druce still felt offended by it. After all, Druce just wanted to please people and to be thought of in a respectable light especially amongst his peers.

Druce lived through times of change in attitudes to collecting; rather than collecting plants like stamps, conservation was becoming a concern. Studies of ecology, physiology and genetics were beginning to come to the fore; they were interesting times botanically. An awareness of disappearing prime localities and the importance of preserving habitats for future generations had struck him. A good friend of his, Charles Rothschild, who was a pioneer of nature conservation in Britain had established the first nature reserve in the UK at Wicken Fen in 1899. He possibly had an influence on Druce. Druce became a trustee of Oxfordshire's first nature reserve at Cothill, known as the Ruskin Reserve, and purchased an adjacent piece of land in 1904 known as Hurst Copse to add to it. In 1916 the Ruskin Reserve was transferred to the ownership of the National Trust and today is managed by English Nature. For the last twenty years of his life Druce served on the council for the Society for the Promotion of Nature Reserves.

Druce was still writing and publishing books in his 80s. His last book, the *Comital Flora of the British Isles* (1932), was published just a month before he died. It recorded the distribution of every British vascular plant across the country. Druce told the reader he had visited all the counties of Great Britain and Ireland. This wide-ranging familiarity of the distribution of British plants and their discovery by botanists of the past was unmatched by anyone else at the time. The work contributed greatly to knowledge of the biogeography of the British Flora. Druce ends the preface to his book paying homage to all his friends and fellow helpers and recalling wonderful visions of habitats visited while looking for plants. He must have felt his fieldwork days were over as he ends with the words 'Hail and Farewell' written in Latin.

References

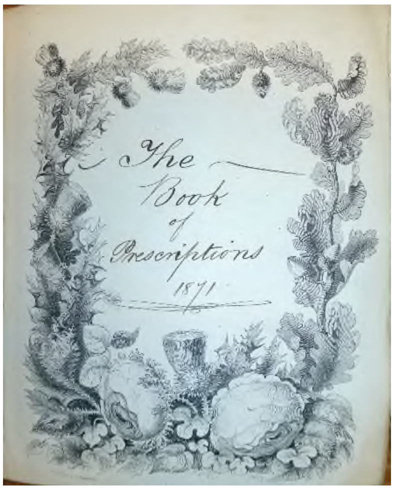
Allen, D.E. (1986). The discoveries of Druce. *The Scottish Naturalist* 1986: 175-189.

Bellamy, F.A. George Claridge Druce. A memoir of his botanical life. From an unpublished manuscript. Sherardian Library: Druce Archive Box 47: 01.

Druce, G.C. (1932). *The comital Flora of the British Isles.* T. Buncle & Co., Arbroath.

Harris, S.A. (2007). Druce and Oxford University Herbaria. *Oxford Plant Systematics* 14: 12-13.

Serena K. Marner
Herbarium Manager



The illustrated front page of Druce's 'Book of Prescriptions' (1871) from the Druce Archives

Some are born rare, some have rareness thrust upon them

Someone working in a wood for three to five years, the length of a typical D.Phil. project, will probably not notice much change in plant species presence or abundance. Yet the vegetation is in a state of flux, which becomes apparent when longer recording runs are available. Since the first recording of the Dawkins plots in Wytham Woods, Oxfordshire, in 1974 we have seen bramble (*Rubus fruticosus* L. agg.) go from a widespread dominant over large areas; to an almost insignificant contribution to the ground flora structure in the 1990s; before recovering to start to becoming a trip hazard again by 2012. The grass *Brachypodium sylvaticum* (Huds.) P.Beauv. was scarce in the 1970s but is now locally dominant.

What about on even longer timescales? Were the plants that are rare now, also rare in the past and if not what has thrust rareness on them? The specimens in the Fielding-Druce Herbarium provide some insights to this question. In his Surrey Flora, Lousley (1976) commented that starved wood-sedge (*Carex depauperata* Curtis ex With.) had been fairly plentiful in woods that had just been felled or coppiced. The Fielding-Druce Herbarium in Oxford contains fifteen different specimens from the Godalming area, collected between 1840 and 1940 and another five from the plant's Somerset stronghold. With the decline of coppice as a common management practice, the sedge's fortunes sank. By 1976 Lousley thought it was perhaps extinct in Surrey; it survived in Somerset but at one stage the sole English colony in the wild may have consisted of just one plant (Rich and Birkinshaw, 2001).

Specimen of *Carex depauperata* collected by G.C.Druce in 1907 from Godalming, Surrey.

The Orchid Trail at Gait Burrows reserve Photo © Keith Kirby

Surrey's woods were greatly affected by the 1987 storm, with many trees and large branches brought down in the Godalming area. Searches were organised to see if the gaps and disturbance might have encouraged buried seed of *C. depauperata* to come back to life. In 1992 a single plant was found in a place where it had been seen once before prior to 1970. It was directly under a gap formed when a large branch had broken off a lime tree in the storm. It was still there in 2017 in a small patch of about six square metres. Seed from it has been re-introduced to another former site to make its revival in Surrey less vulnerable. Several other woodland rarities, more common in the past, seem to have declined as our woods have become more shaded through lack of management.

Cypripedium calceolus from the Druce Herbarium, the left-hand specimen from Castle Eden Dene, the top specimen from Yorkshire and the bottom-right specimen collected from the Lake District in 1865. Photos © OUH

By the 1980s the Lady's-slipper orchid (*Cypripedium calceolus* L.) similarly survived at only one site in the wild in Britain (plus a few British-origin plants in gardens). Its location was closely wardened over the summer flowering-period. In the herbarium there are fourteen specimens collected between 1799 and 1928, from at least six sites. Castle Eden Dene, in Durham seems to have been a popular collecting spot: six of the sheets come from there. A note on one states 'plentiful in parts of the dene but seldom flowering except in open places'. Again, conservation efforts have been rewarded: the wild plant was crossed with garden specimens and young plants have been planted back into former haunts. At one of these, the Gait Barrows reserve in Lancashire there are now signs to the orchid trail; a far cry from the secrecy of the 1980s.

This Lady's-slipper was targeted by collectors, the sort of action that led Arthur Church (1922) to complain that people would 'devastate hedges and woodland, grabbing all available specimens of rarer flowers of aesthetic value for alleged decorative purposes'. He accused collectors of showing no compunction about taking rare plants for their herbaria or to exchange with other botanists. Giving the locality for a rare or interesting plant might be to sign its death warrant.

Other species may be rare in Britain because they are on the edge of their European range. The 32 specimens of the Italian lords and ladies (*Arum italicum* Mill.) come from a scatter of sites across southern England, reflecting its current distribution but with climate change it might become more abundant. The red helleborine (*Cephalanthera rubra* (L.) Rich.) has probably always been largely restricted to the western Cotswolds around Stroud (seven specimens collected between 1799 and 1902) where it still just manages to hold on. There are five sheets of the yellow sedge (*Carex flava* L.), three from its current stronghold at Roudsea Wood, Cumbria. Other relatively stable species appear to be coralroot orchid (*Corallorhiza trifida* Châtel) (19 specimens from eastern Scotland and northern England, 1833-1916); and spiked rampion (*Phyteuma spicatum* L.), 19 specimens (1831-1927), almost all from Sussex. With climate change we might see some of the southern rarities expanding while the northern species may come under more pressure.

Herbarium specimens may incidentally give insights into the social side of the collecting in the accompanying notes. Then as now, trips to see a rare plant might be frustrated because the instructions on where it was to be found were not quite right (George Druce's first attempt to see *Cephalanthera rubra* in the Cotswolds); or when a site is found but then destroyed − an immense colony of *Cardamine impatiens* L. near the Clifton Suspension Bridge was afterwards 'cleared by gardeners'. The finding of *Cynoglossum germanicum* Jacq. in Wychwood was more successful, in the company of Lady Margaret Watney, Lady Isabel Gordon and Lady Edward Grey – could a modern expedition match this clutch of titles?

References

Church, A. H. (1922). *Introduction to the plant-life of the Oxford District.* Oxford University Press.

Lousley, J. E. (1976). *The Flora of Surrey.* Newton Abbott, David and Charles.

Rich, T. and Birkinshaw, C. (2001). Conservation of Britain's biodiversity: *Carex depauperata* Curtis ex With. (Cyperaceae), Starved Wood-Sedge. *Watsonia* 23: 401-412.

Keith Kirby
Woodland Ecologist

Is there no end to it?

In 2015, Wood et al. (2015) published a revision of *Ipomoea* in Bolivia, in which we recognized 102 species. Perhaps thinking the task was done, I did not visit Bolivia at all in 2015, the first year I had not been in the country for twenty-two years. However, a visit to Arizona revealed an undiscovered new species amongst collections loaned to the late Dan Austin from Missouri Botanical Garden. The result was *Ipomoea diminuta* J.R.I.Wood & Scotland published as new in 2017 (Wood & Scotland 2017). Then fieldwork in 2016 revealed *Ipomoea volcanensis* O'Donell grew in Bolivia as well as in Argentina where it had previously been thought to be endemic.

2017 brought new records for the outstandingly interesting species *Ipomoea lactifera* J.R.I.Wood & Scotland and *I. juliagutierreziae* J.R.I.Wood & Scotland, the former the first newly discovered Crop Wild Relative of the Sweet Potato for a hundred years and the latter a weird liana with flowers at the tips of its leafless branches and sister to the clade of tree ipomoeas. And the discovery of flowering and fruiting material of *Ipomoea chondrosepala* Hallier f. hinted that our concept of that species was wrong. Nevertheless, it was only this year after a visit to Paraguay and the collection of authentic *I. chondrosepala* that we have been able to confirm that some of the plants we have been calling by this name appear to be the little-known species from Paraguay *Ipomoea subalata* Hassl., which is distinguished by its winged stems and large corolla, which is indistinctly pubescent on the exterior.

A good day's work collecting

Photo © Maria Tatiana Martinez

Above: *Ipomoea lilloi* with a root to rival the sweet potato. Photo © Maria Tatiana Martinez

The total number of species recorded for Bolivia thus crept up to 106 but there had been no new species since 2015 before a visit early this year, funded unexpectedly by a last-minute grant, came up trumps. Travelling with two local botanists Maira Martinez and Gina Aramayo the journey began interestingly enough in the Chaco region where we refound *Ipomoea lilloi* O'Donell and demonstrated that its tubers (correctly storage roots) can rival those of *I. batatas* (L.) Lam.. However, it was later, on the descent to Pampa Negra in the hot dry inter-Andean valleys to collect material of *I. juliagutierreziae* in leaf that we came across some good populations of a distinctive new species. It clearly belongs to a large South American radiation centred on the Parana region but is distinguished by its dimorphic leaves and proliferating shoots, in which the apical leaves are clearly bracteate in form. This is the usual situation in erect species but highly unusual in climbing species such as this. It is hoped the new species will be published later this year.

My last few days of fieldwork were spent in the Yungas of La Paz. I was fortunate to be accompanied and guided by the doyen of Bolivian botany and founder of the La Paz herbarium, Dr. Stephan Beck. We began by descending the Death Road, but I have to confess it is not as deadly as it once was as a new road now carries most of the traffic. We survived the experience but found no

John collecting the new species above Pampa Negra

Photo © Maria Tatiana Martinez

ipomoeas. The next day we headed for the Serrania de Bella Vista, a ridge enveloped in moist cloud-covered hill forest (*Bosque montano humedo*), which I had visited with Dieter Wasshausen twenty years before to look for Acanthaceae. We did not go unrewarded. Soon after entering the forest (and crucially before entering the clouds), we saw large white flowers decorating the tops of the forest trees up to 20 metres in height. Stopping the car and peering upwards, it was clear we had found another species I could not identify.

The new *Ipomoea* from the Yungas © John Wood

Collecting a specimen was not so easy. The slopes are precipitous and densely covered in forest. Once inside the forest you can see nothing. Two methods led to success. The first involved spotting a tree covered in the *Ipomoea* from below, clambering through the forest in near obscurity, climbing the tree to a height where the stem of the *Ipomoea* was relatively free and then pulling hard. Eventual success was achieved when flowering shoots came down through the tree branches. The second involved finding a landslide and climbing up the unstable slope and entering the forest when reaching the same level as the *Ipomoea*. The third landslide we struggled up yielded success as we found plenty of accessible material where a tree had fallen.

Back in the herbarium in La Paz, we found we had not been the first to collect the plant. A specimen had been collected in 1981 but had remained unidentified because there were no flowers. This fruiting specimen complemented ours nicely as it will enable the preparation of a complete description of what is a spectacular new species, possibly one that climbs higher than any other known species. And, searching through the undetermined material in the herbarium I came across flowerless material of another species of *Ipomoea, I. lindenii* M. Martens & Galeotti, which constitutes the 109th species of *Ipomoea* known from Bolivia. Is there no end to new records?

References

Wood, J.R.I., Carine, M.A., Harris, D., Wilkin, P., Williams, B., Scotland, R.W. (2015). *Ipomoea* (Convolvulaceae) in Bolivia. *Kew Bulletin* 70 (31): 1 – 124.

Wood, J.R.I & Scotland, R.W. (2017). Notes on *Ipomoea* (Convolvulaceae) from the Amazonian periphery. *Kew Bulletin* 72 (10): 1–18.

John R.I. Wood
Research Associate

News from the Herbaria

Fielding-Druce (OXF) and Daubeny (FHO)

Many activities happen behind the scenes in the Herbaria in order to make the collections more easily accessible, easy to locate and available to researchers and general visitors. The collections have to be kept in order, in good repair and information on their collection details and identifications are being added to BRAHMS, the herbarium database, continuously. There is no end to the work of curation staff with a million specimens to maintain!

We are always pleased to see visitors and researchers who are interested in the collections. 2017 saw another record number of visits (see below).

Visitors 2017

310 visits were made which included 18 groups, individuals and just over 100 Oxford University students who were introduced to the collections. Two thirds of the University students were post graduates attending courses with the Doctoral Training Centre and on the Bioscience Doctoral Training Partnership, while the remaining third were undergraduates studying Biological Sciences. A number of different groups visited in 2017 with specialist interests and were shown relevant collections in OXF and FHO starting with some local groups.

14 members of a local Natural History Society were interested in how the understanding of the history of the Oxfordshire flora came about. Examples from Botanic Garden catalogues and the various Oxfordshire Floras published from 1648 to 1998, including ten publications, were shown along with original plant material collected by the authors. The importance of the link between the written record and the physical plant specimen was emphasized when interpreting precisely what was being grown and where it was collected. Several members of the Oxford U3A visited for an introduction to the history of the collections. A selection of recently collected material and recent publications from the Plant Diversity Research group was also highlighted to indicate current work. 15 members of the University's ChemBioPlants network (drawn from the Departments of Biochemistry, Chemistry, Geology and Plant Sciences) were introduced to the research potential of the botanical collections held. Richard Mulholland's study of the pigments used by Ferdinand Bauer in the original watercolours made for the *Flora Graeca* was used to highlight the role played by analytical chemistry in his work (see *OPS* 21: 11-12 (2015).

A group of 15 scientists from the UK Nitrogen Fixation Centre (including many from India) were shown a display focusing on legumes and Indian specimens, several illustrated and described in publications. The material shown from the Sherard Collection in the Library included H.A. van Rheede *Hortus Indicus Malabaricus* Part 1 (1678), R. Morison *Historia Plantarum Universalis Oxoniensis* (1680) and J.J. Dillenius *Hortus Elthamensis* with a selection of seventeenth, eighteenth and nineteenth century specimens. W. Roxburgh's *Plants of the coast of Coromandel* (1795) and J.D. Hooker's *Illustrations of Himalayan Plants* (1855) were also shown with corresponding herbarium material.

The Herbaria were asked to show students, taking part in a number of courses, relevant material for their studies. This included students from the Institute of Historical Research, University of London on a course focused on the History of Gardens. Garden plants and plant introductions from the mid-sixteenth century to the mid-seventeenth century were highlighted from the rich resources available in the Sherardian Library of Plant Taxonomy and Oxford University Herbaria. A new batch of Oxford Sconal Library trainees also came for a session focusing on the links between the herbarium collections and the archives of manuscripts and published works in the Sherardian Library. 15 students taking part in a workshop on nature printing, organised by the Oxford Botanic Garden and Harcourt Arboretum, were shown examples of nature printing from the collections. Apart from seventeenth and eighteenth century examples found in the early herbaria, Thomas Moore's *The Ferns of Great Britain and Ireland* (1855) showing the use of herbarium specimens to create a printing plate was displayed. A manuscript volume of nature prints made in Edinburgh in the mid-nineteenth century which used dried plants directly for printing onto paper was also shown. As in previous years we were delighted to welcome students from Dr Sarah Simblet's Oxford summer-school course on botanical drawing at the Ruskin School of Fine Art to view Sibthorp and Bauer's *Flora Graeca* materials.

14 members of the RHS Orchid Committee also visited while attending a meeting in Oxford. Other special groups included a visit by the University's Chancellor's Court of Benefactors and representatives from the Botanic Gardens of Toyama, Japan.

A number of individuals made visits of more than one day to study specific collections. A doctoral student from Xiamen University, China, visited in connection with her taxonomic studies on the genus *Mallotus* (Euphorbiaceae). A post-doctoral visitor, based at De Montfort University Leicester, for a year (originally from CSIR North East Institute of Science and Technology, Jorhat, India) consulted the collections in relation to ethno-medicinally important taxa in the family *Ericaceae.* Sian Bowen, Professor of Drawing, Arts University Bournemouth and Leverhulme Research Fellow, came to examine Indian historical collections related

Specimens of *Marchantia polymorpha* from the Dillenian Herbarium of the *Historia Muscorum* (1741)

to the *Hortus Malabaricus* and specimens from the Dubois herbarium. Two descendants of the botanist William Williamson Newbould (1819-1886) visited to look at letters, references and herbarium specimens related to their ancestor. Newbould had been a friend and correspondent of George Claridge Druce and had been of much encouragement to him.

Loan material

During 2017 several loans of *Stictocardia* (Convolvulaceae) were received for the studies of Alex Sumadijaya. Five additional loans of Convolvulaceae, mostly of the genus *Ipomoea*, were received for the monographic studies of John Wood. A loan of *Blepharocalyx* (Myrtaceae) was received from Kew for study by a visiting researcher, Carolyn Proença. During the same period, 138 sheets of *Convolvulus* were returned to the University of Texas Herbarium.

193 specimens from six loans were returned to OXF and of these sheets, 20 percent of them were documented as types. An additional four loans consisting of 99 specimens were also returned to FHO, which included three new types.

Internet loans of digital images were made of specific material requested. These were posted online on the BRAHMS/Oxford University Herbaria website for individual researchers, many of the specimens being potential types. We welcome requests of this sort and appreciate the return of determinations so that names are kept up to date in the database and on specimen sheets. Approximately 15% of the whole of Oxford University Herbaria collections have so far been databased, so there is a very large amount of material not as yet online. Therefore we advise researchers, as well as looking online, to email with requests for particular material.

New accessions

To add to the FHO holdings of specimens from Malawi, Dr Joachim Thiede from Hamburg, Germany, kindly sent 98 photographs of miscellaneous species from the Flora of Malawi. The photos of the plants, all determined, have label data as specimens and comprise mostly non-woody plants, therefore making useful additions to the collections. A few Acanthaceae specimens collected in Peru were also sent as a gift from MO and a few Fabaceae collections were received from Kew.

Just over 300 specimens of Convolvulaceae specimens were sent as gifts from Missouri Botanical Garden Herbarium, Colorado University Museum of Natural History Herbarium and the Herbarium at the University of Brasília and will be added to OXF. 100 miscellaneous named vascular plants collected in Japan were also received from the National Museum of Nature and Science, Tsukuba, Japan, as exchange material for OXF.

Serena K. Marner
Herbarium Manager

Under the supervision of Professor Hugh Dickinson, I have been trained to maintain the Department of Plant Sciences' Scanning Electron Microscope (SEM), and to use techniques such as critical point drying and sputter coating. Maintaining the SEM and ensuring that it is always in working order has been challenging but enjoyable. I have also had the opportunity to pass my knowledge of the equipment and techniques on to others. In addition, I have learnt to operate the ultra-microtome, and have made sections of the liverwort *Marchantia polymorpha* L. for viewing under a Transmission Electron Microscope (TEM). I have used these techniques to look at the morphology of fern spores from herbarium material. Working with this equipment has been very insightful to the other research that goes on in the Department and how it can link to the work of the Herbaria.

I have also been involved with digitising the Acanthaceae in Oxford University Herbaria, which has put into perspective the sheer size of the collections here at Oxford. Acanthaceae makes up less than 0.5% of the entire collection. This is part of a programme to make the whole of Oxford's herbarium collections available online.

James Ritchie
Herbarium Technician

Abstracts of systematic theses submitted in 2017

The following D.Phil. theses were submitted and successfully defended in 2017:

Completing the global inventory of plants – Species discovery and diversity

Zoë Goodwin
Department of Plant Sciences, University of Oxford

Supervisors: Professor Robert Scotland (Oxford) and Dr David Harris (Royal Botanic Garden Edinburgh)

To complete an online world Flora by 2020 rapid progress is required towards understanding the taxonomy and distributions of the world's plants. This ambitious target set by the Global Strategy for Plant Conservation is hampered by two facts; first, many species of seed plant remain poorly known and second, the process of improving taxonomy and discovering species is not well understood. Here I investigate in detail the taxonomy and process of species discovery in a genus of tropical plants, *Aframomum* by examining specimens, taxonomic literature and authors of specimen determinations. I demonstrate that >50% of *Aframomum* specimens did not have the correct name prior to a recent comprehensive revision, that the number of specimens in herbaria doubled between 1970 and 2000, and that these results are also found in other taxa. I deconstruct the process of 'species discovery' by identifying four key events: Initial collection, publication, conservation assessment, and distribution mapping. The time lags between the initial collection and completion of a) an accurate conservation assessment (101 years) and b) a comprehensive distribution map (115 years) demonstrate that many seed plant species published in the last 100 years are not fully understood. This is partly due to the fact that most species protologues (>90%) cite too few specimens at publication to produce an accurate conservation assessment. Furthermore, I explore variation in species' distribution patterns over time, taking account of specimen misidentification. Taken together the thesis identifies the lack of taxonomic capacity to efficiently deal with the tremendous influx of specimens since 1970, the poor current state of taxonomic knowledge of many taxa, and three significant time lags in the process of species discovery. Focused taxonomic effort is required for the successful completion of a world online Flora with conservation assessments to meet the 2020 GSPC target.

Do hotspots of species endemism promote novel lineage diversity?

Cicely A. M. Marshall

Department of Plant Sciences, University of Oxford

Supervisors: Professor Stephen Harris and Dr William Hawthorne (Oxford)

This thesis documents patterns in plant species distribution across tropical Africa. Geographic patterns in the distribution of globally rare plants within Upper Guinea are emphasised, and correlates with these patterns are investigated. This thesis argues that globally rare species can and should be emphasised in conservation strategy.

Approximately 3.7 million global occurrence records of 28,803 tropical mainland African vascular plant species are compiled into a database framework. The database is used to propose an updated biogeographic framework for tropical Africa, which is sympathetic to previous chorological frameworks but maximises regional endemism within quantitatively defined boundaries. A definition of Upper Guinea as the forests of West Africa between Sierra Leone and Ghana is recovered.

The concentration of globally rare species in the tropical African flora (bioquality as measured by the GHI) is calculated and mapped at one degree square and half degree square resolution, revealing high bioquality of the horn of Africa. Bioquality is calculated by categorising the global area of occupancy of all tropical African taxa into a Star rating, with the result that a bioquality score can now be calculated at a local scale anywhere in tropical Africa to inform conservation strategy.

At the local scale, variation in bioquality is modelled in two areas of high global endemism within Upper Guinea: the Nimba Mountains and SW Ghana. Disturbance is the only significant variable retained in both models, and shows a strong negative relationship with bioquality. Bioquality scores in forest reserves of SW Ghana are shown to have been stable over 20 years, although our perception of the global rarity and identity of species within the area has altered substantially. This finding supports the GHI as a metric of conservation priority in the face of partial information.

At half degree square resolution, 55% of tropical African cells are estimated to have less than 2.5% of their likely species richness documented. A regression tree model is used to interpolate bioquality scores for cells lacking species distribution data, making use of a range of modern climatic, paleo climatic, geographic and biogeographic variables, found to be predictive of bioquality scores. Areas showing the most stable climates over the past 21,000 years are shown to have the highest modern-day bioquality across tropical Africa.

Areas with relatively stable climates during periods of past climate change have been hypothesised to show high modern endemism as the result of increased speciation in isolated refugia, and/or a lower rate of extinction within the refugia. Two dated phylogenies are estimated for African magnoliids and Rubiaceae species, which show that most of Upper Guinea's globally rare species are young, vicariant species, although at least one species is likely to be a paleo-endemic, supporting both hypotheses.

Areas with historically stable climates showing present day climatic or topological isolation explain areas of high global endemism in tropical Africa, although the introduction of a high disturbance regime can remove this pattern. A conservation strategy which promotes the protection of globally rare species in tropical Africa is feasible, given what we now know of the African flora, and is wise, at least given the success of the Ghanaian programme over 20 years.

Ecological and Evolutionary Significance of Crassulacean Acid Metabolism in the Montane Genus *Puya* (Bromeliaceae)

Juan D. Beltrán

Supervisors: Professor Andrew Smith and Professor Stephen Harris (Oxford)

Little is known about the evolution and ecology of crassulacean acid metabolism (CAM) in the genus *Puya* Molina. CAM is a photosynthetic pathway typified by nocturnal CO_2 fixation and is regarded as a water-saving mechanism. *Puya* is one of the largest genera in the pineapple family (Bromeliaceae), with 226 species distributed across the Andes, Costa Rica and the Guiana Shield, and from sea level to 5000 m. About 21% of *Puya* species are CAM and at least 10 of these CAM species occur above 3000 m. The main aim of this thesis was to uncover new evidence to understand the ecophysiology and evolution of CAM in the montane genus *Puya*. The prevalence of CAM and C_3 species in *Puya* was estimated from carbon-isotope values of 161 species. The climatic niche of constitutive CAM species and C_3 species of *Puya* was modelled using georeferenced herbarium records and climatic variables to evaluate the differences between their niches. The evolution of CAM in *Puya* was investigated by reconstructing the ancestral photosynthetic pathway on an AFLP phylogeny and by studying positive selection in the genes encoding the key enzyme phosph*enol*pyruvate carboxylase (CAM). The cold resistance and thermal lability of PEPC was investigated for high- and low-elevation CAM species of *Puya* to explore the potential molecular adaptations of CAM plants in high-elevation environments. The present study concludes that the common ancestor of *Puya* was a cold-resistant plant. This is suggested to explain the prevalence of *Puya* at high elevations. The evolution of CAM was correlated with changes in the climatic niche, and occurred multiple times in *Puya*. These multiple origins were not independent because the common ancestor of *Puya* was likely to be a weak CAM plant (based on a diagnostic Arg679 residue in the PEPC sequence). It is likely that populations of *P. chilensis* Molina gained CAM by introgression from *P. alpestris* Poepp.) Gay ssp. *zoellneri* (Mez) Zizka et al.. Weak CAM photosynthesis and cold resistance allowed *Puya* to colonise the Andes from south to north, and in the process constitutive CAM and C_3 evolved. The later-evolving species in the genus are suggested to have lost their capacity for CAM as they radiated into more mesic habitats during their colonisation of the northern Andes.

Student reports

Tom Carruthers (D.Phil., 3rd year) ***Evolution of Ipomoea* in the Neotropics**

Supervised by Professor Robert Scotland (Oxford). Funding: NERC.

Over the past year, I have focussed on estimating divergence times within *Ipomoea*. A particular motivation for this has been to determine whether key events in the evolution of the sweet potato (*Ipomoea batatas* L.Lam.) are likely to have occurred in pre-human times. The results of these analyses were published in a recent *Current Biology* article "Reconciling Conflicting Phylogenies in the Origin of Sweet Potato and Dispersal to Polynesia" (see News item page 3). In addition to investigating divergence times in the context of *Ipomoea*, I have also been focussing on a number of theoretical issues relating to divergence time estimation. These include the difficulties of divergence time estimation where there is a highly incomplete fossil record, and where there is genome-wide molecular evolutionary rate variation.

I will continue to develop these themes over the next year. Further, I will also focus increasingly on estimating diversification rates and the evolution of ecological traits in the context of molecular phylogenies. This work will be carried out in the context of *Ipomoea*, for which our group has now constructed a robust and well-sampled phylogeny. Given the size of *Ipomoea* and its distribution in a range of different habitats, this may provide unique insights into the determinants of plant diversification in large tropical clades. In addition, I will also focus on more general theoretical issues relating to estimation of diversification rates and evolution of ecological traits. Overall, this will allow me to address the overall question of my thesis: what can we learn about the evolution of *Ipomoea* from a robust phylogenetic framework?

Claudia Havranek (D.Phil., 4th year) **Plants as indicators in the UK countryside**

Supervised by Professor Stephen Harris (Oxford). Funding: Oxford-HDH Wills 1965 Charitable Trust Graduate Scholarship

Thesis submitted in spring 2018.

Pablo Muñoz Rodríguez (D.Phil., 3rd year) **Systematics of *Ipomoea batatas* (sweet potato) and its closest relatives**

Supervised by Professor Robert Scotland (Oxford) and Dr Steve Kelly (Oxford). Funding: Interdisciplinary Bioscience Doctoral Training Programme, BBSRC.

Three years of sweet potato research

Despite being one of the most important crops in the world, there was much uncertainty surrounding the origin of the sweet potato when I started my DPhil three years ago. Some unanswered questions included: did the sweet potato have a single or a multiple origin? Did it evolve from a single ancestor or from a hybrid origin, and what wild species were involved? When did it originate? A prerequisite to answer these questions is to understand the evolutionary relationship between the sweet potato and its most closely related wild species, known as Crop Wild Relatives (CWRs). These wild species share a common evolutionary history with the crop, and for that reason constitute potential sources of genetic variability of interest for crop improvement; however, their utilisation requires a good understanding of the phylogenetic relationship between the crop of interest and its CWRs.

In the last decades, multiple studies have tried to answer the questions outlined above. However, these studies provided only incomplete, often contradictory results, and the relationship between the sweet potato and its CWRs remained poorly understood. Ultimately, this lack of knowledge hinders the use of wild species in breeding programmes, and thus sweet potato improvement is restricted to using the genetic diversity held within the crop.

The aim of my DPhil research was to conduct a comprehensive phylogenetic study of the sweet potato and its wild relatives and address the questions that remained unanswered. To overcome previous limitations, we designed our sampling to be as complete as possible: we obtained the whole chloroplast genome and 600 nuclear genes from 400 specimens of sweet potato and all its CWRs. This is by far the most comprehensive genomic dataset of this group of plants to date.

Ipomoea trifida, the progenitor species of the sweet potato, growing in a greenhouse at the International Potato Center in Lima, Peru
Photo © J.R.I. Wood

We have spent the last three years using this large amount of genetic data to investigate the evolutionary history of the sweet potato and finally provided answers to most pending questions: we revealed that the sweet potato had a single origin by autopolyploidy from *Ipomoea trifida* (Kunth) G.Don., hence ruling out the hypothesis of a hybrid origin. We also discovered that the sweet potato originated well before humans, at least 800,000 years ago. These results indicate that humans possibly found and cultivated a sweet potato plant that already had a storage root, and therefore this is not a trait of domestication, but rather a pre-adaptation that predisposed this taxon to domestication. Finally, we identified an ancient hybridisation event of the sweet potato with *Ipomoea trifida* that generated two distinct sweet potato lineages, and the varieties used in modern breeding research belong to one or other of these lineages. These results have important implications in our understanding of sweet potato evolution and its domestication and open the door to the use of CWRs in breeding programmes.

In addition, we addressed one further question: how did the sweet potato, a plant of American origin, come to be widespread in Polynesia by the time Europeans first arrived? This question has been a source of controversy for centuries, and the predominant hypothesis was that humans transported it, which implies the existence of human contacts across the Pacific before the European Age of Exploration. Importantly, sweet potato was the only standing biological evidence of these alleged contacts.

Our results using genomic data contradict the traditional hypothesis and indicate that sweet potato most likely arrived in Polynesia by natural long-distance dispersal in pre-human times, which negates the need to invoke ancient human-mediated transport and questions the existence of pre-Columbian contacts across the Pacific. As part of this research, we had the opportunity to sequence and study an iconic sweet potato specimen collected by Joseph Banks in 1769, during the Captain Cook voyage on the *Endeavour*. This specimen, the oldest sweet potato collection from Polynesia, provided an insight into the timescale of sweet potato colonisation of the Pacific.

The findings presented here are the result of three years of collaborative work of the members of Professor Robert Scotland's group at Oxford Department of Plant Sciences with colleagues from the International Potato Centre in Lima (Peru) and Oregon State and Duke Universities (United States). Our recent publication in the journal *Current Biology* has received much attention from the scientific community and has been covered by the media around the world (more than 50 newspapers worldwide in different languages, including interviews in the *New York Times*, *The Guardian* and *Nature*), which highlights the broad impact and general nature of this research.

Alex Sumadijaya (D.Phil. 2nd year) **Systematics of *Stictocardia* Hall. f.**

Supervised by Professor Robert Scotland (Oxford). Funding: LPDP (Indonesia Endowment Fund for Education).

Ipomoea (Convolvulaceae) is a species-rich genus of more than 800 species. Various phylogenetic studies have suggested that *Ipomoea* is not monophyletic due to the presence of several other genera nested within it. One of the nested genera is *Stictocardia*, a poorly known collection of 9 to 12 species distributed mainly in the Old World Tropics. *Stictocardia* is taxonomically problematic at the species-level as well as the fact that several of its species are more closely-related to species of other segregate genera such as *Turbina*, *Lepistemon*, and *Lepistemonopsis*. This investigation based on morphological and molecular data has identified: 1) several distinctive species with clear taxonomic boundaries and 2) species with unclear boundaries that form species complexes. Increased levels of molecular sequence data are required to resolve species boundaries and understand the phylogenetic relationships between species. The goal of this project is to assemble a comprehensive monograph of *Stictocardia* and other relevant species based on the principles of monophyly and diagnosability.

BRAHMS
Management of natural history

New information technology often seems designed to puzzle even the most computer-savvy amongst us. I liked the old system just fine … why change it?

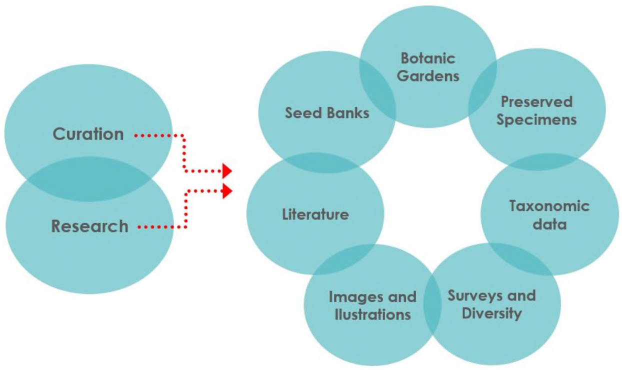
About four years back, we decided that, despite Visual FoxPro's faithful service over the last quarter century, the BRAHMS botanical database had to move to new technology. With a bewildering range of tech-options to choose from, key decisions had to be taken. Would BRAHMS remain a desktop application or become more web based? What sort of data storage to use? How to develop something that would work equally for the itinerant researcher as well as the world's largest museums. Should it remain a 'botanical research and herbarium management system' or branch out more widely for natural history?

The initial specifications were certainly demanding. We envisaged a desktop application but one that could easily be extended with web-based interface components. The data storage had to be entirely separate from the software allowing users to select how and where to store their data. We wanted databases that could run on high capacity servers but also on simple memory sticks. We saw no reason to restrict this new system to herbaria, botanic gardens and seed banks. The wish list began to grow. We needed a system where users could extend their database by adding their own storage fields, for example 'exoskeleton colour', 'USDA Zone' and the like. We also wanted very flexible data transfer links between Excel and BRAHMS. And, as well as storing data in different character sets, a must was that the entire system should be translatable into any language. Finally, in the early planning stages, we dreamt of a system where data could be dynamically associated with maps, ideally something built into BRAHMS itself, thus avoiding complicated GIS installations – the kind of thing where you could click on a dipterocarp in the sea to locate and edit the record in the database.

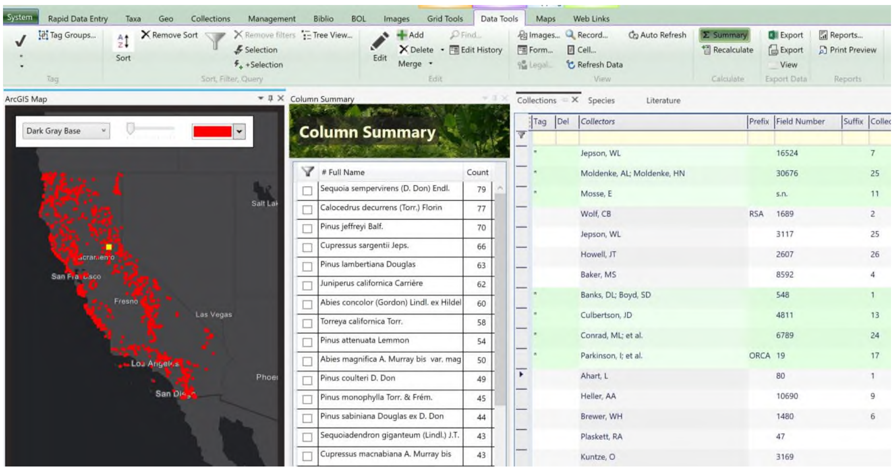
The good news is that all of this and more has now been achieved – a new fully modular BRAHMS has been developed and extended to manage all natural history collections. Despite the B and the H in BRAHMS not being quite right for this broader system, we opted to keep the same name. BRAHMS version 8 will be available for distribution from August 2018. To see more of how it looks and runs, many of the new functions and features are described with screens and video clips on https://herbaria.plants.ox.ac.uk/bol/brahms/software/v8.

Denis Filer and Andrew Liddell
Independent Research Fellows

The module for living collections management is a key focus for BRAHMS v8 with mobile technology a high priority for the next phase of development.



BRAHMS brings together data for collections management and research, increasing outputs and productivity. Each module can be used independently or as part of a more fully integrated management system. Data can be selectively published online.



BRAHMS v8 has an Office-like user interface with intuitive menus and toolbars. Multiple tables, forms and calculation windows can be opened simultaneously across multiple monitors. Direct links are provided between the data and in-built ArcGIS mapping.