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AETFAT 2022 Congress - Book of Abstracts

Diversity and conservation of African plants: Challenges and Opportunities

Edited by
Cyprian Katongo
Yvette Harvey-Brown

22nd AETFAT Congress
27th of June - 1st of July 2022, Livingstone, Zambia

ABSTRACT

The Association for the Taxonomic Study of the Flora of Tropical Africa (French acronym: AETFAT) is an association of botanists and plant conservationists with an interest in African plants whose members and collaborators come from all over the world. Its members and collaborators are interested in the taxonomy, systematics, ecology, sustainable utilization, and conservation of plants. The association is a perfect example of commitment by individual scientists and institutions to use science to generate and communicate knowledge on the sustainable utilization and conservation of the diversity of African plants.

The AETFAT 2022 Congress was the 22nd edition of a series and was held in Livingstone, Zambia, under the overall theme ***Diversity and conservation of African plants: challenges and opportunities***. The venue of the meeting was right on the bank of the Zambezi River, a few metres from the famous Victoria Falls. The congress was hosted by the University of Zambia and officially opened by the Zambian Minister of Technology and Science, Honourable Felix Mutati who was accompanied by the Vice-chancellor of the University of Zamba, Professor Annie Sikwibele. It was attended by about 200 delagates and had 13 thematic areas.

ACKNOWLEDGEMENTS

The successful hosting of the AETFAT 2022 Congress was possible due to financial support from University of Zambia, JRS Biodiversity (USA), Governmnet of the Republic of Zambia, WeForest (Zambia), Inqaba Biotechnical Industries, JBG (France), Chinese Embassy in Lusaka and National Commission for UNESCO. In addition, the following organisations supported large delagations which contributed to the success of the congress: Missouri Botanical Gardens, Royal Botanic Gardens, Kew and Botanical Gardens Conservation International (BGCI).

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2. ROLE OF AFRICAN BOTANIC GARDENS SUPPORTING ECOLOGICAL RESTORATION AND LIVELIHOODS

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Current global interest in restoration and tree planting represents a huge opportunity for delivering species conservation and ecological restoration that benefits biodiversity and people and also captures carbon. Large-scale restoration and tree planting pledges have been made by countries across Africa. However, with a lack of attention paid to species selection in planting programmes, biodiversity and community benefits are often missed. The botanical community is growing increasingly concerned about this. Botanic Gardens Conservation International (BGCI) and its network, including the Ecological Restoration Alliance of Botanic Gardens (ERA), has developed data tools and resources that can help restoration decision-makers and practitioners to shift towards an approach that benefits biodiversity. This presentation shared these tools and also highlighted examples from African botanic gardens that are leading ecological restoration projects that are delivering strong biodiversity and livelihood impacts. With restoration high on political and development agendas across Africa, this represents an important avenue for deploying botanical data and expertise.

Keywords: Restoration, tree planting, biodiversity, community benefits, carbon capture

3. FOREST LANDSCAPE RESTORATION IN AFRICA

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Throughout Africa, Forest Landscape Restoration (FLR) is gaining momentum. Projects across the continent have increasingly shifted from wildlife conservation and rehabilitation to an FLR focus. However, in Africa, poaching was (and remains) a huge problem while land grabbing and human encroachment have increased dramatically in the last few decades and are currently seen as the most important threat to Africa's natural landscapes. This presents risks to ecosystems and to human society at large. WeForest, an international organization, undertakes projects which focus on a holistic and long-term approach to FLR, involving a variety of stakeholders, and tailoring its support to local conditions thereby embracing multiple benefits beyond the restoration of the ecological functionalities. This presentation briefly highlighted the organisation's portfolio, focused on the programmatic approach and identified some research gaps that should be addressed.

4. AETFAT THROUGH THE YEARS: BIODIVERSITY RESEARCH, EDUCATION AND CONSERVATION VISIONS FOR OUR COMMUNITY

OLWEN GRACE

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AETFAT is the main meeting for place for the research community working on the flora of Africa. Congress themes during the intervening decades since the first meeting 71 years ago, in Belgium 1951, track progress in completing floristic treatments and shifting themes that capture attention. Innovations have included the completion of major floristic projects, revision of angiosperm classifications reflecting molecular phylogenetic evidence, and developments in the study of plant biogeography. Conservation of African plants has always been high on the agenda for the AETFAT community; it was the theme for AETFAT in 1966. We are now tasked with completing knowledge gaps with greater urgency than ever, in light of a planetary emergency that threatens to result in species extinctions before they may be scientifically described. Nature-based solutions hold exceptional promise for mitigating anticipated environmental changes expected due to climate change, and baseline information generated by the AETFAT community will influence their

success in Africa. The 22nd AETFAT congress is an ideal opportunity to pause, rethink and regroup to strategically tackle the most urgent tasks in documenting, describing, and conserving the African flora.

Like many of you, I have grown up at AETFATs – Cameroon, Madagascar, South Africa, Kenya and now Livingstone. Although in some respects I still feel like that 20-something year old, giddy at the chance to attend such an important meeting and hear from the leaders in our field. My first AETFAT was in Younde Cameroon in 2007. While preparing for this talk I have spent time thinking about AETFAT the organisation and how I might use this opportunity to reach out to you as the community of experts interfacing with describing and conserving the African flora.

AETFAT was established in 1950 and its first meeting was held in Brussels, Belgium in 1951 with a small number of participants. The closest venue to Africa in the first two decades was in Gran Canaria I978. It took more than 30 years for the congress to be held on African soil. The first congress in Africa was held in Pretoria South Africa in 1982. During the 50-year anniversary in 2000, the editor Robbrecht gave a useful synopsis of themes and proceedings to that date.

An assessment of the proceedings tracks socio-economic and political history (and fashions) through time. Looking back at 70 years of AETFAT illustrates the important advances this community has achieved together. The greatest accomplishment is undoubtedly the vegetation map of Africa, led by Frank White and jointly compiled by AETFAT with UNESCO over a 15-year period. In the huge body of work published in the AETFAT proceedings, there are numerous historic moments in the classification, conservation and understanding of the flora of Africa. To better understand the major themes and areas where we've been particularly active, collectively, and likely therefore influential, I scanned all except three of the proceedings volumes and classified all the papers in categories. It is rather crude and I have simplified them by lumping things.

My assessment of the themes is as follows:

1) Taxonomy and floras
2) Flora progress
3) Taxonomy
4) Ethnobotany and sustainable resources

The AETFAT community has been pivotal in the completion of major flora projects like FZ, FTEA, FWTEA, Flora of Ethiopia, FSA, etc. This is the most fundamental baseline of understanding the plant diversity of a region. In other words, what grows where and how to identify it.

Floras are publictions which are not intended to be complete revisions nor do they require a phylogeny to check monophyly. They are identification tools primarily rather than in-depth, comprehensive monographs. But there remain important gaps in our baseline documentation of the floras of Africa because the work is difficult to fund and is not attractive to scientists.

This evolution in themes reflects how floras and fundamental taxonomy pave the way for downstream conservation, research and utility of biodiversity. This baseline is critical for any evidence-based approach to conservation

With the 75th anniversary of AETFAT approaching in 2026, and in the wake of a hiatus in at least some of our activities, now is a good moment to galvanise our community towards progress on various things including the completion of floras.
Future botanic work should be: (i) focused (e.g. Botanic gardens planning, restoration, ex situ conservation and baseline floristics focused on important plant areas; (2) collaborative - where team work will get things done more quickly by capitalising on synergies between interested parties and avoiding duplication of efforts.

5. BOTANICAL COLLECTIONS AND SPECIMEN DIGITIZATION AS A FOUNDATION FOR FUTURE RESEARCH AND EDUCATION IN CONSERVATION

DAVID KENFACK

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Plant diversity is disappearing at an alarming rate due to habitat loss, overexploitation of natural resources and the adverse effects of climate change. To halt this loss, the Global Strategy of Plant Conservation in his Objective number I calls among other targets, for the development of “an online flora of all known plant species and for “an assessment of the conservation value of all known plant species”. These targets rely heavily on taxonomists to accurately document the diversity and distribution of these species through botanical collections and specimen digitization. Significant progress has been made in recent decades in terms of improving herbarium collections, developing plant databases and digitizing specimens, making them more accessible to a wider scientific community. Still, the botanical exploration of tropical Africa is far from complete, with only a tiny fraction of the area containing sufficient number of specimens to accurately estimate inventory completeness. Here, we argue for the need for continued and even intensified plant collection as well as digitization of plant collection data and continued taxonomic

research, making sure there is a sound foundation for both research and education in plant conservation and development.

6. GOVERNING THE CONSERVATION OF AFRICAN PLANT DIVERSITY

JACOB MWITWA

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Human dependence on forest resources, as an example, is greater in sub-Saharan Africa (SSA) than in any other region (Scherr et al., 2004). CIFOR (2005) indicates that about two-thirds of Africa's 600 million inhabitants directly or indirectly subsist on forest resources for their livelihoods. This dependence includes food security and energy needs as forests provide both food (bush meat, edible insects, fruits, leaves, seeds, nuts, honey, roots, tubers, bulbs and mushrooms) and the fuel to cook it (wood or charcoal). About 68% of forest products harvested by rural households are used to meet households' subsistence needs and only 32% is sold at local markets for cash or in exchange for other household goods (Mataya et al., 2011). In Southern Africa, wild plant resources contribute an income ranging from US$194 to US$1,114 per household and at the national level, many people are engaged in gathering, processing, trading and in other production activities such as the use of wild plants to make mats, thatch and furniture (Arnold, 1995; Tieguhong et al., 2009). Some countries in Southern Africa including Angola, Botswana, Mozambique, South Africa, and Zambia harvest wild plants including edible tubers which are used as foods (Mataya et al., 2011). These have become important especially during periods of flooding or prolonged droughts that result in food shortages. In Zambia, for instance, due to food shortage during persistent floods or recurrent droughts, the importance of these wild products has considerably increased to serve as safety nets for food security (Lehoux and Chakib, 2012). Tubers and bulbs are obtained from forests and used as food and for sale to sustain rural livelihoods during periods of famine (Njovu, 1993; Chishimba, 1996).

7. MAKING PROGRESS WITH IMPORTANT PLANT AREAS FOR CONSERVATION IN TROPICAL AFRICA: UPDATES FROM GUINEA, CAMEROON, UGANDA, ETHIOPIA AND MOZAMBIQUE.

CONSORTIUM OF PARTNERS

Available from team leader: Martin Cheek (M.Cheek@kew.org)

PRESENTATIONS

1. Thematic Area 1: Botanic Gardens/Plant Science supporting sustainable development

1.1 Oral Presentations

1.1.1. BUILDING A SCIENTIFIC FOUNDATION FOR POSSIBLE SUSTAINABLE AND EQUITABLE EXPLOITATION OF *DALBERGIA* (ROSEWOOD) AND *DIOSPYROS* (EBONY) IN MADAGASCAR: CLARIFYING SPECIES-LEVEL TAXONOMY AND DEVELOPING PRACTICAL IDENTIFICATION TOOLS FOR MANAGEMENT AND REGULATION

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Madagascar, an important source of precious woods since colonial times, has during the last two decades suffered unprecedented levels of illegal overexploitation and export of highly valuable rosewood (*Dalbergia*, Fabaceae), primarily to satisfy massive demand in China, and to a lesser extent ebony wood (*Diospyros*, Ebenaceae), prompting CITES to list both genera in Appendix II in 2013. The effective application of CITES assumes that commercially valuable species are well delimited and recognizable, but this was not the case for both *Dalbergia* and *Diospyros* in Madagascar. Moreover, effective management and regulation of these

highly valuable natural resources depend on the availability of a robust taxonomy and reliable identification tools for standing and felled trees (including in the absence of flowers or fruits) as well as of logs, sawn wood and finished products, none of which tools were available. In an effort to overcome these critical deficiencies, the Madagascar Precious Woods Consortium has brought together experts and students in taxonomy, field botany, wood anatomy, spectrometry and DNA sequence analysis to: 1) conduct extensive field work to sample all species of potential commercial value in both genera; 2) clarify species limits and threat status; 3) identify informative characters (including leaves, bark, wood anatomy, heartwood spectral signatures, and DNA profiles) that can be used in various combinations for accurate identification along the entire supply chain; and 4) determine which species (if any) might be appropriate candidates for possible sustainable and equitable exploitation. Field work has generated over 4,000 vouchered wood and DNA samples representing 52 species of *Dalbergia* and 58 species of *Diospyros* that produce wood of potential commercial value, providing invaluable material for the complementary lines of research being undertaken by the consortium members.

Keywords: *Dalbergia*, *Diospyros*, Precious woods, CITES, Madagascar

1.1.2 REFERENCE LIBRARY FOR THE MANAGEMENT OF PRECIOUS WOODS (*DALBERGIA* AND *DIOSPYROS*) IN MADAGASCAR

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Ebony (*Diospyros*) and rosewood (*Dalbergia*) are among Madagascar's most sought-after and heavily exploited precious woods for both domestic and international trade. The sustainable and equitable management of these genera, currently listed in CITES Appendix II, relies on sound knowledge of their species, which must be known, described, recognizable, and distinguishable, both as standing trees and as felled wood. One of the main goals of the project entitled

“Gestion durable des bois précieux, *Dalbergia* et *Diospyros* (G3D)” is to provide expert identification of these species and to build a Reference Library of samples containing a “fingerprint” of each species that can be used for forensic identification, control of international trade, and sustainable and equitable forestry. Taxonomic work on *Diospyros* and *Dalbergia*, along with field work to generate material for the Reference Library, together provide the foundation needed to: 1) inform research being conducted by other teams in the G3D project (anatomy, wood spectrometry, and DNA sequencing), and 2) deliver an updated assessment of the species that are potential sources of ebony and rosewood, essential for the establishment of a sustainable and equitable system to manage these important resources. Field work was conducted throughout the distribution range of each genus to collect wood and bark samples, heartwood cores, and leaf material in silica gel, along with associated photos and herbarium specimens; each was assigned a unique collection and accession number. A total of 37 field trips have recently been carried out over a period of four years, generating 4133 collections (2219 *Dalbergia* and 1914 *Diospyros*). Currently 62 species of *Dalbergia* have been identified as potential sources of commercially valuable wood, 52 (92%) of which are represented in the Reference Library, and 88 species of *Diospyros* are likewise potential sources of ebony wood, 58 (66%) of which have been sampled. The geographic range of some species is sufficiently represented, while additional sampling is required for the others in order to ensure adequate coverage of morphological and genetic diversity, and thereby to provide a reliable and accurately identified reference collection.

Keywords: Precious woods, *Dalbergia*, *Diospyros*, CITES, Reference library, Madagascar

1.1.3 A TRAIT-IDENTIFICATION DATABASE FOR MADAGASCAR PRECIOUS WOOD SPECIES: *DALBERGIA* AND *DIOSPYROS*

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Madagascar has important biodiversity such as precious wood species that are threatened by extinction. In 2013, rosewood, palisander and ebony were listed in Appendix II of CITES (Convention on International Trade in Endangered Species Wild Fauna and Flora). Currently, because of lack of control on the illegal logging, the export of products of two genera, *Dalbergia* and *Diospyros*, from Madagascar is prohibited. In order to strengthen the control of illegal logging and to promote legal

movement and international trade of these woods, species identification tools are needed. Several programs are used including plant morphology, plant anatomy, palynology, spectroscopy, chemistry and molecular biology to produce identification tools. Here, we provide a database (b3dm 1.0) of the identification traits of precious wood species in Madagascar. The database includes more than 1500 records of samples collected since the year 2000 throughout Madagascar. It contains samples obtained from herbarium specimens. Wood, and leaves were analysed based on plant morphology, plant anatomy, plant physiology, palynology, spectrometry, chemistry and molecular biology. This database is the first version developed in Madagascar to centralise, in a structured format amined to share information among researchers and other users. Identification traits data are obtained from field and laboratory analyses of collected samples, literature review, field experiments and observations. The database is structured to take into account the different levels of accuracy of identification traits for each entry. It is developed to receive all information on *Dalbergia* and *Diospyros* obtained at later stages. The b3dm 1.0 should facilitate testing hypotheses on plant identification and helping users to set up the wood traceability in Madagascar.

Keywords: Madagascar, Wood species identification, Database, *Dalbergia, Diospyros*

1.1.4 AN INTEGRATIVE PHYLOGENOMIC APPROACH TO SPECIES DELIMITATION IN THE TAXONOMICALLY CHALLENGING PRECIOUS WOOD GENUS DALBERGIA (FABACEAE)

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The genus *Dalbergia* L.f. (Fabaceae) includes valuable timber species, many of which are threatened by overexploitation. Conservation and establishment of sustainable management rely on viable taxonomy and correct species identification, whether to assess species diversity, to identify population trends, or to verify timber identity declarations. Species identification of *Dalbergia* is particularly challenging in

Madagascar due to a large number of similar species and reliance on flowers and fruits for identification, which are often absent in field specimens. We used recently collected DNA material of Malagasy *Dalbergia* species in combination with older herbarium specimens (including types) to ascertain whether species can be delimited using a phylogenomics approach based on target enrichment of thousands of nuclear genetic loci. All except two species could be assigned to two genetic supergroups of Malagasy taxa that show pronounced differences in flower and fruit characters. We further identified eleven well-supported clades within those supergroups, most of which are clearly associated with different eco-geographic regions of Madagascar. Each clade contained several described species, each of which could be distinguished using our target enrichment approach, but not with traditional DNA barcoding. Results further indicate that several infraspecific and synonymous taxa recognized in the most recent revision of the group are genetically, eco-geographically and morphologically distinct, and should be elevated to the rank of species. Moreover, DNA sequence results and morphology strongly support the recognition of over twenty new Malagasy *Dalbergia* species, the majority of which produce large trees. Our results demonstrate that the current taxonomy of Malagasy *Dalbergia* does not adequately account for the level and patterns of species diversity observed, and they provide insights that are highly informative for a taxonomic revision being conducted on this important genus, which is essential for the development of forensic timber identification strategies that depend on correctly identified reference collections.

Keywords: *Dalbergia*, Madagascar, Species delimitation, Target enrichment, phylogenomics

1.1.5 REVISING THE TAXONOMY OF MALAGASY *DALBERGIA* (FABACEAE): TARGETED COLLECTING AND MOLECULAR TOOLS BRING TO LIGHT AN UNIMAGINED DIVERSITY

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Rosewoods of the genus *Dalbergia* (Fabaceae) are the world's most valuable, sought after and highly prized precious woods. Accordingly, their appeal for black market trade is significant and this drives illegal trafficking, which is having disastrous effects on Madagascar's natural heritage. In light of this problem and with the Malagasy government's desire to manage this important resource, the lack of reliable identification tools for Madagascar's 48 currently recognized *Dalbergia* species has emphasised the need for a taxonomic revision of the genus, and in particular those species forming large-sized trees. Thorough documentation of the occurrence of clearly delimited species and functional identification keys are among the first steps required for curbing illegal overexploitation and regulating any potential harvesting at a sustainable level. To facilitate this process, an ongoing field collection campaign, coordinated by the Madagascar Precious Woods Consortium, has to date produced over 2000 collections, representing at least 46 species of *Dalbergia* from across Madagascar. Our integrative approach, combining cutting edge molecular methods and traditional taxonomic approaches has brought to light an unimagined diversity of species, many hidden in plain sight among a number of ambiguous, broadly circumscribed taxa. Combined morphological and molecular data suggest that as many as 30 out of the 48 currently recognized species may currently comprise more than one evolutionarily distinct lineage. We present some of our progress in revising the genus to date, including an estimate of the number of new species, which is rapidly approaching 40. We further provide examples of three species complexes within the Malagasy *Dalbergia* to illustrate typical problems encountered in the group and how these are being resolved.

Keywords: *Dalbergia*, Taxonomy, Precious woods, Madagascar

1.1.6 MORPHOLOGICAL CHARACTERS PROVIDE INFORMATIVE TOOLS FOR THE MANAGEMENT OF MALAGASY *DALBERGIA* (ROSEWOOD/PALISANDER)

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Dalbergia species are the source of rosewood and palisander, among the world's most beautiful, valuable, and highly prized precious woods. There is a need to control international trade involving many shipments of harvested wood from Madagascar only referred to as *Dalbergia* spp. or rosewood. There is also need to conserve *Dalbergia* populations in the country. The application of CITES (Convention on International Trade in Endangered Species) requires the reliable identification of *Dalbergia* to the species level, but its current taxonomy is out of date, and until it can be refined and associated information and tools are available that permit positive identification of felled timber, it will be impossible to establish robust controls on the exploitation of this important and valuable resource. Practical tools must enable identification when flowers and fruits are lacking in order to serve as an authoritative reference for identifying standing trees, which usually lack these floral structures. The tool being developed is based on morphological variation and documented correlated differences in geographic distribution of all potentially exploited species. Leaflet morphological characters of *Dalbergia* are being examined to determine those that are informative for species identification. Data are being analysed statistically to assess significant variation between species and to confirm which characters are correlated with species. Informative characters will be used to develop a practical identification tool for *Dalbergia* species and will be incorporated into the updated taxonomy now being developed for the genus, without which it will be impossible to establish, control and enforce a program of sustainable exploitation of Malagasy rosewood and palisander.

Keywords: *Dalbergia*, Precious woods, Identification, Conservation, Leaves

1.1.7 PROGRESS ON THE TAXONOMY OF MALAGASY *DIOSPYROS* (EBENACEAE), THE ISLAND'S LARGEST GENUS OF WOODY PLANTS

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In his 1952 revision of Malagasy Ebenaceae, Perrier de la Bâthie recognized 97 species in 3 genera, but botanists consistently had difficulty identifying material using his keys and descriptions, and over time many collections remained unassigned to a species. A careful review conducted 10 years ago retained 86 species, all included in *Diospyros* and all but 3 endemics, placing the others in synonymy, but well over half of the collections clearly did not belong to any of these taxa, suggesting that a significant portion of the diversity represented by the genus in Madagascar remained to be described. Studies over the last decade, based on >15 times as many collections as were available in 1952, largely generated from extensive field work conducted by botanists from the Missouri Botanical Garden, have confirmed this. These studies have reveaed some 170 additional, clearly delimited and easily distinguishable new species, all endemic, bringing the estimated total size of *Diospyros* to about 255 species and making it Madagascar's largest genus of woody plants. Most species belong to one of 12 morphologically coherent and easily recognized groups that have been informally delimited and named, several of which are supported by initial molecular phylogenetic results. To date 57 new species have been described in eight papers, including all 46 previously unpublished species that form large enough trees (≥20 cm DBH and/or ≥20 m tall) to be potential sources of valuable ebony wood, bringing the total to 88 large tree species, more than half of which are threatened, and providing a robust framework for research being conducted by the Madagascar Precious Woods Consortium to inform CITES regulation and possible sustainable exploitation.

Keywords: *Diospyros*, Taxonomic revision, New species

1.1.8 A DIGITAL MULTI-ACCESS KEY NEWLY DESIGNED TO EASILY IDENTIFY LARGE TREE SPECIES OF EBONY WOOD IN MADAGASCAR

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The largest genus of Ebenaceae, *Diospyros*, is the source of ebony, a precious wood characterized by its rich black color. In 2003, Malagasy *Diospyros* was added to CITES Appendix II because many of its species are threatened by over-exploitation and illegal logging for the global trade. However, species delimitation within *Diospyros* remains problematic: nearly 250 species are currently known to occur in Madagascar, 142 are described and only 3 are not endemic. During the last decade, many taxonomic problems have been resolved based on the study of herbarium collections, emphasizing on reproductive organs in addition to selected vegetative features, especially leaf morphology. However, reproductive morphology is of limited use for the control of illegally traded woods, because when fruits and flowers are absent in the field, tree identification is difficult or impossible. This work first focuses on Malagasy *Diospyros* species that are most likely to be exploited or potential sources of marketable ebony. For this purpose, tree species estimated to be sufficiently large, reaching a DBH ≥20 cm or a total height ≥20 m were considered. On the other hand, the development of a reliable and an efficient identification tool through extensive analyses of outer bark, leaves, young twigs, fruiting calyces, and supplemented by ecological data, such as bioclimate, altitude, longitude, and latitude, offers important prospects for improving the control of exploitation and exportation, while facilitating conservation and sustainable management. A digital, easy to use, multi-access key, for the identification of 88 potentially exploitable Malagasy ebony species was developed using the Lucid key building software.

Keywords: Taxonomy, *Diospyros*, Ebenaceae, Bark, Lucid

1.1.9 CONSERVATION *EX SITU* DES BOIS PRECIEUX DE MADAGASCAR DES GENRES *DIOSPYROS* (EBENACEAE) ET *DALBERGIA* (FABACEAE) DANS LES « FIELD GENE BANKS »

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La flore malgache est riche en biodiversité, avec environ 14.000 espèces et un taux d'endémicité d'environ 87%. Cependant, les menaces et pressions anthropiques risquent d'anéantir une partie importante de cette richesse. De 1950 à 2000, 40% de

la forêt naturelle restante ont été détruites et sa perte se poursuit aujourd'hui à un rythme alarmant. Dans de nombreuses régions, toutes les forêts naturelles protégées ou non seront perdues au cours de la prochaine décennie si des mesures de conservation ne sont pas prises. On estime que 13% de la flore n'a aucune mesure de protection. La conservation *ex situ* dans les aires prioritaires pour la conservation des plantes présente un compliment viable et efficace dans le but de lutter contre l'extinction des espèces. Nous avions valorisé la capacité de neuf aires protégées pour créer des endroits sécurisés appelés « Field Gene Banks » pour des espèces de *Diospyros* (EBENACEAE) et de *Dalbergia* (FABACEAE), deux genres qui sont économiquement importants, précieux, très diversifiés et incluent de nombreuses espèces rares et menacées. Les inventaires floristiques, la collecte d'échantillon de graine, et la multiplication végétative de *Diospyros* et de *Dalbergia* dans les habitats naturels non protégés ont été effectués afin de promouvoir leur conservation *ex situ*. Chaque échantillon de graine collecté est lié à une récolte d'herbier de référence afin de permettre une identification fiable de l'espèce. Les graines sont propagées dans des pépinières afin de plantées des jeunes individus dans les « Field Gene Banks ». Comme pour toutes les espèces de plantes ligneuses, cette technique offre une alternative pragmatique et économiquement viable pour la conservation *ex situ*, mais surtout, elle offre à ces deux genres de bois précieux l'avantage de fournir à l'avenir un meilleur accès aux semences bien identifiées et de provenance connue pour des efforts de plantation et de restauration.

Mots clés: Conservation *ex situ*, Bois précieux, Graine, Pépinière, Field Gene Banks

1.2.1 Posters

1.2.1 A GARDEN GUIDE TO NATIVE PLANTS OF COASTAL EAST AFRICA

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The East African coastal ecosystem, stretching for 4,600 km from southern Somalia through Kenya and Tanzania to northern Mozambique, is one of the most biologically diverse regions in the world, but 90% of its original vegetation has been lost, and the destruction continues. To restore the native ecosystem, we must halt the planting of alien species and promote the replenishment of native species. This requires an accessible tool that will enable people to distinguish native from alien plants. To meet this need, *A Garden Guide to Native Plants of Coastal East Africa* presents a

comprehensive approach to the use of indigenous plant species in private and public gardens. The book originated as a school project through Jane Goodall's Roots & Shoots community service group, with students compiling data on native plants, and it grew from a pamphlet into a poster and finally into this book. Separate chapters describe the East African coastal ecosystem, detail 60 native species suitable for domestication, identify threats to biodiversity in that ecosystem with an emphasis on invasive alien species, discuss regeneration of the coastal ecosystem through conservation landscaping, and review the current state of the ecosystem with recommendations for measures that can be used to restore it. An appendix provides recipes using coastal East African plants, and a glossary provides definitions of technical terms. The book is available through Mkuki na Nyota Publishers in Dar es Salaam, Tanzania, and the African Books Collective in Oxford, UK.

Keywords: Alien species, Biodiversity, Conservation, Ecosystem, Indigenous species

1.2.2 CITES *DALBERGIA* CHECKLIST

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Dalbergia (rosewoods) are an economically important genus with a wide range of uses from furniture, medicine and firewood to food. *Dalbergia* species are found across the world, especially in tropical forest and savanna habitats in Africa, Asia and the Americas. Due to the increasing unsustainable demand for rosewood timber, *Dalbergia nigra* from Brazil was listed on CITES Appendix I in 1992 followed by the entire genus listed on CITES Appendix II in 2017. Many plant and animal species listed on CITES have a standard nomenclature reference that can be used in CITES Parties' national legislation, by border control and CITES management and scientific authorities. At the CITES Conference of the Parties 18 in 2019 it was recommended that an annotated CITES checklist of *Dalbergia* was required. The Royal Botanic Gardens, Kew collaborated with a team of *Dalbergia* taxonomists, IUCN Red List assessors and nomenclature experts to produce the first ever CITES checklist for *Dalbergia*. The checklist contains species profiles for 275 accepted species including information on synonyms, common names, two representative herbarium specimens, key literature references, timber libraries, main uses, IUCN Red List status, CITES appendix and annotation, plant habit, plant height, country distribution, altitudinal range and habitats. The checklist also includes a comprehensive list of all published *Dalbergia* names, and a country checklist. The checklist is published in the three official CITES languages of English, French and Spanish. It will be presented

at the next CITES CoP in November 2022 for the approval of the CITES Parties and officially adopted as the standard reference for *Dalbergia*.

Keywords: CITES, *Dalbergia*, Rosewood, Red List, Trade

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2. Thematic Area 2: Flora of Central Africa

2.1 Oral Presentations

2.1.1 WHAT SHOULD BE DONE ABOUT THE SLOW PROGRESS OF CENTRAL AFRICAN FLORAS?

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A Flora is a tool primarily serving the need for plant identification. Additionally floras provide basic information on each species and often provide a crucial entry to additional data. As such, Flora are essential not only in a wide variety of biological research fields, but also in conservation and management. In tropical Africa, the western and eastern regions are covered by several major Floras that are complete (FWTA, FTEA) or almost so (Fl. Zamb.). Halfway through the previous century, three major Flora series related to C. Africa; Flore du Cameroun, Flore du Gabon and Flore d'Afrique centrale, were started up. All have shown rapid progress at the start, with a notable decline in speed after several decades, leading to an asymptotic production curve. For Sao Tomé and Principe, only a Checklist exists (updated in 2011). The Flora of Rwanda, completed in 4 volumess, was published in 1978-1987 and treats 2383 native species. The Flora de Guinea Ecuatorial (c. 5000 species) started in 2002, and has now dealt with c. 30% of the species. Flore du Gabon is advancing well, with c. 80% treated. The Central African Republic and the Republic of the Congo still remain without any Flora initiative to date. Despite major efforts, and even specific funding, progress of the major Floras in the region remains slow. Various reasons are evaluated, but it is concluded that producing a Flora account is no longer a priority for many taxonomic specialists. The development of e-Floras and standards like World Flora Online may support, but probably not speed up the production. Having in mind the huge importance of the availability of good quality Floras, two strategies are discussed. The first is obtaining major funding, possibly per country, for a major program involving salaried positions. The second is drastically changing the focus of the Flora treatments towards identification (keys

and illustrations) and diminishing the taxonomic workload (compiling from literature only). Or maybe a combination of both?

Keywords: Flora, Central Africa, Taxonomy, Botany

2.1.2 TREATMENT OF *PHYLLANTHUS* (PHYLLANTHACEAE) FOR FLORE D'AFRIQUE CENTRALE: A STEP IN THE REVIVAL OF TAXONOMIC RESEARCH IN CENTRAL AFRICA

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The territory covered by the Flore d'Afrique centrale hosts approximately 11,000 species of flowering plants and ferns. This Flora series started in 1948, but at present only ca. 60% of species have been treated. In 2013, Meise Botanical Garden (Belgium) decided to give a new impetus to the publication of this Flora, with an additional focus on the development of local expertise in plant taxonomy in Central Africa. In that region, active taxonomists are indeed very few, seriously jeopardizing the implementation of plant conservation programs. In this context, the junior author of this paper (EI), based at the herbarium of the University of Lubumbashi (Dem. Rep. of the Congo), has received training in herbarium taxonomy during several internships in BR and BRLU. *Phyllanthus* is a cosmopolitan genus comprising about 900 species. The genus is well represented in tropical and subtropical regions, with about 150 species in continental tropical Africa. The genus is notoriously difficult to study due the large number of species and the close morphological resemblance of many of them (Luo et al., 2011). Approximately 5500 plant vouchers in the following herbaria: BR, BRLU, KIP and LSHI have been revised. Based on characters previously shown to be of taxonomic significance in the seminal monograph of Brunel (1987), we prepared a database comprising 50 morphological characters. A checklist comprising 56 Central African species (of which 11 are endemic) was prepared. Six new synonyms are proposed. Two species new to the area are reported i.e. *Phyllanthus engleri* Pax and *Phyllanthus incurvus* Thunb. One variety new to science has been described (*Phyllanthus polyspermus* Schumach. & Thonn. var. *puberula* Ilunga). Most importantly, a character table was developed to produce the first exhaustive identification key to the species in Central Africa. The Flora treatment of the genus has been published in December 2020, along with the remainder of genera of Phyllanthaceae that were prepared by the second author.

The first author is currently working on Verbenaceae, a family of around 28 species, almost all of which are of medicinal interest. He has also selected and locally trained three young candidates (two females and one male) willing to apply for a training in taxonomy at Meise Botanical Garden this year.

Keywords: Central Africa, Plant taxonomy, Capacity building, *Phyllanthus*, Conservation

2.1.3 CONVOLVULACEAE IN FLORE D'AFRIQUE CENTRALE: DEMOCRATIC REPUBLIC OF CONGO, RWANDA AND BURUNDI

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A floristic treatment of the Convolvulaceae occurring within the framework of the Flore d'Afrique centrale (Democratic Republic of the Congo, Rwanda and Burundi) is given. It provides an important update of the studies published by Lejoly & Lisowski in 1992 and 1993. In the present treatment, 23 genera and 132 species are documented, among them 11 subspecies and 21 varieties. Of these, 18 taxa are endemic to the region, while 17 are introduced. The present treatment includes one new combination, three names are treated as synonyms for the first time, and seven lectotypes and one neotype have been designated. A novel key to the genera is presented, which de-prioritises the pollen characters so often used at this level, and maximizes the use of more easily observed morphological characters. We hope that this more practical approach will be particularly helpful in the identification of herbarium material. Species recognition is further facilitated by the inclusion of 59 detailed line drawings and 17 pages of full colour photographs. All genera and species come with a morphological description, synonyms, distribution data, habitat data, conservation information, vernacular names, as well as additional bibliography, taxonomic notes and the citation of representative herbarium specimens. Within the Flora region, the species of Convolvulaceae have a wide range of uses, notably as edible (tubers and vegetables), medicinal and ornamental plants.

Keywords: Climbers, Morning glories, Sweet potato, Systematics, Taxonomy

2.1.4 PODOSTEMACEAE IN GABON: UNPRECEDENTED FIELDWORK REVEALS MANY NOVELTIES

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Podostemaceae is a pantropical family of freshwater aquatic vascular plants restricted to rapids and waterfalls. Species are often assessed as highly threatened because of their small distribution and their restricted habitat, and thus represent a crucial conservation issue worldwide. In Gabon, the resurgence of several hydroelectric projects irretrievably affecting the habitat of the species underlines the urgent need for recent and reliable data on a family that is still poorly known for the country despite the recent publication of the Flore du Gabon. The aim of this study was thus to produce a new checklist of this family for the country and assess a preliminary conservation status for each species. Since 2017, in order to assess the diversity of the family for the country, we have performed eight fieldwork campaigns on the main rapids and waterfalls. Preliminary results indicate that the ca. 185 collections gathered since 2017 represent at least 26 morphospecies, some still needing identifications. These new data bring the total number of Podostemaceae species known in Gabon to 33, including eight new species, in addition to the species already known from Gabon. More species are likely to be discovered, either in the recently collected material or from future field collections. A full conservation status according to IUCN criteria will be established for the most sensitive species.

Keywords: Gabon, Podostemaceae, Inventory, Novelties

2.1.5 PRÍNCIPE ISLAND: A PRISTINE HIDDEN PARADISE OF TREE DIVERSITY

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Príncipe Island, which is part of the archipelago of São Tomé & Príncipe in the Gulf of Guinea, is a small volcanic island of 126 km², culminating at 948 m. The island was designated as a UNESCO Biosphere Reserve in 2012, and its forests are also an Important Bird Area, and part of the Guinean Forests of West Africa Hotspot. In spite of this, Príncipe's flora has, until recently, remained botanically poorly known and unexplored, and the threats affecting it have never been assessed. Since 2016, we have been studying the tree diversity of Príncipe and gathering taxonomical, geographical and ecological data to assess the conservation status of its rare and poorly known tree species, and demonstrating the important link between a botanical research cycle and concrete conservation actions. Transects and general field collections revealed 173 species of woody plants, including many new records for the island or for the archipelago and at least 10 species new to science. We made the first attempt to produce a classification of Príncipe's forests, identifying four types of vegetation. In June 2019, with support from the Central African Plant Red List Authority, we conducted Red List assessments of 25 of Príncipe's tree species, of which 19 were classified as threatened on a global scale and two as threatened on a regional scale. We concluded that the flora of the island has 445 species and infraspecific taxa with 88.5% being native of which 7.6% are strictly endemic to Príncipe and 14.7% endemic to the São Tomé and Annobón Island. To support future botanical research in the country the project created the Principe Herbarium and the Orchidarium of Príncipe Natural Park and trained 13 people from local institutions on plant identification and field techniques to evaluate the diversity of trees in the island. For the next two years, we will implement practical conservation actions for three of Principe's threatened tree species, *Carapa gogo*, *Strephonema* sp. nov., and *Chytranthus mannii*.

Keywords: São Tomé and Principe, Endemism, Red Listing, Conservation, Hotspot

2.2 Posters

2.2.1 *PALISOTA* (COMMELINACEAE) IN ATLANTIC CENTRAL AFRICA REVISITED: DESCRIPTION OF EIGHT NEW SPECIES

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The gathering of nearly 100 collections of *Palisota* in Gabon since 2012 allowed a review of this Commelinaceae genus in Atlantic Central Africa, as a precursor to preparing the treatment for the Flore du Gabon. It resulted in the description of eight new species, all occurring in Gabon, and the re-assessment of the relevance of several morphological key characters and on delimitation of two poorly known species, *Palisota bogneri* and *Palisota satabiei*. Thie latter, thought to be a commonly widespread species in Central Africa, is now considered restricted to South-West Cameroon and Equatorial Guinea. Novelties are mostly described from the rosette or creeping informal groups of *Palisota*. Preliminary Red List conservation status indicates that three of the eight new species are "Endangered", three are "Vulnerable", one is "Near Threatened", and one species is of "Least Concern". Some new species are found throughout Atlantic Central Africa, such as *Palisota repens* or *P. akouangoui*; others have a restricted distribution, such as *P. leewhitei* (Mondah Forest near Libreville) or *P. cristalensis* (Cristal Mountains in Gabon and Equatorial Guinea), a pattern also observed for other known species, such as *P. ebo* (endemic to south-west Cameroon) and *P. pedicellata* (São Tomé, Príncipe and Bioko). Thirty-two species are currently recognized in *Palisota*, 19 of which occur in Gabon, confirming Atlantic Central Africa as the center of diversity for this genus. More discoveries are expected in this genus, as several specimens from the area could not be assigned to any currently described species.

Keywords: Gabon, Commelinaceae, Palisota, Taxonomy

2.2.2 THE VASCULAR FLORA OF BURUNDI: PROGRESS OF INVENTORY AND IMPLICATION FOR CONSERVATION

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A full survey of herbarium material originating from Burundi will lead to the publication of an Annotated Checklist of Burundi Vascular Plants. All data from the ca. 37,000 herbarium collections available from that country are compiled in a dataset and are georeferenced. This dataset was used to determine the current degree of botanical exploration and the inventory of all native and naturalized vascular plant species as well as to depict their distribution. Up to now, 4,200 species have been inventoried out of an estimated 5,200 which the country holds. Several regions are botanically well-explored while for others our knowledge is very scanty. Systematic collecting efforts and the monitoring of the botanical diversity are sadly declining, despite the fact that intensive field work is necessary in less well-known areas but also in well-known areas to monitor diversity changes and issues such as invasive alien weed expansion. Data on invasives in the country are still very incomplete, while there has been no verification of the increase or decline in the number of the acutely threatened species published in the 2018 Red List. As the country is heavily populated and shows high population growth, the creation of new protected areas leads to conflicting interests. The only possibility might be ex-situ conservation (e.g. gene banks) of range-restricted and rare species known from degraded habitats which are close to extinction due to the current high rate of habitat destruction resulting from human activities.

Keywords: Vascular flora, Checklist, Distribution, Conservation, Burundi

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3. Thematic Area 3: Afroalpine and afromontane plants: evolution, biogeography and ecology

3.1 Oral Presentations

3.1.1 AFRO-ALPINE FLAGSHIPS REVISITED: PARALLEL ADAPTATION, INTERMOUNTAIN ADMIXTURE AND SHALLOW GENETIC STRUCTURING IN THE GIANT SENECIOS (*DENDROSENECIO*)

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Distantly related lineages of the enigmatic giant rosette plants of tropical alpine environments provide classical examples of convergent adaptation to a harsh climate with diurnal freeze-thaw cycles. For *Dendrosenecio*, it has also been suggested that parallel adaptation may have been important for within-lineage differentiation. The giant senecios are endemic landmarks of the isolated East/Central African sky islands and show strikingly similar differentiation on different mountains. We collected field samples of all 11 species and all but one of the many subspecies accepted in the most recent taxonomic revision, and genotyped 460 plants representing 109 populations and all major mountains. We tested whether genetic structuring corresponds to geography, as predicted by a parallel altitude/habitat adaptation hypothesis, or to altitudinal belt and habitat rather than mountains, as predicted by a hypothesis of a single origin of adaptations. We also evaluated the remarkably contradicting taxonomies suggested for this genus and potential intermountain admixture. Bayesian and Neighbor-Net analyses showed that the main genetic structure is shallow and corresponds to geography, supporting a hypothesis of recent, rapid radiation via parallel altitude/habitat adaptation on different mountains. The analyses also showed considerable intermountain admixture, suggesting several long-distance dispersals by wind across vast areas of unsuitable habitat. The combination of parallel adaptation, secondary contact, and hybridization may explain the complex patterns of morphological variation and the controversial taxonomy of these rare enigmatic giants, supporting the use of wide taxonomic concepts. Notably, the within-population genetic diversity was very low and calls for increased conservation efforts.

Keywords: Afro-alpine, Fragmentation, Giant rosette plants, Hybridisation, Long-distance Dispersal, Parallel adaptation, Tropical alpine

3.1.2 TAXONOMY AND BIOGEOGRAPHY OF SUBTRIBE MENTHINAE (LAMIACEAE) ON THE TROPICAL EAST AFRICAN ‘SKY-ISLANDS’

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The subtribe Menthinae (Lamiaceae) is a cosmopolitan, complex and species-rich group. It has been subject to several conflicting taxonomic treatments with respect to its generic boundaries, especially the taxa associated with the *Satureja s.l.* complex (e.g. *Satureja, Micromeria, Calamintha, Clinopodium and Acinos*). A recent study based on nuclear and plastid DNA data revealed three well-supported lineages within subtribe Menthinae: *Satureja*, *Clinopodium* and *Micromeria*. However, these newer classifications of *Satureja* or *Clinopodium* have only been partly accepted. The Flora of Ethiopia and Eritrea (FEE) keeps a broad concept of *Satureja*, whereas the Flora of Tropical East Africa (FTEA) splits *Satureja s.l*. into *Clinopodium* and *Micromeria*. Thus, a more comprehensive study dealing with subtribal classification and generic boundaries is needed to resolve these conflicts and improve our understanding of the evolutionary processes that have shaped this group. In this ongoing study, we re-examine the taxonomy and biogeographic history of subtribe Menthinae in tropical Africa using a combination of automated morphometric analyses, genome skimming and RNA sequencing. The particular focus is on the tropical East African 'sky-islands', where the species predominantly occur. We carried out extensive field expeditions to six eastern African high mountains (Simen Mts, Bale Mts, Mt Kilimanjaro, Mt Kenya, Mt Elgon and Ruwenzori Mts) and collected living plants, silica-gel dried leaf samples, herbarium vouchers and ecological data. We supplemented our sampling with RNA from cultivated plants and DNA from herbarium materials to include most of the species and cover the total geographic distribution of the subtribe. We aim to 1) resolve the phylogenetic relationships in this subtribe, 2) unravel its detailed biogeographic history in eastern Africa, and 3) revise the taxonomy of these eastern African species.

Keywords: Biogeography, Genome skimming, Lamiaceae, Morphometry, RNAseq, 'Sky-island,' Taxonomy

3.1.3 ROLE OF THE DRAKENSBERG MOUNTAIN CENTRE IN THE DIVERSIFICATION OF AFROMONTANE AND AFROALPINE FLORAS: A BIOGEOGRAPHIC STUDY OF *HELICHRYSUM* (GNAPHALIEAE, ASTERACEAE)

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The biodiverse Drakensberg Mountain Centre (DMC) of South Africa is well-placed to serve as both a source and a sink for floristic diversification in southern Africa, and as a stepping-stone for migrations northwards of temperate elements along the afromontane archipelago of Africa. Its role in the diversification of the southern African and afromontane/afroalpine floras has until now been explored to only a limited extent. Here we use the largest genus in the DMC, *Helichrysum* Mill. (Asteraceae), to explore the role of the DMC in the diversification of these floras and investigate the extent of *in situ* speciation. In the context of a broadly sampled and dated phylogeny of *Helichrysum* within the HAP clade, we show that the Drakensberg regions (both the DMC and Northern Escarpment of South Africa) have played a major role in the diversification of the lineage in southern Africa since its origin during the mid-Miocene. Ancestral area analyses of dated Bayesian (BEAST) trees based on nuclear DNA sequences reveal that the DMC has played a central role as a source of floral diversity of the temperate and mountain floras of southern and central Africa and beyond, with dispersal playing a much larger role than vicariance. Far fewer dispersals into the DMC have occurred – thus its role as a sink, as opposed to a source, is a lesser one. *In situ* speciation is evident with at least 15 clades including members predominantly in the DMC and at least one endemic species, but no single large radiation has occurred. Adaptations to alpine and montane conditions, in growth form for example, have arisen multiple times within these clades.

Keywords: Afromontane archipelago, Alpine flora, Endemism, Migration, Speciation

3.1.4 ASSESSING REPRODUCTIVE FITNESS TRAITS WITH RESPECT TO CHANGING ENVIRONMENTAL FACTORS: A CASE STUDY OF *ARABIS ALPINA* L. (BRASSICACEAE) IN THE AFROMONTANE REGION OF MOUNT KENYA

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Climate change has shaped natural selection in the Afromontane region of Mount Kenya. This has influenced resource allocation in seeds, particularly in mountain ecosystems. The aim of this study was to investigate the resource-allocation strategies of *Arabis alpina* across the elevational gradient of Mt. Kenya with respect to non-climatic factors. A belt-transect method was used to sample the species. Target species seeds were collected from twenty-eight populations, processed, and germination tests were performed in two trials. The collected soil sub-samples from each of the target species plots were analyzed for soil physicochemical parameters. Seed mass of *A. alpina* was found to be greater in low altitude zones than in high altitude zones and vice versa ($f = 279.1$, $P = 5.521 \times 10^{-14}$). Higher altitude zones had more *A. alpina* seed numbers than lower altitude zones and vice versa ($f = 187.8$, $P = 2.978 \times 10^{-12}$). The trade-off between seed mass and number in *A. alpina* species was significant ($f = 974$, $P < 2.2 \times 10^{-16}$). Nutrient-availability varied in each plot and contributed to seed mass variation in the target species. High soil nutrient concentrations contributed to higher germination ($f = 176.4$, $P = 5.544 \times 10^{-12}$) and survival ($f = 138.6$, $P = 5.732 \times 10^{-11}$) rates of *A. alpina* species in the lower elevations than in the higher elevations.

Keywords: Climate change, Germination, Natural selection, Resource-allocation, Survival

3.1.5 TROPICAL 'ALPINE' HABITATS: IMPROPER USE OF THE TERM ALPINE?

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The term 'alpine habitat' was initially used for habitats situated above the treeline on mountains in higher latitudes, especially in the Holarctic region. The treeline, the highest elevation that sustains tree growth, is considered as a global phenomenon. Consequently, the term 'alpine habitat' is currently in use at the global scale, including for the disjunct and intriguing habitat types located on the tropical high mountains. In this review, we 1) present how treeline and alpine habitats are variously defined in the literature, and elaborate the factors that shape them; 2) describe how tropical 'alpine' habitats differ from the alpine habitats in higher latitudes in terms of climate and plant growth forms; 3) highlight why tropical 'alpine' habitats do not constrain growth of treeline-forming 'trees' and thus do not fit under the current definition of an alpine environment, and 4) reconsider the status of the tropical 'alpine' environments and suggest two alternative solutions: either consistently classifying alpine habitats as tropical vs. high latitude alpine ones to highlight their differences, or treating tropical 'alpine' habitats as a distinct non-alpine ecosystem.

Keywords: Alpine ecosystem, Tropical alpine, Afro-alpine, Treeline

3.1.6 HISTORY AND EVOLUTION OF THE AFROALPINE FLORA: IN THE FOOTSTEPS OF OLOV HEDBERG

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The monumental work of Olov Hedberg provided deep insights into the spectacular and fragmented tropical alpine flora of the African sky islands. Here we review recent molecular and niche modelling studies and re-examine Hedberg's hypotheses and conclusions. Colonisation started when mountain uplift established the harsh diurnal climate with nightly frosts, accelerated throughout the last 5 Myr (Plio-Pleistocene), and resulted in a flora rich in local endemics. Recruitment was dominated by long-distance dispersals (LDDs) from seasonally cold, remote areas, mainly in Eurasia. Colonisation was only rarely followed by substantial diversification. Instead, most of the larger genera and even species colonised the afroalpine habitat multiple times independently. Conspicuous parallel evolution occurred among mountains, e.g., of gigantism in *Lobelia* and *Dendrosenecio* and dwarf shrubs in *Alchemilla*. Although the alpine habitat was ~ 8 times larger and the treeline was ~ 1000 m lower than today during the Last Glacial Maximum, genetic data suggest that the flora was shaped by strong intermountain isolation interrupted by rare LDDs rather than ecological connectivity. The new evidence points to a much younger and more dynamic island scenario than envisioned by Hedberg: the afroalpine flora is unsaturated and fragile, it was repeatedly disrupted by the Pleistocene climate oscillations, and it harbours taxonomic and genetic diversity that is unique but severely depauperated by frequent bottlenecks and cycles of colonisation, extinction, and recolonisation. The level of intrapopulation genetic variation is alarmingly low, and many afroalpine species may be vulnerable to extinction because of climate warming and increasing human impact.

Keywords: Afroalpine, Colonisation, Eastern African mountains, Evolution, Long-distance dispersal, Olov Hedberg

3.1.7 DOCUMENTING DIVERSITY AND DISTRIBUTION OF EPIPHYLLOUS BRYOPHYTES IN MT. KENYA TO INFORM IMPACTS OF CLIMATIC CHANGE

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Epiphyllous bryophytes colonize living leaves of vascular plants in constantly humid environments in tropical forests. They are highly sensitive to environmental perturbation and their occurrence is therefore dependent on stable microclimatic conditions. Documentation and monitoring of the epiphyllous bryophyte distribution can inform effects of climate change on biodiversity. This study demonstrates the first comprehensive documentation of spatial distribution of epiphyllous bryophytes (EBs) as correlated with environmental variables of bio-climatic data, altitudinal changes, forest composition and structure in Chogoria, Mt Kenya. The environmental data was collected from Permanent Sample Plots (PSPs) established at intervals of 200 m from 1,600 m elevation up to 2,800 m. The climatic data (temperature and air humidity) was collected using data loggers for seven months from July 2020 to January 2021. Epiphyllous bryophytes were collected from all the phorophytes in the PSPs at two height levels (0-100 cm and 101-200 cm high). Fifty-nine taxa of EBs were established in Mt Kenya, where several species were new records for mainland Africa. The EBs diversity was highest at 2,200 m elevation dominated by the genus *Cololejeunea*. The new altitudinal peak and a refugia of 45 epiphylls coincides with a unique forest composition structure, characterized by *Kuloa usambarensis* (Engl.) Trofimov & Rohwe and *Afrocarpus gracilior* (Pilg.) C.N. Page, and optimal climatic conditions. The species diversity was dominated by warmth loving EBs, *Odontolejeunea lunulata*, at lowest level (1600 m) and *Cololejeunea malanjae* at 2400 m. The study concluded that the EBs diversity is strongly correlated with environmental variable status and reaches an optimal level at 2,200 m elevation. Further, the epiphyllous species have intermittently colonized ‘islands’ of broad-leaved mixed forests within the bamboo zone and the upper tree line, thus forming an excellent opportunity for monitoring colonization rates of biodiversity in the face of climate change.

Keywords: Afromontane forests, Biodiversity shift, Climatic data monitoring, Lejeuneaceae, Liverworts

3.1.8 INVESTIGATING THE RESILIENCE OF BRYOPHYTES TO CLIMATE CHANGE IN REUNION'S TROPICAL MONTANE CLOUD FORESTS

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Tropical montane cloud forests (TMCFs), characterized by frequent cloud immersion, host a significant proportion of global biodiversity and provide vital ecosystem services. On islands, climate change is expected to cause lifting of the cloud height base, as a result of the increase in temperature, and to increase the frequency of extreme events like drought. Despite the important biomass of bryophytes (liverworts, mosses and hornworts) represented in TMCFs, little is known about their ecophysiological functioning in particular their ability to uptake and to utilize cloud water and their resilience to drought. Using *in situ* lysimeters we followed cloud water interception by bryophytes in the TMCF of Réunion island. We show that two abundant TMCF liverworts possess an excellent ability to intercept and store cloud water, exhibiting daily variation in this ability according to varying climatic conditions. We track photosynthetic efficiency, using chlorophyll fluorescence, in dehydration and subsequent rehydration experiments in 16 species with varying microhabitats. This was accompanied by measurements of water retention capacity and relative water content of the species. Highest Water Retention Capacity and Relative Water Content were recorded for *Sphagnum* sp. (2174 %; 91,37 %) and *Anthoceros* sp. (1540 %; 78,15 %). Dry down curves showed that species with high water storage capacity are favored by maintaining longer optimal photosynthetic activity. After one week of dehydration, half of the species could recover 50% of their optimal photosynthetic activity after 24hrs of rehydration. After 7 weeks of dehydration, most species could not recover their original photosynthetic activity upon rehydration. These experiments highlight the presence of various strategies for managing desiccation by these TMCF bryophytes at the microhabitat level. Bryophytes inhabiting the TMC exhibited a strong strategy of either tolerance or drought

avoidance or a combination of both strategies, indicating a better adaptation to drought than expected.

Keywords: Atmosphere/biosphere, Bryophytes, Ecohydrology, Photosynthetic activity, TMCF

3.1.9 THE EFFECTIVENESS OF DNA BARCODING IN THE IDENTIFICATION OF AFROMONTANE FOREST TREES

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The identification of flowering plants using DNA barcoding proposed in recent years has slowly gained ground in Africa, where it has been successfully used to elucidate the systematics and ecology of several plant groups, and to understand their evolutionary history. Existing inferences on the effectiveness of DNA barcoding to identify African trees are mostly based on lowland forests, while adjacent montane forests floristically and structurally, often differ from the latter. Here, we tested the efficiency of chloroplast DNA barcodes (rbcL, matK and trnH-psbA) used to identify Afromontane forest tree species in a 20.28 ha permanent plot in Ngel Nyaki montane forest, Taraba state, Nigeria. We collected, identified and vouchered 274 individuals with diameter at breast height ≥ 1cm belonging to 101 morphospecies, 92 genera and 48 families. Chloroplats barcodes - *rbcLa* and *matK* used alone or in combination performed better than in lowland forests, with the best species discrimination obtained with the two-locus combination of *matK* + *rbcLa*. The intragenic spacer *trnH-psbA* was too variable to align and could not be tested using the genetic distance method employed.

Keywords: DNA barcoding, ForestGEO, Montane forest, Ngel Nyaki, Permanent plot

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4. Thematic Area 4: Addressing the urgent need for plant conservation in Africa

4.1 Oral Presentations

4.1.1 THE CONSERVATION OF (SUB)ENDEMIC CENTRAL AFRICAN TREES

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With the growing biodiversity decline comes the need to assess the risk of species extinction and identify as well as address the root causes of their decline. To halt the loss of vascular plant species in one of the most biodiverse regions in the world, we coordinated a project to assess the conservation status of all Endemic (and subendemic) Central African Trees (ECAT). Central Africa, as defined here, includes the Democratic Republic of the Congo, Rwanda and Burundi. We carried out this work in close collaboration with the Central African and Eastern African Plant Red List Authorities under the umbrella of the Global Tree Assessment (the largest initiative in the history of the IUCN Red List process). We will briefly outline each of the project's phases, including the compilation of the herbarium specimen dataset, label transcription, georeferencing, data cleaning and the organization of two IUCN Red List workshops. All assessments prepared during the project are now published online (https://www.iucnredlist.org/) and culminated in our book entitled 'Red List of the endemic and subendemic trees of Central Africa'. Our findings show that 221 out of 347 taxa (64%) are at risk of extinction. Of these, 34 are Critically Endangered, of which 25 may already be extinct. Agriculture, livestock farming and logging are the main threats, but charcoal production and mining also provide significant pressures. Because climate change impacts are emerging, our approach will increase understanding of these taxa's distribution and ecological requirements employing Species Distribution Modeling techniques. We will analyze the geographical species richness patterns of (sub)endemic trees today and in the future using several climate change scenarios and compare these with the existing network of protected areas to evaluate the effectiveness of the network and suggest improvements.

Keywords: Central Africa, Conservation, Endemic trees, IUCN, Red Listing, Threatened

4.1.2 TOWARDS A RED LIST FOR GABON?

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The botanical exploration of Gabon spanning over 170 years with more than 100,000 specimens collected to date, has made the country one of the best-known for plants in Central Africa. While over 5,000 species and infraspecies are now documented, with nearly 10% of them endemic, a Red List for the country is not yet available. To achieve this long-term goal of identifying the threatened species of Gabon, we first focussed on endemic and subendemic vascular plant species (918 endemic and subendemic taxa), and conducted inventories in two biogeographical areas: the Lower Ogooué basin, classified as a Ramsar site 10 years ago, and the Ivindo basin, a newly identified area of endemism. At present, 650 of the taxa were analyzed. For each potentially threatened taxon, threats were identified and a preliminary conservation status assessment was made following the Categories and Criteria of the IUCN Red List, which led to the identification of 314 threatened taxa. Key information on these taxa can be viewed online on a TROPICOS-based website, and a book is in preparation.

Keywords: Endemic, Subendemic, Threatened plants, IUCN Red List, Gabon

4.1.3 SEARCHING FOR EXTINCT OR ENDANGERED PLANT SPECIES IN MADAGASCAR

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According to Global Wildlife Conservation, lost plant species are those that have gone unrecorded for years or decades and may therefore be considered as presumably extinct. New records of their existence in the field will result in a change to their status. There can be many causes of the lack of recent records, including: 1) the species' natural habitat has been degraded or completely transformed; 2) the habitat is intact but the population has been reduced in size and has not been documented since earlier collections were made; and 3) no inventory work has been conducted recently. In a study conducted in 2019, we compiled a list of species that had not been collected since 1967, focusing on rare species that are only known from the type collection or from a single locality, as they are the most likely to be threatened with extinction. We mapped their distribution using data from the on-line Catalogue of the Plants of Madagascar. By overlaying the resulting distribution map with Madagascar's network of protected areas and vegetation maps, we assessed the possible extinction status of each target species. We regarded species that occur inside protected areas or at undisturbed sites adjacent to protected areas as having a high potential to still be extant. By using maps of deforestation between 2003 and 2016, we were able to identify species that may be extinct because their recorded distribution coincides with degraded ecosystems or transformed landscapes. In the study, a total of 1740 species were found to be potentially extinct, 413 of which were rare as known only from the type collection or a single locality. The results also enabled us to identify priority sites for future inventory work to attempt to recollect these species and reassess their status. Since that time we have conducted some fieldwork, although this has been hampered by the COVID-19 global pandemic, and we present a summary of the results to date.

Keywords: Madagascar, Presumed extinct species, Plants, Records, MadCat

4.1.4 THE GLOBAL TREE ASSESSMENT: ASSESSING AFRICA'S TREES

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The Global Tree Assessment (www.globaltreeassessment.org) aims to assess the conservation status of every known tree species by the year 2023, focusing attention and directing efforts to ongoing tree conservation assessments where they are needed the most. The outcomes of these analyses provide prioritization information to ensure that conservation efforts are focused on the right species so that no known tree species becomes extinct. We now know that there are approximately 60,000 tree species in the world, but many of them are still lacking information on their conservation status. One-tenth of all the world's trees are found in Africa (>6,000 tree species). Of these tree species, approximately one quarter have a conservation assessment (Northern Africa (37%), Central Africa (21%), Eastern Africa (29%), Southern Africa (20%) and Western Africa (29%)). Red list assessments are already an important part of the work of many botanic gardens and their staff. The results from red list assessments help botanic gardens to effectively guide, plan for and raise awareness of the need for conservation on the ground. They can be used for i) prioritisation of conservation action *in situ* and *ex situ*; ii) monitoring of conservation action; iii) facilitating education and public awareness of conservation issues; iv) supporting international conservation policy; and v) influencing funding allocations. We welcome more contributions to the Global Tree Assessment, and we work with a range of partners, including forestry departments, universities, botanic gardens, herbaria, national red list focal groups but also with individuals that want to contribute one (or many) assessments of their own tree of expertise - no contribution is too small.

Keywords: Tree species, Conservation assessments, Extinction risk, Prioritisation, Tree diversity, Red list

4.1.5 CONTINENTAL-SCALE CONSERVATION ASSESSMENT OF TROPICAL AFRICAN PLANT SPECIES

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Preserving tropical biodiversity is an urgent challenge when faced with the growing human needs. Despite the crucial importance of most tropical plant species for terrestrial ecosystem functions, they lack extinction risk assessments, which limits our ability to identify conservation priorities. Assessing extinction risk using the International Union for Conservation of Nature (IUCN) Red List method is recognized as the most objective and comprehensive approach for identifying species-level conservation priorities. Using a novel approach aligned with IUCN Red List criteria, we conducted a continental-scale preliminary conservation assessment of 22,036 vascular plant species in tropical Africa. Our results underline the high level of extinction risk of the tropical African flora: 33% of the species are potentially threatened with extinction and another one third are likely rare and therefore may become threatened in the near future. Four regions are highlighted as having a particularly high proportion (> 40%) of potentially threatened species: Ethiopia, West Africa, central Tanzania, and southern Democratic Republic of the Congo. Our

results underline the high level of extinction risk across tropical African plant diversity. Our approach represents a first step toward data-driven conservation assessments applicable at the continental scale, providing crucial information for incorporation into sustainable economic development initiatives.

Keywords: IUCN Red List criteria, Continental scale, Tropical Africa

4.1.6 WHERE ARE MOZAMBIQUE'S MOST CRITICAL SITES FOR PLANT CONSERVATION?

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Mozambique hosts a wealth of plant diversity including over 6,000 native and naturalised plant taxa (species, subspecies and varieties), of which around 670 are endemic or near-endemic. In recent years, the number of plant species known from Mozambique has grown as targeted botanical surveys of previously unbotanised and botanically interesting areas are undertaken. While also being hugely biodiverse, Mozambique's flora provides a range of important ecosystem services on which people rely, including provision of food, fuel and medicines alongside the regulation of soil quality and water availability. However, the demand for land and natural resources is growing rapidly as the human population of Mozambique expands, increasing pressure on natural habitats and leading to an increased risk of biodiversity loss through the extinction of rare and threatened plants. To address this issue, the Mozambique Tropical Important Plant Areas (TIPAs) project was launched in 2017 with the aim of identifying and documenting the most critical sites for plant conservation in Mozambique, and promoting their conservation and sustainable management. The project was implemented through: (i) compiling and publishing a list of Mozambique's endemic and near-endemic plants; (ii) a programme of IUCN Red Listing focused on these plant taxa; (iii) targeted field surveys of botanically under-explored sites across the country; and (iv) analysis of data and expertise to inform which sites should be identified as Important Plant Areas (IPAs). Here we

present the network of 57 IPAs identified over the course of this project, evaluate the extent to which they capture Mozambique's floral diversity and assess the coverage of IPAs within protected areas. With the IPA network covering less than 3% of Mozambique's land area but encompassing populations of 82% of the country's threatened plants, the Mozambique TIPAs project has identified several fantastic opportunities to conserve the most critical areas of Mozambique's flora.

Keywords: Important Plant Areas, TIPA, Endemism, IUCN Red List, Botanical survey

4.1.7 UPDATING THE KEY BIODIVERSITY AREA ANALYSIS IN THE LOFA-GOLA-MANO AND NIMBA COMPLEXES

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Scattered among Guinea, Liberia, Sierra Leone and Ivory Coast, the complexes of Lofa-Gola-Mano and of the Nimba Mountains contain some of the last elements of montane Guinean forests and of lowland forests of West Guinea, two habitats that are globally highly threatened. The Key Biodiversity Area (KBA) method is an important tool for the identification of conservation priorities. Nevertheless, knowledge on flora and vegetation of these two complexes remains incomplete and presents significant local differences. As a consequence, for those two areas, KBA analyses were mainly based on the presence of important faunal groups such as birds and mammals. Through identifying the threatened components of local flora and ecosystems, this project aims at refining the KBA analyses to better assess their

efficiency in conservation. By conducting existing data compilation and fieldwork, knowledge on plants and ecosystems diversity will be increased in poorly known areas, and the threatened components of flora and ecosystems will be assessed following the IUCN Red List Criteria. These assessments will feed into an updated KBA analysis, which is expected to highlight the crucial role of the remaining forests and humid habitats in the conservation of the threatened flora and ecosystems in West Africa.

Keywords: KBA, Lofa-Gola-Mano, Nimba, IUCN Red List

4.1.8 PLANT CONSERVATION IN GUINEA - TROPICAL IMPORTANT PLANT AREAS AND BEYOND

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For the first time in Tropical Africa under the Global Strategy for Plant Conservation (GPSC) Target 5: Important Plant Areas (IPAs) have been evidenced, designated and accepted by a national government. The IPAs are assessed using 3 criteria: A) threatened species, B) botanical richness and C) threatened habitats. The scheme aims to promote sustainable management and protection of designated IPAs through engagement with policymakers, landowners and international initiatives. In Guinea this required red listing of threatened plant species, fieldwork to collect data and identification of nationally threatened habitats. Guinea is a botanically diverse country and home to the only African Bromeliaceae species, *Pitcairnia feliciana*. A cross-institutional working group was set up to assess and validate Tropical Important Plant Areas (TIPAs) and Conservation Action Plans (CAPs). The resulting 22 TIPAs will be incorporated into national legislation and the Protected Area Network. From 2016-2019, Royal Botanic Gardens, Kew have been working with the National Herbarium of Guinea (HNG), the Guinea government and local NGOs e.g. Guinee Ecologie to designate TIPAs to assess the conservation status of the Guinea flora. Data collected since 2005 and historical collection data has been used for IUCN Red List assessments, resulting in a provisional list of 270 threatened species out of 200 were assessed as part of the project. Nine nationally threatened habitats have been identified and described and 22 TIPAs have been agreed upon. These

have been published in the book “Threatened Habitats and Tropical Important Plant Areas of Guinea”, the first book of its kind for Tropical Africa. Twenty CAPs have also been written, a first step to promote and target conservation efforts and funding. The CAP for the proposed National Flower of Guinea, *Vernonia djalonensis*, recently formed the basis of a successful funding proposal to protect this species. Plant conservation is in the early stages in Guinea and building on TIPAs, our partnership is now working to protect these areas with local communities and influence policy to shape future conservation of threatened trees and wild socioeconomic species.

Keywords: Important Plant Area, Guinea, Red List, Conservation, Threatened

4.1.9 COMPLETING CAMEROON’S TROPICAL IMPORTANT PLANT AREAS

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The Tropical Important Plant Areas (TIPAs) project aims to prioritise areas for plant conservation using the (Important Plant Areas) IPA concept developed by Plantlife International and revised in 2017 for greater global application. The IPAs are aligned with target 5 of the Global Strategy for Plant Conservation (GSPC). Cameroon has been one of the first targets for Royal Botanic Gardens, Kew’s TIPAs project because of the known high levels of phytodiversity, and the relevance of previous work identifying threatened species using the IUCN Red List system. The opening workshops were held in Yaoundé in 2016 with relevant parties including government departments. Data compilation began in 2019 and datasheets for 46 sites are now complete, covering all regions of Cameroon and ranging in size from inselbergs and waterfalls of less than 50 ha to large national parks such as Dja. The Ebo Forest in Littoral region was one of the first sites targeted and results from there are published on the online portal. The resulting data were used to support the case for suspending the Ebo logging concession, a decision made by a presidential decision in August 2020. Other sites have so far been proposed predominantly under IPA criterion A(i) based on the presence of global Red List taxa. The project has boosted the number of Cameroon Red Listed plants to over 900 out which Ebo has 84, while five other sites have over 100 globally threatened taxa. Of the latter, three are national parks already (Campo Ma’an, Korup and Bakossi) but Mt Kupe and the Ngovayang massif are, like Ebo are without protection. The Ngovayang Massif is particularly threatened by iron ore exploitation. Overall, the network of sites proposed so far incorporates 660 Red List taxa within 4.8% of the national area. Future work will aim to assess

sites against further IPA criteria, by compiling national lists of useful species, endemics and threatened habitats.

Keywords: TIPA, Conservation, Ngovayang, Ebo, IUCN

4.1.10 HOW TO RECOGNIZE, IDENTIFY AND PROTECT PODOSTEMACEAE SPECIES IN AFRICA: SOME THOUGHTS FOR THE NEAR FUTURE

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The IUCN Red List of threatened species (iucnredlist.org) assesses the risk of threat of organisms at species level. According to it, forty-seven (47) species of sub-Saharan Africa Podostemaceae are threatened due to various reasons, but particularly because of the high number of already realized or planned hydroelectric dams along the rivers and waterfalls (more than 700 for the whole continent). Over the last c. 20 years, molecular data (e.g. DNA barcoding) has increasingly helped in the recognition and discrimination of species. Latest developments in molecular techniques ("Next generation sequencing") allow for even more comprehensive analyses, and so provide new ideas for defining what may be viewed as a "species". Various field botanists / taxonomists, however, continue to discover and describe species new to science without conducting any molecular analysis. Such "first-aid approaches" based solely on morphological and anatomical data remain relevant. If we depend too strongly on molecular data, we may lose valuable time (and money) that is urgently needed for exploration and monitoring of species and their populations in and around threatened habitats. Highlighting the endemicity of species to such localities may help to minimize or compensate the impact of such infrastructure projects, leading to better conservation of some populations of endangered species. In light of these ever-encroaching "outposts of progress", careful population studies and transplantation experiments prior to dam construction for hydroelectric power projects are urgently needed. For yet unknown reasons, no single Podostemaceous species can be grown *ex situ* until present (except for few *in vitro* experiments). Here we present Podostemaceae taxa from Africa illustrating the collaboration of Cameroonian and European botanists.

Keywords: Podostemaceae, Threatened, Africa, Molecular data, Morphological characters

4.1.11 DIGITAL FLORISTIC KNOWLEDGE AND PRIORITIES FOR INVENTORY, DOCUMENTATION AND CONSERVATION IN KENYA

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Current trends of globalization and consumerism call for proper quantification and documentation of biodiversity and associated knowledge, especially in developing nations. Since most of the information is not documented, the challenge is in developing an accessible knowledge base of biodiversity in all its complexity so as to preserve and use these resources sustainably. Species inventories provide the foundation for more complex analytical studies and are the basis for effective global and local monitoring initiatives; however, if they are to provide reliable information in the long term, their level of completeness needs to be estimated and validated objectively. This study investigated the completeness of geographic knowledge of the approximately 7,010 plant species in Kenya, with the aim of establishing distribution patterns and identifying gaps that will guide and justify priority setting for future floristic work. Specimen data were obtained from the Botanical Research and Herbarium Management Systems (BRAHMS) database of the East African Herbarium and Global Biodiversity Information Facility (GBIF) datasets and cleaned via an iterative series of inspections and visualizations to detect and document inconsistencies in taxonomic concepts, geographic coordinates, and dates of collection. We further integrated and analysed data spatially in order to generate distribution patterns for the various thematic and functional groups including endemic, medicinal, threatened, timber and alien invasive species. Kernel Hotspot analysis was used to generate hotspots, representing Minimum Viable Conservation Areas which if conserved will ensure protection of maximum plant diversity. Preliminary results indicate high inventory activity in the traditional species-rich areas of the country; the Western Kenya region (the Mau complex/Kakamega); the coast and Central Kenya ecosystems (Nairobi, the Aberdares and Mount Kenya). This knowledge is critical to science and society – for harnessing the country's plant

resources, economic advancement, human health, and food security, hence improving the quality of human life and contributing to sustainable development.

Keywords: Hotspot analysis, Minimum Viable Conservation Areas, Digitisation

4.1.12 TOWARDS A BETTER CONSERVATION OF GABONESE SAVANNAS

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Gabon is 85% covered by evergreen forest and is one the most diverse and intact countries of Central Africa. Savannas, which cover less than 10% of the country, harbor a significant part of its plant diversity, are poorly represented in the country's network of protected areas, and are facing new threats such as palm oil plantations. This study aimed at identifying the threatened habitats occurring in the savannas, as part of the country-wide (High Conservation Value) HCVs project. More specifically, we aimed to (i) propose a typology of the savannas of Gabon on the basis of their structural and floristic characteristics, and (ii) identify which charatceristics are the most important for conservation. Data collection consisted of inventorying as many habitats as possible using a phytosociological approach. The identification of highly threatened and important savannas for conservation was based on the scarcity of habitats across the country, the intensity of the threats, and the presence of rare or threatened species. Four main types of savannas have been identified: permanently wet savannas, seasonally flooded savannas, dryland savannas and dry coastal savannas, which altogether harbor 459 species. Five habitats were identified as threatened and of conservation importance: dry coastal savannas on white sands, dry savannas on lateritic crusts, dolines, swampy depressions, and flooded savannas. Results from the study were presented to the various stakeholders and

are available on the website of the project, so they can be taken into account in the current landscape management design.

Keywords: Conservation, Savanna, Habitat, Gabon

4.1.13 SAVING TANZANIAN TREES FROM EXTINCTION: AN INTEGRATED APPROACH

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Tanzania is a relatively large East African country with protected areas covering approximately one-third of its land area. Despite concerted efforts by the Government of Tanzania and numerous national and international organizations, 348 Tanzanian tree species are in the three IUCN Red List threatened categories (Vulnerable, Endangered, and Critically Endangered), with 64 more assessed as Near Threatened. Case studies are presented for conservation of two Critically Endangered Tanzanian trees. *Karomia gigas* (Lamiaceae) is currently known from two small forest reserves in southeastern Tanzania, with only 23 known individuals. Initial efforts to germinate wild-collected seeds failed due to seed damage by fungal attack. A second germination trial at the Missouri Botanical Garden (MBG) in which seeds were extracted from fruits and treated with fungicide resulted in 30 healthy seedlings, the first successful propagation of *K. gigas*. We can now report previously unknown flower morphology, and DNA sequencing will elucidate genetic diversity of the wild individuals. *Gigasiphon macrosiphon* (Fabaceae) is known from three coastal sites in Kenya and four more inland sites in Tanzania, with only 38 mature individuals recorded. Seeds germinate easily, but reproduction in the wild is rare because of severe seedling predation by various animals, especially forest antelope and feral pigs. Base Titanium Ltd. has established a nursery in coastal Kenya and planted over 1,400 individuals of *G. macrosiphon*, with saplings beginning to flower at 8-10 years of age. The Tanzania Forestry Service (TFS) Agency has collected seed of *G. macrosiphon* on the Rondo Plateau in southeastern Tanzania and planted saplings at its Seed Production Station in Morogoro. Tanzania Forestry Service and MBG have designed a program to develop propagation facilities and tree nurseries in

Tanzania, have expanded seed collection and propagation efforts to other threatened tree species, and organized seed collection of target species for propagation in Tanzania and at MBG.

Keywords: *Gigasiphon*, IUCN Red List, *Karomia*, Nurseries, Propagation

4.1.14 RESSOURCE FINANCIERE, UN OBSTACLE POUR LA REALISATION D'UNE BONNE PRATIQUE DE LA RESTAURATION FORESTIERE A MADAGASCAR

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La restauration forestière est inscrite dans les Stratégies et Plans d'Actions Nationaux pour la Biodiversité (SPANB) du gouvernement de Madagascar, conformément aux objectifs d'Aichi. Ils se traduisent dans les plans de gestions des aires protégées de Madagascar. Toutefois, à part les compagnies minières, le financement destiné à la restauration est relativement limité et par conséquent les pratiques sont encore restreintes à une simple plantation avec des résultats médiocres. Pour tenter d'améliorer les résultats de la restauration forestière, en particulier sur les zones difficiles à restaurer, Missouri Botanical Garden Madagascar a essayé, dans trois aires protégées parmi nos sites d'intervention (Oronjia, Analalava et Ankafobe) de mettre en place des expérimentations sur la restauration forestière en suivant des protocoles scientifiques bien définis et avec des techniques inhabituelles et innovantes. L'étape initiale d'expérimentation est suivie d'une analyse comparative entre le cas expérimental et le cas d'une simple plantation concernant les dépenses relatives aux mains d'œuvres et les matériels utilisés en se référant sur le même nombre de plantules. Nous avons constaté dans ces trois sites que certaines innovations ont amélioré les paramètres liés à la survie et à la croissance des plantules. Cependant, les dépenses nécessaires sont 3 à 4 fois plus importantes par rapport aux coûts d'une simple plantation. Si on envisage alors de faire une réplication à grande échelle de ces techniques de restauration forestière après expérimentation, il faut envisager une analyse coûts-avantages afin de définir les interventions efficaces à appliquer. Dans les cas où les moyens financiers sont limités, la réussite d'une restauration sur des zones difficiles peut être extrêmement coûteuse.

Mots clés: Restauration forestière, Plantation, Conservation, Ressource financière, Madagascar

4.1.15 *DRACAENA UMBRACULIFERA* A RATHER COMMON PLANT CLASSIFIED AS EXTINCT: LESSONS FOR BOTANICAL INVENTORY AND RISK OF EXTINCTION EVALUATIONS

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Information presented in the IUCN Red List suggests that *Dracaena umbraculifera* originates from Mauritius and is extinct in the wild. However, research by botanists from Missouri Botanical Garden (Edwards *et al.* 2018) revealed that the Mauritian plants were not native to the country but had likely originated from Madagascar. Although no herbarium specimens of this species were known from Madagascar, recent searches in the wild have, to date, revealed 12 subpopulations - three in protected areas, spread over an area of some 1600 km², containing over 500 mature individuals. *Dracaena umbraculifera* is a large and impressive plant whose stout stems bear apical clusters of long strap-shaped leaves that terminate in a massive inflorescence of large white flowers: how then did this plant remain undetected in the Malagasy flora until now? Several explanations can be proposed. First, many of the new populations were found in forest fragments never before visited by botanists. Second, the condensed inflorescence is held above the clusters of leaves where it is shielded from view by those below and the spent flowers tend to rot in place and not fall to the ground where they might be discovered. Third, field botanists are biased against collecting plants that are difficult to fit in the press, such as this thick-stemmed *Dracaena*. Fourth, field botanists tend to respond to the needs and interests to taxonomists that in the recent past have not included *Dracaena* of Madagascar. All those working on the Malagasy flora appreciate that it is poorly known, but this narrative suggests that it is even more poorly known than we imagine. This situation is particularly alarming given the rapid loss of unprotected forests in the country – most of them unvisited by botanists.

Keywords: *Dracaena*, Madagascar, inventory, extinction, Red List

4.2 Posters

4.2.1 THE IMPORTANCE OF INHAMBANE PROVINCE FOR CONSERVATION OF PLANT DIVERSITY IN MOZAMBIQUE

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Mozambique is one of the largest centres of biological diversity in Southern Africa, with currently 7,099 plant species recorded, of which more than 600 are endemic and near-endemic and it is also believed that there are many more yet to be discovered in the under-explored parts of Mozambique. However, with the human population growing and intensification of pressure on the natural environment, there is a rapid process of replacing conservation areas with other land uses, such as urbanization and agricultural lands. Inhambane Province is located on the South Coast of Mozambique and it includes the northern extension of the Maputaland Endemism Centre (MEC). It contains a diverse range of floristic systems such as wooded forests, savannas, wetlands and marshes, all of them threatened today. Inhambane is considered a province with Important Plant Areas (IPAs) due to its richness in endemic and rare plant species, of which the majority are threatened according to the IUCN Red List categories and criteria. There are also a considerable number of species that are data deficient (DD) as they are only known from few old records. Thus, the aim of this study is to document the Inhambane's priority plants for conservation, their geographic distributions, conservation status and the threats they face in order to demonstrate to policy makers the botanical importance of this province and the need for urgent conservation action to safeguard their future.

Keywords: IPA, Endemic, Priority species, Red List, Conservation, Inhambane

4.2.2 SPECIES DISTRIBUTION MODELLING, PHYLOGENETIC SIGNAL AND EXTINCTION RISK ASSESSMENTS OF THE GREATER CAPE FLORISTIC REGION THESIUM (SANTALACEAE)

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Of the reported increasing alarm in loss of biodiversity due to climate change, narrow-ranged species are at greater risk of extinction than generalists. The Greater Cape Floristic Region (GCFR) *Thesium* L. (a genus with the highest species number in the Santalaceae and most diverse in Africa) having both ecological specialists and generalists typifies an appropriate system for evaluating both the correlates of range extent and specialisation and the relative extinction risks associated with both. Here, we quantified each species' geographic range extent and ecological specialisation. We then determined if range size and specialisation are phylogenetically structured and whether this will impact *Thesium* phylogenetic diversity. In the context of species distribution modelling, we developed MaxEnt models for the past, present and future environmental scenarios to assess their impact on the distribution of the GCFR *Thesium* species. There was strong positive correlation between environmental variables and species range extents. Of the 101 *Thesium* species modelled, 71 species (83%) reflected high range size during the Last Glacial Maxima (LGM), 27 species (13%) recorded range contractions historically to present. Similarly, 45 species (44%) are predicted to potentially expand their ranges while 51 species (50%) are predicted to reduce ranges in future. Interestingly, although five habitat specialists (5%), experienced range reduction from the LGM to present, they will persist in the face of future climate change. However, the range extent, ecological specialisation and extinction risk are phylogenetically random and therefore with labile impact on the phylogenetic diversity of the GCFR *Thesium*.

Keywords: Climate change, Ecological specialisation, Evolution, Systematics, GCFR *Thesium*

4.2.3 SPATIALLY EXPLICIT ASSESSMENT OF THE SUITABLE AREAS FOR THE CONSERVATION OF THREATENED IROKO (*MILICIA EXCELSA* WELW. C.C. BERG) IN BENIN: A COMBINATION OF GEOSTATISTICS AND ECOLOGICAL NICHE MODELLING

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Although Iroko (*Milicia excelsa*) is listed as Endangered and has a great socioeconomic and cultural importance in Benin, there have been few attempts to define sustainable conservation strategies for the species. This study explored the spatial patterns of the species and tested if the species distribution may be affected under future climates forecasts. The Moran index was used to measure the spatial autocorrelation of the abundance of Iroko. For the niche modelling, records of the species were added to bioclimatic variables (current and future conditions) and soil layers in the maximum entropy algorithm. Results showed an overall spatial dependency between the Iroko populations according to density ($P < 0.001$). The population density seems similar between 0 and 3 km but differs from 3 to 150 km. A slight increase was noted from the present-day distribution to the future forecasts (4.71% and 6.95% respectively following the scenarios RCP4.5 and RCP8.5). Urgent conservation actions are needed to safeguard the remnant populations of Iroko in Benin.

Keywords: *Milicia excelsa*, Spatial autocorrelation, Suitable habitats, Benin

4.2.4 A NEW CHECKLIST OF THE FLORA OF THE REPUBLIC GUINEA

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Stanislas Lisowski finished his masterful *Flore de la République de Guinée* in 2000, although it was not published until 2009. In connection with identifying Tropical Important Plant Areas (TIPAs) in Guinea, a comprehensive effort has been undertaken to collect specimen information from multiple sources, and a total of

26,900 collections have been identified and georeferenced where possible. Over 15,000 of these collections have been made since 2005. The bulk of these collections were made for environmental assessments of mining projects in the east of the country. Important collections have been made in preparing for assessments of TIPAs. A comprehensive species list has been prepared and reviewed by specialists. Nomenclatural changes have been made and identifications validated to the extent possible. The results are summarized on this poster. Lisowski's flora documents 3,001 taxa of angiosperms, including 320 introduced plants. We have made 637 updates to the taxon names, based on the African Plant Database, Plants of the World Online, and expert opinion. To these taxa we have added a further 1010 angiosperms and 150 bryophytes, increasing the number of taxa in the documented flora by 33%. Much of the increase is based on range extension of taxa known from neighbouring countries and newly recorded from Guinea. About 260 taxa are currently or tentatively rated as globally threatened. Over 1,200 of the taxa are recorded from a single specimen or observation, many from Lisowski's observations of aquatic and cultivated plants, but also including rare and threatened species. This checklist and database will provide a basis for plant biodiversity conservation in Guinea. Many areas of the country are still under-collected. This checklist demonstrates that continued collection is critical to understanding the Floras of many parts of Africa and the world.

Keywords: Continued collection, Environmental assessments, Lisowski, Mining projects, Guinea

4.2.5 A CHECKLIST OF VASCULAR PLANTS OF EWE-ADAKPLAME RELIC FOREST IN BENIN, WEST AFRICA

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Covering 560.14 hectares in the south-east of Benin, the Ewe-Adakplame Relic Forest (EARF) is a micro-refugium that shows insular characteristics within the Dahomey Gap. It is probably one of the last remnants of tropical rain forest that would have survived the late Holocene dry period. Based on intensive field investigations through 25 plots (10 × 50 m size) and matching of herbarium specimens, a checklist of 185 species of vascular plant belonging to 54 families and 142 genera is presented for this forest. In addition to the name for each taxon, we described the life form following Raunkiaer's definitions, chorology as well as threats to habitat. The family Rubiaceae was the richest (20 species) followed by the Fabaceae (15 species). Life forms showed the preponderance of phanerophytes (88%). The Chorological spectrum was dominated by Guineo-Congolean species (66%). Species richness estimates were 200.52 ± 9.2808 for Bootstrap; 217.62 ±

14.5972; 224.16 ± 15.3725 and 242.67 respectively for *Chao, Jacknife1* and *Jacknife2*. Bootstrap appears to be the estimation closer to the field records. In Benin, EARF is home for Rinorea species described as West African forest bio indicators and is a single location for *Nesogordonia papaverifera, Mansonia altissima, Englerophytum oblanceolatum, Octolobus spectabilis, Vitex micrantha* and it is where most species *(Drypetes aframensis, Drypetes afzelii, Drypetes gilgiana and Drypetes leonensis*) of the tribe Drypeteae are recorded. Our results provide baseline information for further in-depth analysis of vegetation history of Benin by raising the question on the past floristic connection of the Dahomey gap and community engagement in conservation.

Keywords: Dahomey Gap, Flora, Ewe-Adakplame, Refugium, Benin

4.2.6 THE ROAD TO IDENTIFICATION OF THE MOST CRITICAL SITES FOR CONSERVATION OF PLANTS IN UGANDA

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We are compiling data and information for identification of sites most important for plant conservation in Uganda under the Tropical Important Plant Areas (TIPA) Project of the Kew-Makerere University partnership. Key sources of this data include the *Flora of Tropical East Africa*, specimen label data in herbarium collections, as well as validated data from other institutions and individuals. As part of this work, we will produce an updated Red List of threatened species for Uganda, and will draw on the Acanthaceae dataset for East Africa as a proxy for wider angiosperm diversity. The software BRAHMS is being used to collate and develop a database of taxonomic, geographic and other specimen data of plant species that may trigger (Important Plant Areas) IPA status. Targeted field surveys are being conducted in order to update and/or verify the existing records but also to collect any new data. Key stakeholders' input is being sought to further update and verify the data set, and strengthen the conservation status assessment process by making it more participatory. The revised criteria for IPA qualification are being applied for identification of potential IPAs. From the data compiled to-date, a total of 68 sites meet the requirements, or have a potential to trigger IPA status consideration. Of the sites identified so far, 42% fall within some form of protection while the rest are outside the formal protected area network. The outcome of this process will be beneficial and applicable to a range of end-users including government and non-government agencies. Publication of the IPA network for Uganda will guide decision-making on sites that need top priority for avoidance, minimising, restoration or off-

setting of impacts from development ventures. The product will publicise and raise the profile of the sites and also influence policy formulation to support conservation of plants in Uganda and beyond.

Key words: Endemic, Important plant areas, Threatened, Uganda

4.2.7 DIVERSITÉ DES ESPÈCES D'ARBRE UTILISÉES DANS LES MÉTIERS DU BOIS : CAS DE LA FABRICATION DES MORTIERS ET PILONS AU CENTRE-BÉNIN

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La présente étude réalisée au centre du Bénin a porté sur la diversité des espèces utilisée pour la fabrication des mortiers et pilons, deux ustensiles du quotidien des communautés rurales dont les espèces servant à la fabrication deviennent rares. Elle vise à faire l'état des lieux de la diversité et la disponibilité de ces espèces au Centre-Bénin. Une enquête ethnobotanique a été faite dans 30 villages où 84 fabricants de mortiers et/ou de pilons ont été questionnés, la valeur marchande des ustensiles a été étudiée à travers des enquêtes de marché et des inventaires forestiers ont été faits dans deux forêts communautaires (Gbadagba et Fita) pour évaluer la disponibilité des espèces dans la végétation. Ces travaux ont permis de recenser 24 espèces végétales dont 2 servent exclusivement à la fabrication de pilon et, 10 exclusivement pour la fabrication des mortiers; les autres pouvant servir aussi bien pour la fabrication de pilons que de mortiers. La famille des Leguminosae est plus représentée (38%), suivie de celle des Meliaceae (13%). Deux espèces (*Prosopis africana* et *Pterocarpus erinaceus*) sont largement documentées et antérieurement connues pour la fabrication de ces ustensiles. Au total 6 espèces, (soit 25% des espèces recensées sont inscrites sur la liste rouge mondiale de l'Union Internationale pour la Conservation de la Nature (UICN) et sur celles du Bénin). Les inventaires forestiers réalisés ont révélé une faible disponibilité des espèces (1 à 45 pieds/ha dans la forêt de Fita et 1 à 64 pieds/ha dans celle de Gbadagba) avec des structures diamétriques en J renversé, traduisant la raréfaction des sujets adultes nécessaires pour la fabrication, surtout des mortiers, dans les habitats. Il existe une diversité d'espèces pouvant servir la fabrication des mortiers et pilons au centre du Bénin, mais le potentiel disponible est loin de satisfaire les besoins des fabricants.

Motsclés: Biodiversité, Forêts, Conservation, Gestion durable

4.2.8 CONTRIBUTIONS OF THE MISSOURI BOTANICAL GARDEN TO THE PUBLICATION OF NEW BOOKS ON THE AFRICAN AND MALAGASY FLORAS

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Over the last four years, Missouri Botanical Garden (MBG) has been involved in the publication of four books that have contributed to improving the knowledge and conservation of the African and Malagasy floras. In Gabon, *Plantes à fleurs du Gabon* presents one species per genus (1/3 of the flora), each with photographs and a short description. *Le Delta de l'Ogooué* details the biodiversity of this 250×50 km wetland area, the best-preserved of Africa's major deltas: each chapter, written by specialists, covers the history, geography, vegetation, zoology and flora, offering a synthesis of the current knowledge of this Ramsar site, supporting its conservation and management plan. Both are available online from Botanic Garden, Meise. In Madagascar, a three-volume, *The Terrestrial Protected Areas of Madagascar: Their History, Description and Biota*, with text in French and English, was just published. The introduction covers historical and legal aspects, soils, climate, and the biota, with chapters on vegetation and flora, and a synthesis for all 98 terrestrial protected areas, including botanical information. In Tanzania, *A Garden Guide to Native Plants of Coastal East Africa* presents a comprehensive approach to the use of indigenous plant species in private and public gardens. Chapters treat East Africa's coastal ecosystem, detail 60 native species suitable for domestication, identify threats to biodiversity with an emphasis on invasive alien species, discuss regeneration through conservation landscaping, and review the current state of coastal forests, with recommendations for measures that can be used to restore it. The book will soon be available through the African Books Collective in Oxford, UK. Additional books currently in preparation at MBG or with staff input, to be released in the upcoming years, include a first Red List data book for Gabon, a revised edition of the *Natural History of Madagascar*, and *The Genera of Vascular Plants of Tropical East Africa*.

Keywords: Books, Flora, Vegetation, Africa, Madagascar

4.2.9 SEED COLLECTING IN GUINEA FOR THE GARFIELD WESTON TREE SEED PROJECT, KEW'S MILLENNIUM SEED BANK

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The Garfield Weston tree seed project of the Royal Botanic Gardens, Kew's Millennium Seed Bank enabled four years of seed collecting in various African countries. Six seed collecting expeditions to Guinea were accomplished in the years 2016 - 2019. Five local seed collectors participated in these expeditions. Local seed collectors also collected on their own during the four years. Though the focus was on collecting seeds of rare trees, seeds of all other plant species were collected as well and 275 seed collections were made. These seeds were stored in a newly established seed bank at the National Herbarium of Guinea, in Conakry, and at Kew's Millennium Seed Bank in the United Kingdom. Seeds of many rare species were collected; several of these were known only from a single collection made more than 50 years before present. Several undescribed species were discovered, and seed was collected from most of these. Rare fire-free shrubland vegetation, rich in rare species, was discovered on remote uninhabited table mountains. The seed collecting work in Guinea has made a large contribution to plant conservation in Guinea, not only by collecting seeds of many rare species, but also by increasing the knowledge of the distribution of rare plant species in Guinea.

Keywords: Africa, Guinea, Rare species, Seed collection

4.2.10 DIVERSITE, LOCALITE et ECOLOGIE DE CAFEIERS SAUVAGES MALGACHES ENDEMIQUE DE LA COTE OUEST DE MADAGACAR: BARACOFFEA (RUBIACEAE)

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A Madagascar, près de 75% des espèces de caféiers malgaches sont classées vulnérables, menacées ou fortement menacées de disparition selon la liste de l'UICN. C'est l'une des conséquences directe de la déforestation et d'autres activités anthropiques. Parmi ces espèces de caféier, il y a le groupe des *Baracoffea* (sous-genre de *Coffea*). *Baracoffea* regroupe 9 espèces endémiques, exclusivement présentes dans les forêts sèches de la côte Ouest de Madagascar, constituent une base importante pour échapper à des problèmes au niveau des caféicultures, puisqu'il comprend des espèces xérophytiques avec des caractéristiques morphologiques d'adaptation à la sécheresse. Cette étude a comme objectif de caractériser la diversité des espèces du groupe de *Baracoffea* dans la région ouest de Madagascar vu son statut UICN, notamment dans la région Boeny (Parc National Ankarafantsika et la forêt d'Antsanitia) et de caractériser leur exigence écologique afin de pouvoir donner des recommandations pour sa conservation. Une étude écologique a été effectuée, comme l'inventaire floristique ; analyse de recouvrement de la végétation ; abondance numérique (nombre d'individu et population); et étude de la distribution de ces espèces. Il a été révélé de cette étude que 3 espèces de *Baracoffea* sont présentes près de la ville de Mahajanga, telles que : *Coffea ambongensis*, (forêt d'Antsanitia), *Coffea boinensis* (forêt du Parc National Ankarafantsika) et *Coffea bissetiae* (commune aux deux forêts). Le nombre de population par espèce et par site est en général peu nombreux, pour celui d'Ankarafantsika : 4 populations de *C. boinensis*, 6 populations de *C. bissetiae*; tandis que pour celui d'Antsanitia : 2 populations de *C. ambongensis* et *C. bissetiae*. Nous pouvons en déduire que l'habitat le plus favorable à ces espèces est la forêt protégée dont le Parc National Ankarafantsika, contrairement à la forêt d'Antsanitia qui est une forêt à accès libre, c'est pourquoi on n'y trouve que 2 populations seulement pour chaque espèce localisée. Vu l'état actuel de la forêt d'Antsanitia, ces espèces seront bientôt classées en voie de disparition, ce qui demande une réflexion et prise de responsabilité de notre part, pour leur sauvegarde et protection. Une collection *ex situ* serait une solution primordiale pour la sauvegarde de ces ressources biologiques.

Mots clés: *Baracoffea*, Caféier sauvage, Diversité, Écologie, Distribution, Région Boeny, Madagascar

4.2.11 RHEOPHYTIC BRYOPHYTES IN GHANA

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Rheophytic bryophytes occur in riparian ecosystems where they are usually attached to rock or other solid substrata and are seasonally inundated. Globally they are poorly documented. The actual number of rheophytic bryophytes is uncertain and therefore speculative. One estimate puts the number at 500 taxa. In many herbaria specimens of rheophytic bryophytes are underrepresented. Also, herbarium labels hardly indicate the micro-habitat and ecological conditions for bryophytes collected in riparian ecosystems. Rheophytic bryophytes are important in primary productivity in riparian ecosystems and in monitoring river health. However, their habitats are threatened worldwide by dam construction and other anthropogenic activities. The paucity data on rheophytic bryophytes is partly due to lack of systematic collection effort. This is, however, changing as many more surveys targeted at collecting bryophytes (including rheophytic types) are being carried out in recent years. Two botanical surveys dedicated to bryophytes were carried out in Ghana in 2014 and 2017. In 2014 the survey was confined to the Atewa Forest Reserve (Eastern Region). In 2017 Atewa Forest Reserve was surveyed again in addition to the Kakum Forest Reserve (Central Region), and Ankasa Forest Reserve (Western Region). Findings of the two surveys indicated that of the 203 bryophytes documented at least 7 are rheophytic. Bryologists are encouraged to target riparian ecosystems in future botanical surveys. Infrastructure development practitioners and conservationists should make the conservation of rheophytes in riparian ecosystems a priority in development planning in Africa.

Keywords: Bryophytes, Forest Reserves, Ghana, Rheophytes, Riparian ecosystems

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5. Thematic Area 5: Botany and Ecology of Miombo Woodlands

5.1 Oral Presentations

5.1.1 ECOLOGICAL AND FUNCTIONAL KNOWLEDGE OF TREE SPECIES: A BASIS FOR SUSTAINABLE MANAGEMENT OF THE NATURAL ECOSYSTEMS OF MIOMBO OF HAUT-KATANGA

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The Miombo ecosystem of Haut-Katanga is a dry forest, very vulnerable to anthropogenic pressure. However, it has a very high richness (about 70 tree species/ha, dbh threshold >10 cm) in relation to the type of substrate. In this forest, some species are more exploited than others (e.g. *Pterocarpus tinctorius*) at a rate that does not allow the regeneration of forest capital. Other vulnerable species occur in sub-types of the ecosystem such as dense dry forest (muhulu) and gallery forest (mushitu), including *Beilschmiedia ugandensis* and *Treculia africana*. Taking into account the substrate, topography and texture appear to be the two major soil factors influencing the establishment and coexistence of the tree species. To stimulate reflection, we present two case studies on *Pterocarpus* and *Julbernardia*. During our research, we have noticed that some species belonging to these genera are very different, if not contrasting, in terms of ecological and functional patterns. They do not flower at the same time, often do not develop on the same substrate and do not have the same behaviour with regard to light requirements. Several other genera seem to have the same behaviour e.g. *Combretum* and *Erythrophleum*. The best plan for the sustainable management (restoration and/or conservation) of these species should take into account the ecological and functional aspects of the tree species for its success, with forest botanical knowledge being more crucial upstream.

Keywords: Miombo, Anthrpogenic pressure, Sustainable management, Haut-Katanga

5.1.2 EVOLUTION DE LA FORMATION DE BOIS DE TAPIA AUX DIFFERENTS REGIMES DE FEUX

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Les bois de Tapia, dominés par le Tapia (*Uapaca bojeri*, Phyllanthaceae) et localisés sur les hautes terres centrales de Madagascar, sont des formations végétales distinctes, parfois considérées comme analogue au bois de Miombo de l'Afrique

continentale. Quatre aires protégées renferment ces bois de Tapia qui brûlent plus ou moins fréquemment; les gestionnaires ont essayé différentes stratégies pour stopper l'entrée des feux dans ces zones mais avec très peu de succès. Aujourd'hui, il est reconnu que le feu fait naturellement partie de cet écosystème, mais le régime de feu optimal pour la conservation de la biodiversité reste à clarifier. Pour répondre à ce besoin, une cartographie de la fréquence des feux à l'aide des données MODIS de 2000 à 2017 a été effectuée dans deux aires protégées, Ibity et Itremo. Ensuite, en utilisant des photos aériennes et des images satellites, une comparaison de l'évolution de la superficie des bois de Tapia de 1947 à 2006 aux différents régimes de feux a été réalisée suivant la carte de fréquence des feux obtenus après analyse cartographique. Les résultats de cette analyse montrent que les zones occupées par les bois de Tapia sont très stables quelques soit la fréquence des feux dans ces deux aires protégées. Cependant, les informations sur la structure des classes de diamètre de *Uapaca bojeri* provenant des parcelles inventoriées régulièrement suggèrent, suivant le régime des feux, que la régénération est moins fréquente dans les zones souvent brûlées par rapport aux zones où les feux sont rares ou occasionnels. Ainsi, il semblerait que les bois de Tapia puissent être impactés par des fréquences de feu élevées, mais il pourrait prendre des siècles avant de réduire significativement la superficie de la zone couverte. Le régime de feux nécessaire pour une gestion optimale, qui sera obtenu après des analyses actuellement en cours, sera intégré dans les stratégies de gestion d'Ibity et d'Itremo afin de préserver cet écosystème.

Mots clés: Bois de Tapia, Feux, Aire Protégée, Photo aérienne, Cartographie

5.1.3 THE IMPORTANCE OF FORESTS TO RURAL LIVELIHOODS AND THE DEPENDENCE OF FOREST PRODUCTS ON POLLINATORS

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Zambian miombo forests support rural livelihoods by supplementing income, providing nutritional support, and fulfilling a cost-saving function through the supply of building and other materials. Unsustainable forest use undermines these support functions and exacerbates Zambia's already high deforestation rates. Despite their importance, little is known about the role of pollinators in providing many important forest products. Measuring the sustainability of forest use is key if forest habitats are to be managed sustainably. Sustainability is often context-specific and is not directly

measurable, necessitating the use of composite indicators that combine multiple variables that are measurable. We assess the dependence of two key miombo tree species on pollinators and the sustainability of forest use by rural communities in North-Western Zambia using several forest use variables aggregated into a composite indicator. Pollinator exclusion experiments on two common miombo ecoregion tree species were conducted to determine their dependence on cross-pollination and the degree to which they are affected by pollen limitation. The sustainability assessment indicated that if certain harvesting practices that currently involve unnecessary tree felling were addressed, this would improve the sustainability of forest use considerably. The pollinator exclusion experiment showed variable dependence on cross-pollination: *Syzygium guineense* subsp. *barotsense* displayed self-compatibility while *Julbernardia paniculata* displayed more reliance on cross-pollination to produce seeds. Furthermore, *J. paniculata* showed signs of pollen limitation. Although pollen limitation is not uncommon amongst plants it could be exacerbated by deforestation, unsustainable forest use, and the subsequent loss of pollinator habitats. Addressing destructive harvesting practices could help to ensure that tree pollination is not negatively affected and that rural communities continue to benefit from forest products in a sustainable way.

Keywords: Forest products, Miombo breeding systems, Pollination experiment, Sustainable Forest use, Sustainable rural livelihoods

6. Thematic Area 6: Monocots

6.1 Oral Presentations

6.1.1 AFRICAN GRASSES HAVE CONQUERED THE WORLD

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African grasses have conquered the world. Much of the city of Bogota, Colombia, is covered by *Cenchrus clandestinu*s, also known as kikuyu grass. The Brazilian cerrado was transformed by the African pasture introduction *Urochloa decumbens*. *Andropogon gayanus* is taller than humans at up to 3.5 m, changing fire regimes across northern Australia. African grasses built the African savannas, the cradle of mankind. The creeping grazing grasses feed much of Africa's megafauna, while the erect fire grasses drive pyrodiversity, which supports other biodiversity. So why is

there still no full evolutionary tree of African grasses? Why have so few Poaceae collections been made since the 1960s? Why are many botanists reluctant to even attempt grass identification? Why do African grass species concepts and classification systems at BR, EA, K, P, PRE and other herbaria still not match? This paper will present an overview of our knowledge of African grasses, and discuss priorities for strategic collaborations across Africa. Integration between fundamental taxonomy, phylogenetics and phylogenomics, functional ecology and vegetation models will be explored. The author's long-term research on Madagascar's grasses will be presented as an example, and compared to Africa's most advanced and integrated grass species knowledge system achieved in South Africa. Please join us and get to know your grasses better.

Keywords: African grasses, Identification, Taxonomy, Diversity

6.1.2 A PHYLOGENETIC ANALYSIS OF THE GENUS *SCADOXUS* (AMARYLLIDACEAE)

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With the current circumscription of the genus *Scadoxus* (Amaryllidaceae) it consists of nine species, all occurring in sub-saharan Africa. Some are widespread, like *S. multiflorus, S. puniceus* and *S. cinnabarinus* while others are narrow endemics, namely *S. cyrtanthiflorus, S. longifolius, S. nutans, S. membranaceus, S. pole-evansii* and *S. pseudocaulus*. An early cladistics analysis concluded that the genus was separated into two clades, a rainforest clade (*S. cinnabarinus, S. cyrtanthiflorus, S. nutans, S. pseudocaulis*) and a mainly woodland clade (*S. membranaceus, S. multiflorus, S. pole-evansii, S. puniceus*). Thorough morphological analyses were

undertaken during the 70s and 80s. We are here testing whether this delimitation and these clades are supported by molecular methods. We have used six chloroplast and nuclear DNA regions (Sanger sequencing) and also NGS (genome skimming). The molecular methods did only partly confirm the species delimitation based on morphology. Morphological species contradicted by the molecular phylogenetic analyses were found in the most widespread species in the genus, namely *S. puniceus* and *S. multiflorus*. Generally, the phylogenetic trees displayed strong geographic structures. The following taxonomic changes are proposed: 1. Ethiopian material of *S. multiflorus* subsp. *multiflorus* should be delimitated at species level as *S. abyssinicus* comb. nov., 2. *S. multiflorus* subsp. *katherinae* should be reinstated at species level and recombined as *S. katherinae* comb. nov., 3. *Heamanthus fax-imperii*, earlier reduced to *S. puniceus*, should be reinstated at species level recombined as *S. fax-imperii* comb. nov. 4. *Scadoxus goetzei* earlier reduced to *S. puniceus*, should be reinstated at species level recombined as *S. fax-imperii* comb. nov. 5. *Scadoxus longifolius* should be reduced to synonymy under *S. cinnabarinus.*

Keywords: *Scadoxus*, Morphology, Genome skimming, Sanger sequencing, Phylogeny

6.1.3 AN INTEGRATED APPROACH FOR DELIMITING TAXA OF *DRIMIOPSIS*, *LEDEBOURIA* AND *RESNOVA* (ASPARAGACEAE, SUBFAMILY SCILLOIDEA)

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In this integrative systematic study, we are focusing on three African monocot genera: *Drimiopsis, Ledebouria* and *Resnova* (Asparagaceae, subfamily Scilloidea, formerly Hyacinthaceae). Due to the scarcity of phylogenetically informative characters, both morphological and molecular, taxon delimitation in this clade has historically been challenging. Although the three genera together constitute a well-supported monophyletic group, the relationships within the clade remain poorly resolved. Preliminary results suggest a paraphyletic *Ledebouria*, with *Drimiopsis* and *Resnova* as sisters to one *Ledebouria* clade each. To obtain a resolved phylogeny for the clade, all the way down to species level, we have applied a target sequence capture approach. Using the Angiosperms353 probe set, we have obtained a multi-locus data set that, along with a broad geographical sampling, will provide the basis for inferring a more natural classification at all levels of the target group. To help taxon identification in the field, we hope the resolved phylogeny will provide the

framework needed to identify a set of phylogenetically informative morphological characters. We will present our preliminary phylogenetic results and discuss the utility of the Angiosperms353 probe set in this clade.

Keywords: Scilloidea, Systematics, Phylogeny, Target capture, Angiosperms353

6.1.4 RECONSIDERATION OF THE GENERIC POSITION OF *CHLOROPHYTUM CALYPTROCARPUM* (BAKER) KATIVU (ASPARAGACEAE)

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Selected species of *Chlorophytum* were sequenced (Sanger sequencing, several chloroplast and nuclear regions), and parsimony and Bayesian analyses performed. The generic delimitation of *Chlorophytum* has been altered several times in the past decades, with some contention on the delimitation of *Anthericum* and *Chlorophytum*. *Chlorophytum calyptrocarpum* (formerly *A. calyptrocarpum*) has never been considered outside the *Chlorophytum* group. Our recent DNA analysis, however, showed that the species resolves outside the *Chlorophytum* clade. The species is considerably variable morphologically, and is characterized by unusually small, shallowly deltoid capsules that remain covered in remains of the perianth, and tiny, irregularly folded seeds. Its growth form is characterized by glandular, grass-like leaves and narrow cylindrical stems that often bear plantlets. The latter character, is so far only recorded in *Chlorophytum comosum*, a distantly related taxon. The DNA evidence strongly supports consideration of *C. calyptrocarpum* elsewhere outside genus *Chlorophytum*.

Keywords: *Chlorophytum calyptrocarpum,* Delimitation, Variable morphology, Sanger sequencing, Phylogeny

6.1.5 PHYLOGENETIC RELATIONSHIP OF *KNIPHOFIA* SPECIES IN ETHIOPIA: A STUDY USING DNA SEQUENCE DATA

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The genus *Kniphofia* Moench, commonly known as 'red hot pokers', belongs to the family Asphodelaceae in the sub-family of Asphodeloideae. The genus comprises about 70 species from Africa and one species from Asia. In Africa they are chiefly distributed in southern and eastern Africa, preferring temperate mountainous grasslands and moist habitats. The Ethiopian endemic species are located between 6° 00' N to 14° 00' N latitude and 33° 00' E to 41° 46' E longitude (from 2,000 - 4,000 m.a.s.l.) that falls within the mountainous areas of the country. The genus *Kniphofia* is generally perennial, acaulescent and herbaceous taxon which shows variation in size according to the site and availability of water and occupies habitats that range from low and wet savannah grassland to montane and alpine vegetation. Economically, the genus *Kniphofia* is useful in the field of apiculture, horticulture and pharmacy. The objective of this study was to use plastid and nuclear DNA sequence data to reconstruct a species level phylogeny to understand intra-generic species relationships and evolutionary processes of Ethiopian kniphofia species. In the study, phylogenetic reconstruction datasets of both plastid (*trnL-trnF, psbA-trnH, trnt-trnL* and *matK*) and nuclear (ITS and AT103) that is 22 from newly sequenced accessions and 52 from gene bank markers were used. Finally, the data was analysed by using both maximum likelihood and bayesian analyses of plastid DNA and nuclear DNA. The study shows that the two phylogenetic trees were topologically similar. The species from Ethiopia are placed in one separate and strongly supported clade in both plastid DNA and nuclear DNA phylogenies, indicating a separate evolutionary history of the Ethiopian species. Within these clades the results show poorly resolved phylogenies especially for the nuclear region AT103, which has no resolution.

Keywords: *Kniphofia*, Asphodelaceae, Phylogeny, ITS, AT103, *trnL-trnF* and *psbA-trnH*

6.1.6 TARGET-CAPTURE AND ANGIOSPERM-353 PROBE-SET ON *CHLOROPHYTUM*: A VIABLE WAY TO DETERMINE SPECIES COMPLEXES?

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Chlorophytum (Anthericaceae) is a genus whose circumscription has been largely changed over time, from its family placement to its species composition. *Chlorophytum comosum* is the species that has been used the most in varied scientific research, ranging from plant physiology to medicine. However, it is a species complex that has largely assimilated previously recognized species into its name. The fact that the *C. comosum* species-complex remains unsolved is an issue for studies that have used it for research in medicine, conservation, plant physiology and as a model organism. Here we used the novel Target-Capture approach in an attempt to solve the *C. comosum* species-complex since the traditional approach through polymerase chain reaction and Sanger sequencing has remained unable to fully resolve it. We used the Angiosperm-353 probe set along with recently developed bioinformatic tools, such as HybPiper, to improve our understanding of the species-complex. In conclusion, we demonstrate that *C. comosum* is limited to southern Africa, which indicates the need to rename the remaining *C. comosum* clades throughout the rest of the African continent.

Keywords: *Chlorophytum*, Species-complex, Phylogeny, Target-capture, Angiosperm-353

7. Thematic Area 7: Systematics of African plants

7.1 Oral Presentations

7.1.1 A TAXONOMIC REVISION OF THE GENUS *LEUCOBRYUM* HAMPE (LEUCOBRYACEAE, BRYOPHYTA) IN MADAGASCAR

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The level of endemism of Madagascar's vascular flora is about 87%, while that of the island's moss flora, represented by 751 species, is estimated at 34%. The 19 species of the moss genus *Leucobryum* stand out in that they are mostly endemic and comprise more than half of the known diversity of the Afro-Malagasy region (34 species). Species of *Leucobryum* grow as tufts on the ground as well as on rocks, dead wood, and living trees. They are rather easily recognized in the field by the pale, whitish cushions they form, but due to a very high level of similarity among species in the appearance of their gametophyte, coupled with the scarcity of

sporophytic collections and a lack of recent taxonomic studies, it is very difficult to identify *Leucobryum* specimens to the species level. The most recent study of Malagasy *Leucobryum* dates back to the work of Renauld (1900). The revision we have undertaken involves an integrative taxonomic approach that combines morphological investigations and molecular analyses. We used the non-tree based Automatic Barcode Gap Discovery (ABGD) method along with tree-based species delimitation methods; the Yule coalescent model (GMYC) and the Poisson tree process (PTP) and present our new hypotheses of species delimitations, using a score-matrix to help species recognition decisions. We do not recognize *L. isleanum* var. *molle* (Müll. Hal. ex Renauld) Cardot as a distinct variety. We describe a new species and propose some additional nomenclatural updates. The ecological preferences of the species are characterized (e.g., *L. madagassum* Besch is the only member of the genus in Madagascar found in dry and high altitude areas). In our revision, each species description is accompanied by detailed original illustrations and a distribution map. A dichotomous identification key is also provided.

Keywords: *Leucobrym*, Bryophytes, ABGD, GMYC, PTP, Key, Madagascar

7.1.2 SYSTEMATICS OF *BULBINE* AND *TRACHYANDRA* (ASPHODELACEAE: ASPHODELOIDEAE): TAXONOMY, PHYLOGENY AND EVOLUTION

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The Asphodeloideae (Asphodelaceae) is a subfamily that comprises eight genera of petaloid monocots. The phylogenetic relationships and taxonomy of the genera are in great need of study, compared to the well-studied subfamily Alooideae that recently underwent a generic reclassification. This presentation will focus on *Bulbine* Wolf. and *Trachyandra* Kunth., both of which have been the subject of ongoing systematics studies over the last few years. The genus *Trachyandra* Kunth. comprises ca. 60 species which are widely distributed in Africa and Madagascar,

with most of the species concentrated in the Greater Cape Floristic Region of South Africa. *Bulbine* comprises ca. 70 species distributed in South Africa and Australia. In South Africa, the genera have a centre of diversity in the Greater Cape Region where some 48 species occur. Several new species in both genera have been uncovered and the studies thus far have provided much insight into relationships between the taxa in both genera. In *Bulbine*, especially, some taxa currently recognized at the species level need to be synonymised. Data from DNA sequences from nuclear (ITS) and plastid (*matK, rbcLa*, *rps16, trnL-F* and *trnH-psbA*) regions indicate that while *Bulbine* is monophyletic, *Trachyandra* is not. These results have implications for generic circumscriptions in the Asphodeloideae and the proposed taxonomic changes will be discussed. The results from this study have provided vital information on the taxonomy of *Bulbine* and *Trachyandra*, and paves the way for revisions of these genera across their distribution ranges.

Keywords: Asphodeloideae, Petaloid Monocots, Phylogeny, Taxonomy, New Species, Southern Africa

7.1.3 TAXONOMY, SYSTEMATICS AND BIOGEOGRAPHY OF AFRICAN *ENTOSTHODON* (FUNARIACEAE)

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The Funariaceae are a large family (ca. 250 spp.) of soil-inhabiting, annual to biennial mosses of worldwide distribution. Members of the family have served as model organisms in studies of evolutionary development (e.g. *Physcomitrium patens*), hybridization, physiology and genetics and their popularity over other bryophytes for such studies is likely a result of their shortened life cycle and often highly simplified morphology. A recent revision of the genus *Entosthodon* in sub-

Saharan Africa and neighboring islands recognises 26 species, of which six are newly described. Phylogenomic inference, based on organellar and nuclear loci, suggest that the genus is largely paraphyletic with respect to *Physcomitrium* and comprises no fewer than 3 major lineages. Each of these major lineages are represented on the African continent and/or neighboring islands, often by multiple species, suggesting a complex dispersal history. Species of *Entosthodon* otherwise occur throughout sub-Saharan Africa, although centers of diversity are found in the Cape provinces of South Africa and in East Africa. Biogeographic reconstructions recover an African origin for the two most diverse clades within *Entosthodon*, although, the extant diversity is probably best explained by a combination of cladogenesis and repeated dispersal into the region.

Keywords: Taxonomy, Systematics, Phylogeny, Mosses, Biogeography

7.1.4 *CYPERUS MARGARITACEUS* AND ITS RELATIVES: HOW MANY SPECIES ARE THERE?

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The *Cyperus margaritaceus-niveus* complex (Cyperaceae) is a group of tropical plant species (*C. karlschumanii, C. ledermannii, C. margaritaceus, C. niveus, C. nduru, C. obtusiflorus*, and *C. tisserantii*) from sub-Saharan Africa & Madagascar united by the combination of a capitate inflorescence, white glumes and swollen bulb-like bases. Recent molecular studies in the C4 *Cyperus* clade, have shown the complex to form a monophyletic group sister to the rest of the C4 *Cyperus* species, although regional floras have been unable to reach a consensus on inter-species relationships, presenting differing opinions on the circumscriptions of these taxa. In this study, we use multivariate morphometric analyses - Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA) and Classification and Regression Tree Analysis (CART) - to test the robustness of the species circumscriptions presented in these floras. Unlike flora accounts which only use a partial subset of the taxa, we use all species represented in the complex from across their entire geographical range. The analyses show that six taxa are recognised for the LDA, and eight taxa are recognised for CART. Both the PCA and LDA showed *Cyperus karlschumanii* and *C. ledermannii* as separate taxa in the multivariate space, whilst there was considerable overlap between *C. margaritaceus, C. niveus, C. nduru, C. obtusiflorus*, and *C. tisserantii*. Notable results include: 1) the LDA cross-validation showing *C. margaritaceus* to form a robust entity despite its

overlapping with the other taxa, and 2) the failure of *C. niveus* to form a distinct entity in both LDA cross-validation and CART. The computational approach attempted here is a useful tool to add to traditional taxonomic methods in resolving other species complexes in the Cyperaceae.

Keywords: Cyperaceae, Species complex, Taxonomy, Multivariate morphometrics

7.1.5 COMBINED ANALYSIS USING MORPHOLOGICAL AND GENETIC MARKERS REVEALS SIX SPECIES IN THE WIDESPREAD TAXON *KHAYA ANTHOTHECA* (WELW.) C.DC (MELIACEAE)

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The combination of genetic and morphological markers has been shown to be highly efficient in delineating cryptic species or complexes of poorly differentiated species. Speciation is not always accompanied by sufficient divergence in morphological characteristics to enable clear separation of species. Sometimes, what is considered a single species on morphological grounds is likely to contain a complex of biological species. This is the case of *Khaya anthotheca*, one of the African mahoganies of the family Meliaceae. Due to its morphological variability, the delimitation of this taxon varies according to different authors. By combining a morphological study of

herbarium specimens with the genotyping of hundreds of samples using nuclear genetic markers (SNPs), we propose an assessment of the taxonomic limits of *K. anthotheca*. Nuclear SNPs allowed us to distinguish six different genetic groups. Four of these five groups have parapatric distributions and two of them are locally sympatric. Recognition of these genetic groups was reinforced by a fine analysis of morphological characters, so that they should be considered as separate species. The majority of these species recognized by all these analyses correspond in fact to species previously described but put in synonymy within *K. anthotheca*. However, two species are described for the first time. These results are particularly important given the pressure of logging on African mahoganies, as some of these groups may correspond to cryptic species that could be threatened by overexploitation.

Keywords: African mahoganies, *Khaya*, Species delimitation, Genetics, Morphology

7.1.6 MOLECULAR PHYLOGENY OF ETHIOPIAN *ARTEMISIA* SPECIES BASED ON TWO NUCLEAR RIBOSOMAL DNA (ITS & ETS) AND THREE PLASTID DNA (PsbA-trnH, matK & trnL-trnF) REGIONS

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One of the largest genera world-wide, the genus *Artemisia* L. belongs to the Compositae or Asteraceae family. Even if there is no universal consensus about the number of taxa, this genus comprises more than 500 taxa at specific and infra-specific levels distributed in six subgenera. In Ethiopia, *Artemisia* L is represented by four species, namely the endemic *A. schimperi, A. abyssinica, A. afra* and *A. absinthium*. Except for trees, the genus contains all forms of growth such as shrubs, sub-shrubs and perennial herbs which may be both biennial or annual. With vast ecological plasticity, the genus *Artemisia* occurs all over the world except in Antarctica. Some members of the genus are cosmopolitan and a few are aggressive weeds while others are endemics. Many species of the genus have several economic values such as medicinal, ornamental, food, forage and soil stabilizing. The objective of this study was to reconstruct a molecular phylogeny and assess the phylogenetic positions of Ethiopian *Artemisia* species. In the study 9 newly generated sequences of two nuclear ribosomal DNA (ITS and ETS), three plastid DNA (PsbA-trnH, matk & trnL-trnF) and 98 previously published sequences from Genbank were used. The analysis was carried out through a combined dataset using

Bayesian Inference (BI), Maximum Likelihood (ML) and Maximum Parsimony (MP). The nuclear DNA and plastid DNA analysis showed that Ethiopian representatives of the tribe divide into three and four separate clades respectively. The result of both nuclear ribosomal and plastid DNA analyses show that material collected in Ethiopia and called *A. absinthium* (previously *A. rehan*) resolves in a different clade than that of the downloaded sequences of European *A. absinthium*. The two are also morphologically distinct.

Keywords: *Artemisia*, Plastid DNA, Nuclear DNA, Clades, Morphologically distinct

7.1.7 MOLECULAR SYSTEMATIC STUDIES IN SOUTHERN AFRICAN *PLECTRANTHUS*

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Plectranthus L'Hér., a genus consisting of some 350 species in the Lamiaceae, is distributed largely in Africa, but also in India, Australia and Japan. They vary from small decumbent herbs to tall shrubs that possess flowers of variable corolla tube length known to attract a variety of pollinators; these include long-tongued flies that are adapted to visiting species and populations that possess longer floral tubes. In southern Africa, where approximately 53 species occur, they inhabit the moist forests and grasslands of the eastern and northern regions of South Africa, and the arid semi-desert regions of northern Namibia. The classification of southern African *Plectranthus* and its allied genera has changed repeatedly since the description of the genus in 1788, with recent phylogenetic studies resulting in the accommodation of this group in three genera. However, the morphologically diverse taxa in southern Africa have not been subject to extensive phylogenetic study, which prompted us to initiate a molecular systematics study on the species in this area. To this end, the whole chloroplast genome of *Plectranthus ecklonii* was sequenced using Ion semi-conductor sequencing. Gene sequences were compared with those of *Tectona grandis*, *Origanum vulgare* and *Salvia miltiorrhiza* and the two most variable chloroplast gene regions, trnQ-rps16 and trnL- rpl32, were identified. Primers were designed based on their conserved flanking regions and these were used for amplification and sequencing. Suitable primers were also used for the amplification and sequencing of the nuclear ITS region. Species of the closely related genera, *Rabdosiella, Thorncroftia, Solenostemon, Aeollanthus*, *Tetradenia* and suitable

outgroups were included. The generated phylogenies will be presented which provide new insights into the relationships within this group and will have implications for the classification and taxonomy of the genus *Plectranthus*.

Keywords: Lamiaceae, *Plectranthus*, Ion semi-conductor sequencing, Phylogeny, Classification

7.1.8 THE LAMIACEAE IN AFRICA AND MADAGASCAR - RECENT ADVANCES IN GENERIC DELIMITATION

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The Lamiaceae, a large cosmopolitan family, is well-represented in Africa and Madagascar, where the numerous genera present are frequently encountered in diverse biomes and in a great diversity of habitats. The family has also given rise to many garden ornamentals as well as culinary and medicinal herbs. During the past 20 years, research on the family has advanced significantly with the publication of a number of flora treatments for the African region, and with others currently in press. Nethertheless, generic limits have been problematic and difficult to determine and this has hampered a better appreciation of the diversity of many groups in the field and herbarium. Recently, phylogenetic work in a number of groups, notably in the Nepetoideae (Ocimeae) and the Ajugoideae have shown the need for dramatic

changes in generic circumscription, and this work, coupled with morphological studies, has resulted in highly revised generic concepts in many groups at a global scale. Many of the necessary nomenclatural changes for Africa and Madagascar have now been published, and the authors hope that these changes will be adopted by the botanical community at large and will also facilitate recognition of the genera concerned. We provide an overview of these changes as they pertain to the region's floras and in the light of this we contrast the Lamiaceae flora of Madagascar with that of mainland Africa.

Keywords: Lamiaceae, Diversity, Phylogeny, Distribution, Flora, Africa, Madagascar

7.1.9 UNRAVELLING THE SYSTEMATICS AND EVOLUTION OF AFRICAN EUPHORBIACEAE

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Within Euphorbiaceae, 63 genera and ca. 1,014 species are estimated to be present in Africa and Madagascar. The main goal of our collaborative project is to update and resolve the taxonomy of several groups of African Euphorbiaceae in conjunction with phylogenetic inference of their evolutionary histories. Using the only available family-level phylogeny (Wurdack *et al*. 2005) as the starting point, we will build better-resolved phylogenies for these lineages with contrasting evolutionary patterns based on a target-sequence capture (Hyb-Seq) kit designed to employ genome resources from *Ricinus communis* and *Euphorbia esula*. Hyb-Seq has been shown to work well with historical herbarium samples, which is crucial due to the difficulty of obtaining field-collected samples from many areas of Africa. Progress has been made on completing the taxonomic sampling across the selected 20 clades, clarifying the taxonomy of several groups, improving the identification of the existing material and recognizing new species. To date we have identified several new Malagasy and West African taxa, including the paleotropical subtribe Claoxylinae. We are now initiating work to understand the evolutionary history of this mostly dioecious subtribe, which includes ca. 160 currently recognized species in five genera, three endemic to Africa and Madagascar. Most of these groups are rather poorly characterized due to a lack of floral features available to differentiate the species, a situation complicated by their dioecious breeding system and the lack of

recent taxonomic revisions. We will develop a phylogenomic approach in Claoxylinae as a model for the other African Euphorbiaceae clades selected for our study.

Keywords: Africa, Euphorbiaceae, Hyb-Seq, Madagascar, Phylogenomics, Taxonomy

7.1.10 SYSTEMATICS, SPECIES DELIMITATION AND CONSERVATION IN TSEBONEAE, A MADAGASCAR ENDEMIC TRIBE OF SAPOTACEAE

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Although Madagascar contains around 10% of all known Sapotaceae species in the world, Malagasy lineages are understudied and many new taxa have been described in recent years. Massive deforestation and selective cutting is threatening several endemic species with extinction, and the implementation of conservation measures is hindered by the weak taxonomy of the group. In the context of a project that aims to perform a taxonomical review of the entire family in Madagascar, we focused first on the Tseboneae, an endemic tribe that contains three genera and 28 described species. To address the study in a phylogenomic context, we have performed a Gene Capture protocol able to provide 793 genetic markers for the entire Sapotaceae family, as well as up to 227 microsatellites for some *Capurodendron* species. The methodology used was able to provide sequences for herbarium specimens of up to 86 years old. A phylogenomic reconstruction of the Tseboneae using 519 genes produce a highly supported tree, showing *Tsebona* as the most basal clade, with *Bemangidia* and *Capurodendron* as sister clades. Taxon delimitation was helped by STACEY species delimitation software, showing species with high statistical support and phenotypically well characterized. Our results show that Tseboneae may contain up to 52 species instead of 28, with one of the new species in *Bemangidia* and the others in *Capurodendron*, making the latter the largest endemic plant genus in Madagascar. *Capurodendron* tree topology suggests a recent species radiation, enhanced by the colonization of the dry areas. Two species complexes have been detected, one from the eastern rainforest (Eastern Complex) and another from south-western dry areas (Arid Complex). The last one shows hybrid specimens and current speciation. Additionally, outgroup taxa used for the study show that *Gluema* and *Inhambanella* lineages should be considered as new tribes.

Keywords: Tseboneae, Threatened, Endemic, Madagascar, Gene capture, Delimitation

7.1.11 GENERIC CIRCUMSCRIPTIONS AND RELATIONSHIPS OF FELICIA AND ALLIES (ASTERACEAE, ASTEREAE)

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The horticulturally well-known daisy genus *Felicia* Cass. (Asteraceae, Astereae) comprises ca. 85 species of annual and perennial herbs or shrublets. Most of the diversity occurs within southern Africa with only a few species extending north to Nigeria, Ethiopia and Saudi Arabia. Recent generic-level phylogenetic analyses of the tribe Astereae confirmed the placement of Felicia in a clade together with other members of the subtribe Homochrominae (viz. A*mellus* L., *Chrysocoma* L., *Gymnostephium* Less., *Nolletia* Cass., *Poecilolepis* Grau, *Polyarrhena* Cass., *Roodebergia* B. Nord., *Zyrphelis* Cass.) and indicated that several of these genera may be embedded within *Felicia*. As these analyses included only at most a few accessions of each genus and were based on only a single gene region (nrITS), we here explore the generic circumscriptions of *Felicia* and allied genera with the use of greatly expanded phylogenetic analyses for the clade based on the nuclear regions ITS and ETS and the plastid region trnL-F. Grau's sectional classification of *Felicia* is largely supported although *Felicia* is clearly paraphyletic with allied genera embedded within. *Roodebergia* is embedded within the Felicia sect. *Neodetris* Grau, *Amellus* is recovered as sister to *Felicia* sect. *Dracontium* Grau and sect. *Neodetris*, *Polyarhenna* and *Zyrphelis* are embedded within a clade comprising members of *Felicia* sect. *Anhebecarpaea* Grau and sect. *Lignofelicia* Grau, while *Chrysocoma*, *Nolletia* and *Poecelolepis* were recovered within *Felicia* sect. *Felicia*. The implications for generic circumscriptions within the clade are explored.

Keywords: Felicia, New classification, Phylogeny, Paraphyletic, Southern Africa

7.1.12 WEIRD COUSINS IN THE FAMILY: THE DEHISCING-FRUITED SAPOTACEAE OF TROPICAL AFRICA

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The family Sapotaceae, very diverse in flower types, has in turn remarkably homogenous fruits: fleshy berries with shiny-testa seeds and a rough scar. However, a dozen of Tropical African evergreen forest species make an exception to the dominant zoochorous dispersal syndrome. They disperse balistically with the help of a dehiscent fruit that expels its seed several tens of meters away upon maturation. The relationships of these species, all currently classified in three genera within Pennington's Gluemineae subtribe of his Mimusopeae tribe, have remained so far incompletely resolved. Because many of these species have been rarely collected, sequencing DNA of ancient specimens has proved difficult. Preliminary results were based solely on several ITS sequences, and suggested that the group was polyphyletic, but critical nodes had low support. Access to recent collections and use of Next Generation Sequencing (NGS) techniques have helped to significantly improve our understanding of the group. SNP polymorphism of 519 genes and an extended ITS phylogeny has revealed that the group is monophyletic and consists of four main lineages. Due to its presumably early divergence, we propose to consider this group as a tribe on its own, and the four lineages at generic level: *Gluema, Lecomtedoxa*, and *Neolemonniera* being maintained and *Walkeria* being resurrected. Several species need transfer, and key characters to circumscribe these four genera have to be reassessed.

Keywords: Tropical Africa, Sapotaceae, NGS, Polyphyletic

7.1.13 SPECIES DELIMITATION IN MALAGASY *DONELLA* (SAPOTACEAE) USING HUNDREDS OF GENES SEQUENCED FROM OLD HERBARIUM MATERIAL

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Like many Malagasy angiosperm lineages, the Sapotaceae genus *Donella* shows high rates of endemism. Among the currently 11 recognized species in Madagascar, ten are endemic. Only one of the Malagasy species is considered to have a wider distribution, ranging from India to Queensland and the Solomon Islands. Six further *Donella* species are found only in tropical continental Africa but not in Madagascar. Despite a recent morphological revision, several questions about the systematics of the Malagasy *Donella* species remain open which affects threat assessments and conservation planning. In this study, we aim to resolve some of these open questions with a molecular approach. First, we want to unravel the relationships of the morphologically similar species; *Donella delphinensis, D. analalavensis* and *D. fenerivensis*, occurring along a precipitation gradient. Second, we will address a putative species complex around *D. perrieri*, a very widespread and morphologically highly variable species. Around 750 herbarium specimens were reviewed in Paris and Geveva and 99 of them have been selected for genomic analysis including up to 100-year- old specimens. We combined Illumina sequencing with a target enrichment method to capture over 700 nuclear low-copy genes previously selected for Sapotaceae. Preliminary results show a clear phylogenetic delimitation between Malagasy and continental African *Donella* species. While the phylogeny of the continental species is consistent with existing species boundaries, the Malagasy species form a polytomy probably resulting from a rapid radiation event. This phenomenon was also observed in other Sapotaceae genera of Madagascar. Several species appear polyphyletic in the tree and hybridisation signals were detected. Further analyses, such as STACEY or STRUCTURE, are used to test species limits and putative hybrid patterns.

Keywords: *Donella*, Madagascar, African, Illumina sequencing, Delimitation, Polytomy

7.1.14 SPECIES DELIMITATION OF EAST AFRICAN ISLAND TREES: PHYLOGENOMICS AND PATTERNS OF GENE FLOW IN MASCARENE EBONY (*DIOSPYROS*)

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The ebony genus (*Diospyros*, Ebenaceae) is a group of dioecious, largely tropical trees and shrubs, comprising >800 species, whose diversity is centered in the islands off the east coast of Africa. The Mascarene Islands have 13 extant described species, all endemic, 12 of which form a monophyletic group, and all but two are endemic to Mauritius. It is unclear whether each species represents a distinct lineage; they frequently occur in sympatry and display overlapping morphological characters, suggesting that species boundaries may resemble those observed in some temperate tree groups which display porous species boundaries and hybridize readily, forming groups known as syngameons. The goals of this study were to: 1) test whether the species that were differentiated previously based on morphology correspond to distinct lineages with well-defined patterns of genomic differentiation; 2) determine whether interspecific hybridization has occurred and if so; 3) explore patterns of hybridization, including whether the occurrence of hybrids is correlated with phylogenetic relatedness, geographic proximity, or both. We sampled multiple individuals from multiple populations of each of the 13 extant Mascarene species and used a 2bRAD-seq approach to genotype individuals. We analyzed SNP and DNA sequence data using population genomics and phylogenomics approaches, respectively. Genetic boundaries among species largely corresponded with species delimitations based on morphology. Phylogenomic analyses provided good resolution of the evolutionary relationships among species; they also revealed that, while hybridization currently occurs only between closely related species, it has likely been ongoing throughout the history of the group, confirming that Mascarene *Diospyros* form what may be the first documented case of a tropical syngameon. This has potentially important implications for understanding tropical tree species diversity and the role of hybridization in its formation.

Keywords: *Diospyros*, Gene flow, Species boundaries, RAD-seq, Hybridization

7.1.15 MULTIPLE PLEISTOCENE REFUGIA AND RECENT DIVERSIFICATION FOR *STREPTOCARPUS IONANTHUS* (GESNERIACEAE) COMPLEX: INSIGHTS FROM MULTIPLE MOLECULAR SOURCES

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Streptocarpus ionanthus (H. Wendl.) Christenh. (Gesneriaceae) is endemic to Tanzania and Kenya, distributed in the Eastern Arc Mountains and coastal lowland forests in three geographical regions (Tanga, Morogoro and Kilifi). The species houses nine subspecies, characterized by complex morphotypic variations and poorly understood evolutionary relationships, and thus is an ideal model for investigating evolutionary dynamics over time. Using multiple approaches, we sought to test our hypothesis that the infraspecific taxa in *Str. ionanthus* are slightly variable and actively-evolving populations. Here, we examined the genetic diversity and phylogeographic structure among 23 populations of *Str. ionanthus* complex using both chloroplast and nuclear molecular markers. We then estimated the divergence time of *Str. ionanthus* lineages and modeled past and future distributions. Despite *Str. ionanthus* exhibiting bottleneck events across its range, the populations maintain relatively high genetic diversity attributed to historical population admixture or local adaptation arising from habitat heterogeneity. The phylogeographic and genetic structure revealed a high connection among the Usambara mountains populations, while molecular dating suggested most diversification of haplotypes began ~1.32–0.18 million years ago and intensified toward the present, a conclusion of active evolution. The phylogenetic relationship of the cpDNA haplotypes revealed five main lineages (with unique haplotypes) that could be suggestive of past isolated refugia during the Pleistocene climate shifts. This coincides with niche modeling results where the stability of suitable areas during the Last Glacial Maximum (LGM) are presumed to have offered protective micro-habitats that have preserved the genetic diversity of *Str. ionanthus* to date. In conclusion, our findings suggest a complex Str. *ionanthus* with slightly variable lineages or populations attributed to multiple refugia and on the verge of divergence.

Keywords: *Streptocarpus ionanthus*, Eastern Arc Mountains, Pleistocene, Isolated refugia, Diversification, Phylogeography,

7.1.16 ONE IN, ONE OUT: GENERIC CIRCUMSCRIPTION WITHIN SUBTRIBE MANILKARINAE (SAPOTACEAE)

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Manilkarinae is a monophyletic subtribe consisting of four related genera: *Manilkara* Adans., *Labramia* A.DC., *Faucherea* Lecomte and *Labourdonnaisia* Bojer. Previous phylogenetic studies raised several issues, among which them unresolved relationships and unclear generic delimitations. Using the Next generation sequencing (NGS) approach, our phylogenetic reconstruction based on 634 nuclear markers shows a well-resolved backbone with four main lineages: the *Labramia* clade, the *Manilkara* main clade, a clade consisting of intermingled species of *Labourdonnaisia* and *Faucherea*, and a clade of three Indo-Pacific Manilkara species. The Manilkara main clade is retrieved as sister to *Labramia*, and the *Labourdonnaisia-Faucherea* clade is now clearly assessed as sister to the three Indo-Pacific *Manilkara* species. Morphological analyses were then performed to discern relevant characters that were consistent with the molecular classification. A time divergence estimation was conducted to understand the evolutionary history of the subtribe. And finally, we performed an ancestral state reconstruction of flower characters, which shows that the Manilkarinae ancestors were characterized by a hexamerous corolla structure, a developed dorsal appendage and staminodes, as well as a pubescent ovary. Within the *Labourdonnaisia-Faucherea* clade, the reduction of dorsal appendages and staminodes constitute a derived state which developed during the radiation of Malagasy and Mascarenes ancestors and were retained through all extant species; while the increase in the corolla and androecium merism seems to have evolved through two independent changes within the clade. The former results therefore led us to revise the Manilkarinae's traditional circumscription, in order to accommodate the four clades retrieved and their morphological characteristics: two genera are synonymized: *Faucherea* is lumped into *Labourdonnaisia*; and an old genus name is resurrected for the three Indo-Pacific *Manilkara* species.

Keywords: Manilkarinae, Madagascar, Mascarenes, Pacific Islands, NGS, Derived state, Taxonomy,

7.1.17 PRUNING THE IRONWEEDS: DIVERSITY, EVOLUTION, AND PHYLOGENETIC PLACEMENT OF THE DISTINCTIVE GENUS DISTEPHANUS (COMPOSITAE)

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The taxonomic challenge in the “ironweed” tribe, Vernonieae (Compositae) has been illustrated vividly throughout its history by researchers who have ascribed a number of pejoratives to the group, from the “Vernonia problem” to “Evil Tribe”, and most recently “purgatory” conjuring images that can frighten even the most headstrong systematists. These images are manifested in extreme morphological diversity of continuous variation among species in the tribe. One of the most distinctive and species-rich genera in Vernonieae is the geographically widespread genus, *Distephanus*, which is readily distinguished from all other species in this tribe by yellow corollas and trinervate leaf venation. Recent phylogenetic studies have called the position of *Distephanus* in Vernonieae into question, due to the unclear relationships between the small tribe Moquinieae and Vernonieae. Here we present a densely sampled molecular phylogenetic reconstruction of the genus *Distephanus* from across its geographic range that includes 70% of the 43 species and four molecular markers, as well as a representative sampling of African Vernonieae and Moquinieae. This work represents the largest and most well-resolved phylogeny of *Distephanus* to date and our results have great significance for the circumscription of Vernonieae bringing strong support to recognize that lineage as a distinct tribe and interesting insights into the biogeography and evolution of this diverse and widespread genus.

Keywords: *Distephanus,* Ironweed, Vernonieae, Biogeography, Morphological diversity

7.2 Posters

7.2.1 APIACEAE OF TROPICAL AFRICA AND MADAGASCAR: USING FRUIT ANATOMY FOR TAXONOMIC PURPOSES

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The relatively small number of African genera in the Apiaceae were for many years overlooked in global treatments of the family. It was only in 1991 that the critical importance of the African Apiaceae to the understanding of relationships within the family was first pointed out. In Tropical Africa and Madagascar there are currently about forty-five Apiaceae genera. A number of these are poorly studied and the taxa within them difficult to identify, especially vegetatively. Fruit structural characters are still recognized as being of much systematic value in this taxonomically challenging family. The fruits (schizocarps) of Apiaceae are unique, and some of the terminology used to describe them is applicable only to members of this family. The taxonomically most important fruit characters are illustrated in representatives of nearly all the Tropical African and Madagascan genera. These fruit characters include carpophore structure; size; shape; mericarp symmetry; degree of development and nature of the ribs/ wings; surface structures [where present, the type(s) and position]; pericarp (exocarp, mesocarp and endocarp) structure (degree of development, cell types and shapes); position and nature of the vascular tissue; commissural width; secretory structures [type(s), number and position]; crystals (if present, type and position) and the shape of the seeds in transverse section.

Keywords: Africa, Apiaceae, Fruit anatomy, Madagascar

7.2.2 REVISION OF THE MALAGASY SPECIES OF THE GENUS *ALCHORNEA* SW. (EUPHORBIACEAE: ACALYPHOIDEAE)

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Alchornea is a pantropical genus of Euphorbiaceae which includes c. 60 species of shrubs and trees. The genus is divided into three sections: Sect. *Alchornea*, Sect. *Cladodes*, and Sect. *Stipellaria*. The Malagasy species all belong to Sect. *Stipellaria*, which is characterized by having ornate fruits and leaves with basal stipel-like structures. The most recent revision of the Malagasy species of *Alchornea* was published by Leandri in 1941, who recognized three species: *A. alnifolia* (Bojer ex Baill.) Pax & K. Hoffm., *A. humbertii* Leandri, and *A. perrieri* Leandri. We have identified eight new Malagasy species, five of them restricted to dry regions, two to subhumid region, and one to subarid and dry regions. The Malagasy species differ from each other mainly by differences in their leaf shape and size, the length of the

style and its degree of fusion, the number of flowers in female inflorescences, and fruit ornamentation. The relationships between *Alchornea* and the Malagasy genera *Bossera* and *Orfilea* need further studies.

Keywords: Madagascar, *Alchornea*, New species, Taxonomy

7.2.3 TAXONOMIC REVISION OF THE AFRICAN SPECIES OF *DRYPETES V*AHL (PUNTRANJIVACEAE)

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Drypetes is a pantropical genus of ca. 210 species, of which 80 are found in forests and savannas throughout sub-Saharan Africa and the Malagasy Region. It has been suggested that the genus is an indicator of good-quality, undisturbed forests. Species of *Drypetes* are shrubs or medium-sized trees. Leaves are simple, petiolate and present a slightly to markedly asymmetric base. The trunk is orthotropic and the branches are frequently plagiotropic. They are mostly dioecious plants with solitary or clustered flowers, arranged in leaf or leafless axils along the branchlets or on slightly raised woody cushions on older branches or the main trunk. Their flowers are apetalous and bear nectariferous disks. In rainforest plots across the tropics, parataxonomists, ecologists, and taxonomists often find it hard to identify trees in *Drypetes*. This could be related with the lack of a modern global taxonomic revision, their high taxonomic diversity, and the fact that they can range from narrow endemics to widely distributed species. *Drypetes* species, as well as the rest of Putranjivaceae, are notable because they are the only group outside the Brassicales known to have the glucosinolate biochemical pathway and produce sulphur-containing products called “mustard oil bomb,” which play an important role in the defense against herbivores and the attraction of pollinators. Our team is currently working on the taxonomic revision of the African species of *Drypetes*. Since 2020 we have already published three new species and five more are already described and will be published in the near future. In 2021, we published a treatment of the genus in Flore du Gabon (vol. 57) and we are now preparing the corresponding one for Flore d’Afrique Centrale. At the same time, we are also carrying out IUCN Assessments for each of them.

Keywords: Africa, Malpighiales, New species, Systematics, Taxonomy

7.2.4 SPECIES DELIMITATION IN THE CAESALPINIA GROUP IN SOUTHERN AFRICA

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Genus *Caesalpinia* L. belongs to the tribe Caesalpinieae Benth. in the Fabaceae family, subfamily Caesalpinioideae. The tribe Caesalpinieae is the second largest after Detarieae and comprises about 420–450 species in 56 genera with wide distribution mainly in the tropics and subtropics. Recent phylogenetic studies in the *Caesalpinia* revealed a new generic system for the pantropical members of this group. The newly amended generic concepts and species transfers across genera from southern Africa all necessitate the taxonomic revision of the group for the region. We studied the taxonomy of members of the putative *Caesalpinia* group sensu Gagnon in southern Africa using numerical analysis. Both the principal coordinate and cluster analyses revealed the existence of distinct clusters at levels corresponding to taxonomic categories of genera and species. Ten species are recognized, six of which are endemic to the region; four are non-indigenous species of which two species are declared invasives in South Africa. Diagnostic characters are illustrated and discussed; key to genera and species, as well as distribution maps are provided for each species.

Keywords: *Caesalpinia*, Invasive alien species, Numerical analysis, Southern Africa

8. Thematic Area 8: Ethno-botany & use of African Plants

8.1 Oral Presentations

8.1.1 ETHNOTAXONOMY AND ETHNOMEDICINE OF ENSETE VENTRICOSUM IN GEDEBANO-GUTAZER-WELENE DISTRICT, GURAGE ZONE, SOUTHERN NATIONS, NATIONALITIES AND PEOPLES' (SNNP) REGIONAL STATE, ETHIOPIA

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The aim of this study was to document local knowledge on classification and medicinal uses of *Ensete ventricosum* (ENSET) in Gedebano-Gutazer-Welene district. Seven study sites (KEBELES) were selected on the basis of well managed ENSET gardens. A total of 150 informants were engaged, among which 30 were key informants. Ethnobotanical data collection was conducted by using techniques of Participatory Rural Appraisal (PRA). Analyses of data employed simple descriptive and comparative statistical tools. Degree of dissimilarities among the ENSET varieties was done by using Principal Coordinate Analyses (PCoA). A total of 33 farmers' varieties were reported, which were clustered in two defined groups within which had six subgroups. This indicates the high intra-specific variation of the species, which might be the result of rapid adaptive radiation. Besides, the result will have taxonomic implications adding to the existing knowledge on farmers' variety as well as posing molecular systematics queries. In addition to its importance as staple food, products from different parts of ENSET are very crucial in the local health care system. Cure of broken bone, wound, compromised immunity and other maternity related problems are among the many medicinal uses of ENSET reported in this study. Different varieties of this plant are utilized as inducers of milk production during breast feeding and as inhibitors as the case may be. The wide range of variety specific medicinal use might indicate a high intra-specific diversification mainly in the biochemical characters of the species. Having tremendous uses and being an indigenous plant species, the plant should be given conservation attention. The usefulness of the plant also calls for better processing and production technologies for sustainable use and economic benefits.

Keywords: ENSET, Farmers' variety, Principal Coordinate Analyses, Ethnobotanical use

8.1.2 FARMING AND FOODWAYS UNDER THE MICROSCOPE: HISTORICAL ECOLOGY OF THE EARLY IRON AGE IN CENTRAL-SOUTHERN AFRICA AND THE INTERDISCIPLINARY CAMPAIGN FOR FOOD SECURITY

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Human interaction with the environment is a central research theme across an ever-growing number of academic disciplines. In the last decade issues of food security, climate break down, and globalisation have come to the forefront of public debate and created a renewed focus on farming and food production. Over the past century, sub-Saharan Africa has seen the widespread adoption of high yielding New World crops such as maize and cassava. Recent droughts have diminished maize yields creating a serious food security crisis affecting tens of millions of people. This coupled with predicted impacts from climate breakdown have led policy makers to turn back to African domesticates such as sorghum, finger millet, pearl millet, and indigenous fruits and plants which are generally more resilient to climate variability. This research is focused on the modes of food production in central-southern Africa in the 1st millennium CE when farmers first introduced these crops to the region from other parts of Africa. The analysis of plant macrofossils recovered from archaeological sites in Zambia and comparative ethnobotanical surveys can provide significant case studies of past foodways and farming practices using these indigenous crops and fruits. This research draws upon methods from multiple disciplines in the social and natural sciences to provide a wide view of resilience and sustainability from an ecological and cultural perspective. The author welcomes deeper integration of research objectives within the natural and social sciences to address food security issues. Finally, this paper calls for a robust stakeholder engagement strategy that encompasses many stakeholders ranging form policy makers to tenant farmers to maximise the impact of our research.

Keywords: Historical Ecology, Ethno-botany, Archaeology, Food Security, Climate Change, South-Eastern Africa

8.1.3 IMPROVING THE VALUE OF AFRICAN PLANTS

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Africa has a great diversity of plants that often have many values to local people, built up over generations. In the modern era, some plants have become increasingly and disproportionately valued over others, through development research and engagement with international markets. These species often come from abroad and

are promoted as food (e.g. *Zea mays* L. - maize) or material crops (e.g. *Eucalyptus* spp.). This has resulted in the conversion of large areas of land into farms or plantations creating conservation problems for the indigenous species whose historic values are eroded away. Some of projects implemented by Botanic Gardens Conservation International (BGCI) aim to counter this by increasing the value of indigenous plants to people. They incorporate local plants into restored landscapes and look to create new sustainable products from them to ensure benefits for people, wildlife and the wider environment. These are practical conservation projects with *ex situ* and *in situ* actions, which include some of the world's most threatened tree species. Projects draw upon the specialist skills of the BGCI network, and focus efforts in areas where capacity is limited. In Malawi, Mulanje Cedar (*Widdringtonia whytei* Rendle) experts from the Ecological Restoration Alliance of Botanic Gardens visited the Mulanje Mountain to advise the Mulanje Mountain Conservation Trust on designs for trials to improve restoration practices. A plant economist and a plant chemist also supported the research development of new sustainable product opportunities from the tree. Some projects also work to build capacity for tree conservation by producing resources and delivering training. In Uganda, Tooro Botanical Garden trained four community nurseries to raise nearly 300,000 seedlings of over 100 target indigenous species which can provide many different products to local people (medicines, food and plant materials). These projects provide models of best practices that can be replicated and used in the national restoration strategies of local forest areas, providing benefits to conservation and local people.

Keywords: Indigenous plants, BGCI, Conservation projects, Mlanje Cedar, Malawi, Tooro, Uganda

8.1.4 DISTRIBUTION, SOCIOECONOMIC IMPORTANCE, THREATS AND RISK OF EXTINCTION OF *OXYTENANTHERA ABYSSINICA* (A. RICH.) MUNRO (UMUSUNU, POACEAE) IN BURUNDI

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The present study aims at the sustainable conservation of the bamboo *Oxytenanthera abyssinica* (Umusunu) in Burundi. It contributes to the mapping of the geographic distribution area of the species, assesses its socioeconomic importance, its threats and its risk of extinction in Burundi. The study was carried out by prospecting the distribution area of the species, recording the geographical coordinates of its sites and by a survey. The results of the study reveal the presence of *O. abyssinica* in the Ruvubu National Park and in 14 communes of four provinces

(Cankuzo, Ruyigi, Rutana and Makamba) belonging to the natural regions of Kumoso and Buragane. The survey reveals that the species is of great socio-economic and ecological importance for the country. It improves the quality of the soil and is used in the construction of houses and fences, and it is used as firewood and timber. In handicrafts, the species is used mainly for the manufacture of baskets and vans, ceilings, beehives as well as doors, attics and beds. The species covers an estimated area of 1,170 km^2 (area of occupancy) and an occurrence of over 4,940 km^2. Land clearing for agriculture, bush fires and overexploitation constitute its main threats but its disappearance is not foreseeable in the near future although the stock of this resource may be depleted. This study classifies the species as Near Threatened (NT). To guarantee the population's access to this resource of inescapable importance and for its sustainable conservation, we are proposing the domestication of the species and a better governance of its stock.

Keywords: Burundi, Bamboo, *Oxytenanthera abyssinica,* Geographical distribution, Socio-economic importance, NT, Sustainable conservation

8.1.5 UTILITY OF ORNAMENTAL SUCCULENT PLANTS, *KALANCHOE* (CRASSULACEAE) IN KENYA

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The genus *Kalanchoe* (Crassulaceae) has about 150 species of succulent shrubs and perennial, annual or biennial herbs, native to tropical Africa with most of its distribution in tropical southern Africa and Madagascar. The plants are cultivated as ornamental house or garden plants. Only a small percentage of *Kalanchoe* have their utility known, which makes it impossible for them to have priority in management and conservation plans. Utility data of *Kalanchoe* species in Kenya was obtained from informants of varied sex, age and experience in different parts of the country, between August 2019 and December 2020, using interviews and semi-structured questionnaires. Simple random sampling method was used to sample plants from populations in regions where they are distributed following plant collecting guidelines. Utility data was analysed using PAST (4.08) software and Microsoft Excel using descriptive statistics. Use value (UV), frequency of citation (FC), relative frequency of citation (RFC), Informants consensus factor (ICF), citation and use percentages were computed. The results revealed that the general uses of

Kalanchoe species in Kenya include treatment of sprained leg or hand, swollen body and body parts, skin infections and wounds, respiratory system infections, gastrointestinal problems, relieving pain, cleansing the blood and against most microbial infections in human and poultry. *Kalanchoe prittwitzii, K. densiflora, K. lateritia, K. crenata, K. marmorata* and *K. lanceolata* were cited as the most used species of *Kalanchoe* in Kenya. Kalanchoe plants are threatened with overexploitation due to increased human population; habitat fragmentation and destruction due to agricultural practices, construction, deforestation, leasing of forested land to locals for cultivation, cutting and burning of bushes, new generation and modern cultures/societies being ignorant of the value of the plants and declining number of local herbalists. There is an urgent need for sustainable utilization, proper conservation and protection of threatened species of *Kalanchoe* in Kenya.

Keywords: *Kalanchoe*, Ethnobotany, Ethnotaxonomy, Utility, Threatened, Kenya

8.1.6 ADAPTATION DANS LA SOCIETE MALAGASY SUR L'UTILISATION DES PLANTES FACE A LA PERTE DE LA BIODIVERSITE

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Madagascar est un pays réputé par sa richesse en biodiversité mais aussi par son identité culturelle qui est souvent liée aux ressources naturelles. Chacune des 18 groupes ethniques présentent dans toute l'île, possède son propre art de vivre et ses traditions qui amènent à la diversité des cultures. Depuis quelques décennies, les diversités biologiques sont en détresse due à la déforestation permanente qui réduit drastiquement la surface forestière de Madagascar. De plus l'invasion des modèles technologiques et économiques d'occident a banni les valeurs de la tradition locale. En conséquence, une perte de savoirs traditionnels est de plus en plus imminente puisque certaines espèces de plantes utiles sont disparues avant même d'être inventoriées alors que d'autres ont été remplacées par les espèces disponibles en milieu naturel. Face à cette disparition de certaines espèces utiles dans la nature, une adaptation de mode de vie dans la société rurale Malagasy a été observée. Pour illustrer cette observation, des enquêtes ethnobotaniques basées sur les entretiens semi-structurés et les focus group ont été menées au sein de quelques communautés rurales de l'île. Les questionnaires sont basés sur la variation des espèces de plantes utilisées pour une catégorie d'utilisation donnée. Les entretiens ont montrés que les plantes utilisées dans la catégorie culturelle, construction et

vannerie changent suivant leur disponibilité dans la nature. Dans des cas extrêmes de dégradations des milieux naturels, les plantes sont mêmes remplacées par des ressources industrielles. Cette étude a permis de soulever l'importance de l'ethnobotanique dans la compréhension du changement et de l'évolution de la société rurale Malagasy. Enfin les résultats obtenus de nos enquêtes ethnobotaniques peuvent être utilisés dans la prise de décision sur le choix des espèces cibles lors des activités de restauration forestière.

Mots clés: Plantes utiles, Variation, Ethnobotanique

Madagascar is a renowned island not only for its biodiversity richness but also for its cultural identity which is often linked to natural resources. Each of the 18 ethnic groups that exist throughout the island has their own way of life and traditions leading to cultural diversity. For some decades now, biological diversity has been suffering from permanent deforestation which drastically reduces the forest area of Madagascar. In the recent past, the introduction of western models of technology and economy has banished the value of local tradition. So loss of traditional knowledge is imminent as some useful plant species have disappeared before they have even been inventoried. Moreover, others have been replaced by plant species available in the near areas. Faced with this disappearance of some useful plant species in the wild, adaptation of Malagasy rural societies was studied ethnobotanical surveys based on semi-structured interviews and focus group discussion which were conducted in some rural communities. Questionnaires were based on the variation in plant species libnked to a given category of use. Surveys showed that the plants used in the cultural and construction category have changed according to their availability in the wild. This study raised the importance of ethnobotany in understanding the change and evolution of Malagasy rural society.

Keywords: Useful plants, Variation, Ethnobotany

8.1.7 INDIGENOUS PLANTS PROMOTING FOOD SECURITY AND ESTORATION

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Uganda is endowed with agro-climatic conditions suitable for the cultivation of a wide range of African indigenous plants. However, few of these plants are domesticated, the majority being wild or volunteer plants and are at the verge of extinction due to unprecedented forces of degradation. Uganda has relatively good soils, a mild climate and a well-distributed rainfall in most areas. It is divided into 11 major agro climatic zone districts, each with its own traditional agricultural system, a particular mode of livelihood and distinct communities which have evolved their own food

preferences and habits. In normal times, there is abundant food supply to meet human requirements that leave other indigenous plant species abandoned. A few of them have been collected and domesticated. Current efforts to collect and conserve traditional vegetables have been hampered by lack of funds. Few collections have been done since 1993. The most important traditional vegetables in Uganda are *Cleome gynandra, Solanum nigrum* and *Corchorus olitorius*. They contain protein, calcium, phosphorus, potassium, iron and vitamins A, B and C in sufficient quantities and are either curative or preventive of a number of diseases. Trees species edible for food and medicine include *Citropsis articulata, Irvingia gabonensis, Syzygium* spps (*S. guineense* and *S. cordatum*). Threatened and other high value tree species such as *Afzelia africana, Khaya grandifoliola* and *Prunus africana* play priceless roles in biodiversity conservation and restoration within a diversity of ecosystems. Restoration and conservation of indigenous plants reduces environmental degradation, helping to conserve water and prevent erosion, and providing people with improved access to diverse and healthy diets. Planting native species increases this impact because they are adapted to the local environment thereby increasing smallholders' resilience. They also support local wildlife by providing habitats and sources of food. Efforts are being made to increase awareness of the importance of native plants, and to encourage the general population to cultivate and sustainably consume these species. Tooro Botanical Garden (TBG) is implementing initiatives to integrate the ideas for native trees and shrubs to promote food security and restoration of degraded forest landscapes in Uganda through establishment and management of diverse native plant nurseries, restoration demonstration plots and agroforestry extension in different agro ecological zones.

Keywords: TBG, Uganda, Indegenous plants, Food security, Restoration

8.2 Posters

8.2.1 THE BIOACTIVITY- GUIDED FRACTIONATION OF THE METHANOL ROOT EXTRACT OF *AZANZA GARCKEANA* (MALVACEAE) ON ISOLATED WISTAR RAT UTERINE SMOOTH MUSCLES

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Pregnant women in Chongwe, Zambia, traditionally use the root of *Azanza garckeana* (F.Hffm.) Exell & Hillc (Malvaceae) to induce or accelerate labour. A

previous study on the plant showed that the crude root extracts possess uterotonic potential on isolated Wistar rat uterine smooth muscles. In addition, the methanol crude root extract was the most potent. The study aimed to isolate the compound with the heighest uterotonic activity using the bioactivity-guided fractionation method from the root of *A. garckeana*. The study suggests the presence of a significant amount of a uterotonic phytochemical constituent which may be related to the family of glycosides in the methanol root crude extract of *A. garckeana*. The study has provided scientific evidence suggesting that the root of *A. garckeana*, a plant used traditionally for inducing or accelerating labor, possesses uterotonic activity. Further pharmacological and toxicological studies need to be undertaken on the plant.

Keywords: *Azanza garckeana*, Plant root extract, Uterotonic activity, Bioactivity-guided isolation

8.2.2 ETHNOBOTANIQUE DES PRODUITS FORESTIERS NON LIGNEUX (PFNL): CAS DE *PARKIA BIGLOBOSA* (JACQ). DANS LES COMMUNES DE DASSA-ZOUME, GLAZOUE ET SAVE (COLLINES) BENIN

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Les Produits Forestiers Non Ligneux (PFNL) contribuent de façon significative à la subsistance en milieu rural et à l'économie nationale de plusieurs pays de l'Afrique au Sud du Sahara en général et du Bénin en particulier. Cette étude réalisée dans les communes de Dassa-Zoumé, Glazoué et Savè est intitulée ethnobotanique des Produits Forestiers Non Ligneux: cas de *Parkia biglobosa*. L'objectif de cette étude est d'évaluer l'importance ethnobotanique de *Parkia biglobosa* un PFNL très apprécié des populations des trois Communes. La méthode de collecte de données est faite d'enquêtes ethnobotaniques réalisées en langues française ou locale auprès de 231 personnes (agriculteurs, guérisseurs traditionnels, commerçantes, transformatrices des graines etc.) au moyen des fiches d'enquêtes. Les résultats ont montré que les organes de *Parkia biglobosa* sont exploités pour quatre (4) utilisations (alimentaires, médicinales, magico-spirituelles et commerciales). L'utilisation alimentaire est la plus citée, grâce aux graines qui sont transformées en moutarde. Près de 51 maux sont guéris par les organes du *Parkia biglobosa*. La

décoction est le mode de préparation le plus employé. La voie orale est le mode d'administration par excellence des recettes.

Mots clés: PFNL, *Parkia biglobosa*, Importance Ethnobotanique, Bénin

8.2.3 ETHNOMEDICINAL USE OF PLANTS AMONG LOCAL HEALERS IN BIÉ PROVINCE, ANGOLA

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This study documents traditional botanical knowledge on medicinal plants in Bié Province, central Angola. We documented knowledge of 10 traditional healers of Chokwe and Ovimbundu ethnicities in 2 distinct areas of Bié Province through participatory observation, semi-structured interviews and transect walks. In order to rate traditional botanical knowledge and determine culturally most important taxa, we calculated a number of quantitative ethnobotanical indices. We documented a total of 87 plant species distributed over 57 genera and 36 botanical families, with Fabaceae being the best-represented family with 18 species. Roots were the most commonly used plant part (79%). Supposedly, continuous and increasing collection of plants together with often unsustainable land clearing practices may threaten local plant populations in future. The culturally most important medicinal species identified in this study, i.e. *Securidaca longepedunculata, Garcinia huillensis, Annona stenophylla, Afzelia quanzensis* and *Strychnos cocculoides*, were previously reported for the same use in neighbouring countries and elsewhere in Africa. Among the medicinal plants investigated, there are several locally valuable species with yet unexplored pharmacological potential, e.g. *Alvesia rosmarinifolia, Diplorhynchus condylocarpon, Eriosema affine, Paropsia brazzaeana, Rhus squalida, Sclerocroton cornutus* and *Xylopia tomentosa*. The high number of medicinal plants used for a variety of ailments reflects the rich ethnomedicinal knowledge prevailing in the area.

Overall low similarities between species used and type of uses when compared based on gender, ethnicity or locality confirm the richness of traditional botanical knowledge in this part of Angola and the need for further documentation and preservation of this knowledge.

Keywords: Medicinal plants, Chokwe, Ovimbundu, Traditional knowledge, land clearing, Quantitative ethnobotany,

8.2.4 STUDIES ON ETHNOBOTANICAL PROFILE OF POKOT PLANTS IN KOPOCH HILLS

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Ethnobotanical study of Kopoch hills, West Pokot County in Kenya revealed that out of 187 plants species of ethnobatical importance belonging to 75 families, 64 families belong to Dicots, 5 families to Monocots, 3 families to Pteridophytes, 2 families to Gymnosperms and one to Fungi. Important families present in the area were Poaceae (16 spp.), Rosaceae (14 spp.), Asteraceae (10 spp.), Solanaceae (9 spp.), Lamiaceae (8 spp.), Cucurbitaceae (7 spp.), Brassicaceae (3 spp.), Fabaceae (6 spp.) Vitaceae (3 ssp.) and Euphorbiaceae (5 spp). Based on their use, plants were classified as medicinal (98 spp.), agro forestry based (54 spp.), vegetable and pot herb (39 spp.), ornamental (32 spp.), honey bee attracting (31 spp.), agricultural tool making (32 spp.), edible fruit yielding (30 spp.), plants used in naming (28 spp.), thatching and sheltering (27 spp.), fencing and hedge plants (19 spp.), poisonous (16 spp.) and timber yielding (14 spp.). The vegetation of the area is under high anthropogenic pressure as a result of indiscriminate deforestation and overgrazing. People utilize wood mainly as fuel and remove trees to clear more land for agriculture. Indiscriminate collection of medicinal plants has threatened the existence of some important medicinal plant speices like *Osyris lanceolatai*, *Harissonia abyssinica*, *Artemsia afra* and *Carissa spinarum*.

Keywords: Kenya, Kopoch Hills, Ethnobotanical study, Important medicinal plants, Indiscriminate collection

9. Thematic Area 9: Biogeography of African Plants

9.1 Oral Presentations

9.1.1 POPULATION DIFFERENTIATION AND GENE FLOW IN *STAUDTIA KAMERUNENSIS* WARB. (MYRISTICACEAE)

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The impact of Pleistocene climatic oscillations on the biodiversity of lowland tropical rain forests of Africa remains poorly understood. A growing body of phylogenetic studies shows that species responses in Lower Guinea are mainly idiosyncratic. However, knowledge on patterns in the Congo Basin is severely lacking. We can gain insight to the history of the Central African rain forest by investigating intraspecific diversification of representative tree species. Here, we aim to elucidate it by studying *Staudtia kamerunensis* Warb. (Myristicaceae), a ubiquitous evergreen tree species abundant in the lowland rainforests of Central Africa. We used nuclear microsatellite markers and plastid sequences to date the species and its plastid lineages, explore genetic diversity, and determine whether the species has a spatial genetic structure. Using Bayesian Inference and Maximum Likelihood, we reconstructed five plastid lineages that all diverged during the Early or Middle Pleistocene and are parapatric. In addition, a Bayesian clustering analysis based on 14 nuclear microsatellite markers revealed the existence of five parapatric genetic clusters, their spatial structure being mostly consistent with the plastid lineages. Several of the genetic clusters showed significant levels of differentiation. We found stark differences between populations in Lower Guinea and Congolia. Nucleotide diversity of plastid sequences was generally higher in lineages from Lower Guinea, and highest close to the Cameroon Volcanic Line. Overall, our results indicate past fragmentation, and that patterns between genetic clusters and plastid lineages are largely congruent. Moreover, they show that the impact of climatic oscillations during the Quaternary might have been vastly different between the two floristic sub-centres of Central Africa.

Keywords: Myristicaceae, *Staudtia*, Nuclear and plastid markers, Populations, Central Africa

9.1.2 DIVERGENCE, INTROGRESSSION AND POLYPLOIDIZATION UNDERLYING PHOTOSYNTHETIC DIVERSITY IN THE GRASS *ALLOTEROPSIS SEMIALATA*

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More than 60 lineages of flowering plants independently evolved the C4 photosynthetic pathway, a complex assemblage of anatomical and biochemical novelties that together boost productivity in tropical conditions. The intraspecific origins of C4 photosynthesis remain however poorly understood, and the grass *Alloteropsis semialata* represents an outstanding study system as it includes C4 and non-C4 individuals. We couple ecological, morphological and genomic comparisons of individuals spread across Zambia and other African countries to infer the eco-evolutionary processes leading to functional innovations in grasses. Our investigations indicate that the photosynthetic types diverged within the Zambezian Miombo woodlands, but were not linked to immediate ecological shifts. Instead, two lineages with distinct photosynthetic types have co-existed in the region over the past two million years. Each is characterized by a strong genetic structure, reflecting the topological complexity of the region, which likely facilitated photosynthetic divergence in isolated patches. We find evidence of episodic genetic exchanges among the photosynthetic types, but these are limited by strong selection against hybrids. Recurrent polyploidization however facilitates the co-occurrence of C4 and non-C4 individuals in some populations by limiting hybrid production. In addition, polyploids are able to expand their ecological niche by colonizing more disturbed habitats. Finally, sporadic hybridization with the sister species *A. angusta* allows the migration across Miombo/wetland habitats. Overall, the genetic isolation allows local adaptation, creating a reservoir of diversity that was recurrently used by lineages that spread outside of the Zambezian region. In addition, frequent hybridization and polyploidization events diversified the niche of the species complex, leading to its successful colonization of multiple habitats inside the Zambezian region.

Keywords: Grasses, C4 photosynthesis, Phylogeography, Morphological, Genomic, Zambezian Miombo

9.1.3 PATTERNS OF FLORISTIC ENDEMISM IN WESTERN CENTRAL AFRICA: A RE-APPRAISAL OF THE FOREST REFUGIA SCENARIOS

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Pleistocene glaciations affected the extent of the African tropical forest, likely causing its fragmentation into disjunct blocks called forest refugia. In western Central Africa (WCA), these refugia were hypothesised to either be located in mountainous landscapes because of the persistence of low stratiform clouds (Maley hypothesis), or to follow the current precipitation regimes (Anhuf hypothesis). Assuming the forest cover dynamics explain current patterns of biodiversity, the co-distribution of plant taxa was used as a proxy to delineate past forest refugia. However, so far, the ranges of only a few plant species were used. Here, we test whether the distribution patterns of all forest vascular plant taxa endemic to WCA and the patterns of local tree diversity in Gabon are spatially congruent with these scenarios. Based on the distribution of 1,003 forest taxa endemic to WCA, we delineated (i) areas of endemism (AoEs) through bipartite network analysis and a novel method to refine bioregion boundaries, and (ii) centres of endemism taking into account sampling heterogeneity. We used four hundred and seventeen (417) 200-m transects to reveal the forest tree alpha diversity patterns in Gabon. We tested whether the proportion of

endemic taxa and tree diversity decays with distance to putative forest refugia. Ten AoEs are recognized, six of them are located in putative forest refugia. The rates of endemism and tree diversity tend to decrease with distance to forest refugia. However, areas of high diversity also occur outside forest refugia under both scenarios. We conclude that forest refugia may have persisted on mountain ranges and along the Atlantic coast but also further inland, particularly in eastern Gabon. We demonstrate that the paleovegetation model proposed by Anhuf is not well supported by the current diversity patterns. We advocate to consider other mechanisms that could explain forest persistence during past climate change in WCA such as the presence of shallow water tables.

Keywords: African tropical forests, Areas of endemism, Centres of endemism, Forest refugia, Tree diversity, Glaciations

9.1.4 UNRAVELING THE ROLE OF RHIZOBIA IN DRIVING LEGUME BIOGEOGRAPHY IN SOUTHERN AFRICA

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Our knowledge on rhizobia, bacteria involved in symbiotic nitrogen fixation, has increased tremendously throughout the last decades. Within southern Africa, most of these associations involve the plant family Leguminosae, with the mimosoid and papilionoid lineages as the predominant hosts. The rhizobia fall mostly within the alpha- (e.g. *Mesorhizobium, Bradyrhizobium*) and beta- (e.g. *Burkholderia*) Proteobacteria groups. Biogeographic patterns of these rhizobia appear to be structured among major biomes, with the winter rainfall fynbos biome nearly exclusively hosting *Mesorhizobium* and *Burkholderia* while the summer rainfall areas have *Bradyrhizobium*, based on field collected nodules. We tested this observation in common garden experiments using soils from the three biomes (fynbos, grasslands, savanna). Overwhelmingly, legumes form nodules in their native soils but also cases of nodule formation with soils from other biomes (e.g. fynbos legumes in grasslands) were observed. Fynbos soils were dominated by *Mesorhizobium* and *Burkholderia* whereas grasslands and savannah had *Bradyrhizobium*. Furthermore, the symbiotic relationships are phylogenetically structured, whereby the legume tribes Podalyrieae and Psoraleeae are nodulated by *Burkholderia* and *Mesorhizobium*, respectively. While particular edaphic habitats support discrete legume assemblages, the rhizobia have complex evolutionary patterns including reticulation. We hypothesize that edaphic specialization of rhizobia, together with phylogenetically clustered symbiotic association, is a major driver of legume biogeography and may explain the lack of

shared legumes between the Fynbos and other biomes. These findings may explain broad biogeographic patterns among legumes and have implications in efforts to grow particular taxa outside their native ranges.

Keywords: Fabaceae, Rhizobia, Symbiosis, Fynbos, Grasslands, Savanna

9.1.5 POLLINATION REVERSAL IN THE GENUS *OCHNA* AVOIDS DEAD-END IN THE SAVANNA BIOME

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The genus *Ochna* L. is the second largest genus in the family Ochnaceae with ca. 86 species. It mainly has a palaeotropical distribution occurring across continental Africa, Madagascar but has four species in Asia. The species are of ecological and conservation importance as they constitute a significant element of woody vegetation in tropical dry forests which are severely under threat. The fruits provide an important food source for birds and other fauna, while some species have poricidal anthers known to be a specialized adaptation to the buzz-pollination syndrome. An integrated study with morphological and molecular data is used to provide insights into species relationships and produce a well-supported updated infrageneric classification. The robust phylogenetic framework is used to explore the evolutionary history of *Ochna*. Divergence estimation, character reconstruction and biogeographical analysis reveal a morphological shift in anther dehiscence associated with biome shifts. We show that the shift in anther dehiscence is a reversal back to a generalist state and allows speciation within the savanna biome escaping an evolutionary dead-end. Further, we found evidence for correlated evolution of multiple traits as adaptations in species occurring in the savanna biome which are likely to be associated with more seasonal rainfall patterns.

Keywords: *Ochna* Biomes, Pollination shift, Dehiscence, Generalist, Classification

9.2 Posters

9.2.1 TAXONOMIC ASSESSMENT OF PLANT SPECIES DISTRIBUTION ACROSS NASARAWA STATE, NIGERIA

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This research was carried out to assess the plant species diversity in Nasarawa State, Nigeria with a view to obtaining an accurate database and inventory of the naturally occurring plant species in the state for reference and research purposes. This preliminary report covers a total of nine (9) local government areas (LGAs) in the state. The work involved intensive survey and several visits to the sample sites for plant identification and enumeration exercise. The diversity status of each plant and the distribution across the state were also determined using standard methods. A total number of 275 plant species belonging to 61 plant families were identified out of which the families Asteraceae, Poaceae, Combretaceae, Euphorbiaceae, Moraceae and Papilionaceae were the most highly distributed across the entire study area. There was a great extent of diversity in the distribution of plants across all the LGAs sampled. However, the highest diversity in terms of different species was recorded in Wamba LGA. The most predominant food crop across the state was found to be *Sorghum* spp. This preliminary work has provided a baseline data and reference point for future taxonomical and biosystematics stratagem in Nasarawa State, Nigeria.

Keywords: Nasarawa State, LGAs, Nigeria, Plant diversity, Conservation, *Sorghum*

10. Thematic Area 10: Flora/Lichenology/ Mycorrhiza/Mycology

10.1 Oral Presentations

10.1.1 DO THE ATRIBUTES OF DEAD WOOD AFFECT THE DIVERSITY OF TROPICAL WOOD-INHABITING FUNGI?

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Wood-inhabiting fungi are one of the most important groups of organisms as they contribute substantially to carbon and nutrient cycles by decomposing dead wood. Current knowledge of their occurrence, distribution, and drivers of their diversity derives almost exclusively from temperate and boreal forest ecosystems. We sampled wood-inhabiting fungi across Benin, a tropical country in West Africa with a strong north–south seasonality gradient consisting of three macroclimatic zones. We aimed at determining whether the resource (size or amount of dead wood, number of host tree species, and stage of wood decomposition) is more for their diversity. Variation partitioning revealed a partial effect of resource on fungal species richness and a strong effect of macroclimate on the community composition. A more detailed linear mixed-effects model revealed a significantly positive effect of host richness, amount of dead wood, and macroclimate on fungal species richness and a significantly positive effect of macroclimate and stage of wood decomposition on the community composition. These findings are consistent with patterns found in temperate and boreal ecosystems, which indicates the existence of a general pattern of the diversity of wood-inhabiting fungi. Based on these results, we recommend, that any size of dead-wood objects of diverse tree species should be conserved to protect tropical wood-inhabiting fungal diversity.

Keywords: Africa, Benin, Tropics, Macroclimate, Dead wood, Fungi

10.1.2 TWO NEW AFRICAN SIBLINGS OF *PULVEROBOLETUS RAVENELII* (BOLETALES)

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Several books on West African mycology mention *Pulveroboletus* aff. *ravenelii*, a species of bright yellow color and quite common in the Guineo-Sudanese and Zambezian forests. The study aims to clarify the taxonomy of species associated with *Pulveroboletus ravenelii* based on morphological and genetic characters. We used a combination of anatomorphologic characters, as well as phylogenetic analyzes of DNA sequences from 41 African *Pulveroboletus* specimens and compared to North American and Asian species to describe the two new species. Amplification and sequencing of the atp6, tef1 and rpb2 genes were performed using primer pairs ATP6-1M40F and ATP6-2M, EF1-983F and EF1-2218R, and bRPB2-6F and bRPB2-7.1R. Phylogenetic analysis has shown that African specimens form a sister subclade of the Asian and American taxa. Although clamp connections have already been reported from *Pulveroboletus*, all specimens of the African subclade show very small clamp connections. Two new African species, *Pulveroboletus africanus* sp. nov. and *P. sokponianus* sp. nov., are described and illustrated. The African collections represent two separate species, *P. africanus* sp. nov. and *P. sokponianus* sp. nov., both macroscopically similar to *P. ravenelii*. Macroscopically both African taxa can be distinguished based on the color of the scales on the cap and the stipe, being brown in *P. africanus* and greenish grey or yellow in *P. sokponianus*. Finally, phylogenetic analysis shows that all specimens of *Pulveroboletus* studied, including the new species, form a strongly supported monophyletic clade (BS = 100%). It is interesting to note that specimens of the new African species form a distinct subclade (BS = 100%), separated from the sibling subclade formed by American and Asian species.

Keywords: Boletales, *Pulveroboletus*, New species, Morphology, Phylogeny, Taxonomy

10.1.3 IDENTIFICATION AND DOMESTICATION OF WILD EDIBLE MUSHROOMS FROM BURUNDI INDIGENOUS FORESTS

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In Burundi, the mushroom industry has significant potential to support food and nutritional security and income generation. However, limited work has been done to comprehensively identify and commercialize high yielding mushroom strains from indigenous forests. The previous studies carried out on mushroom cultivation have focused on exotic strains which are expensive with difficult access, making cultivated mushrooms expensive, irrespective of preferences of local people. This is the first study undertaken on domestication of wild edible mushrooms (WEM) from Burundi

indigenous forests. Nine WEM samples were collected during the rainy season from Kibira National Park, Forest Natural Reserve of Rumonge, Protected Landscape of Makamba and Ruvubu National Park and characterized using phenotypic and molecular markers. Germplasm isolation through tissue culture techniques, spawn production and cultivation studies were undertaken in the microbiology laboratory at the University of Burundi. Mushroom samples were identified as *Pleurotus citrinopileatus, Lentinus squarrosulus, Hypholoma fasciculare, Laetiporus sulfureus, Macrolepiota dolichaula, Trametes polyzona, Amanita zambiana, Lactarius delicious* and *Amanita verna*. Spawn production was successful in six of the nine collected species. Fruiting body production was successful for *Pleurotus citrinopileatus, Lentinus squarrosulus, Hypholoma fasciculare* and *Trametes polyzona*. Mushroom yield of successfully domesticated species varied from species to species and ranged from 15.3 to 30.6%. The biological efficiency also varied from one species to another and ranged from 41.2% to 81%. *Macrolepiota dolichaula* and *Laetiporus sulfureus* remained at the secondary mycelium stage while *Amanita zambiana, Lactarius delicious* and *Amanita verna* did not develop even the mother spawn. This study shows that Burundi indigenous forests harbour wild edible mushrooms with potential for domestication. More research should be conducted to domesticate them for food and nutritional security.

Keywords: Burundi indigenous forests, Wild edible mushrooms, Germplasm isolation, Spawn production, Fruiting bodies

10.2 Posters

10.2.1 FOUR NEW NODULOSE-SPORED SPECIES OF *INOCYBE* (AGARICALES) FROM WEST AFRICA

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We describe four new nodulose-spored species of *Inocybe* from tropical regions of Africa: *I. beninensis, I. flavipes, I. fuscobrunnea* and *I. pallidiangulata*. The new species are recognized based on morphological data and phylogenetic analyses of ITS, 28S and RPB2 sequences. Phylogenetic analyses indicate that *I. flavipes* and *I. beninensis* are part of a grade leading to the *I. calida* group. *Inocybe fuscobrunnea* appears sister to the *I. asterospora* group. *Inocybe pallidiangulata* is nested within a clade of mainly tropical species from South Asia, Africa, and South America, close to the subclade of *I. lilacinosquamosa* and *I. ayangannae* from Guyana. Complete descriptions and illustrations, including photographs and line drawings, and a key to nodulose-spored taxa of tropical African species of *Inocybe* are provided.

Keywords: *Inocybe*, New species, Tropical Africa, Morphology, ITS, 28S, RPB2, Phylogeny, Systematics

10.2.2 TRACE METALS AND SAFE CONSUMPTION OF EDIBLE FUNGI FROM UPPER- KATANGA (DR CONGO)

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In Upper Katanga region (DR Congo) wild edible fungi are an important source of food and income. This study is the first to present the trace metal content of six edible mushrooms collected from the mining region around Lubumbashi. Samples were taken in places where local people collect fruit bodies for consumption. Inductively coupled plasma spectrometry (ICP-OES,) was used to determine concentrations of ten trace metals (Al, Cr, Cu, Co, Pb, Cd, Fe, Ni, Mn and Zn) in *Amanita loosii, A. pudica, Cantharellus congolensis, C. densifolius, C. platyphyllus* and *C. ruber*. Concentrations of Cr, Ni and Pb are under the EU norm in all six species, but values for Al, Co, Cu, Fe, Mn, and in some cases also for Zn or Cd are above. Significant differences between species were observed for Al, Cd, Co, Cr, Cu, Mn and Zn. Concentrations of Cd are highest in *Amanita* while Al and Co reach highest concentrations in *Cantharellus* species. Recommended tolerable, monthly, weekly or daily intake of metals and average metal concentrations in edible fungi were used to calculate the safe weekly consumption (SWC, in kg fresh weight/week) for a 60 kg person. Results indicate that Cd limits the consumption of *A. loosii* and *A. pudica* to 0.6-1.2 kg FW/week, Fe limits *C. congolensis* and *C. platyphyllus* to 2.2-2.5kg FW/week and Al limits *C. ruber* and *C. densifolius* to 3.5-3.8 kg FW/week. Recommendations are listed to further reduce the intake of metals through the consumption of wild edible fungi.

Keywords: Mushrooms, Heavy metals, Toxicity, Food safety, Miombo Woodland, Upper-Katanga

10.2.3 ASSESSMENT OF ANTIFUNGAL AND ANTIBACTERIAL ACTIVITIES OF HEXANE AND CHLOROFORM CRUDE EXTRACTS OF THREE SPECIES OF *RIGIDOPORUS* (BASIDIOMYCOTA, POLYPORACEAE)

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This work aimed at assessing the antifungal and antibacterial activities of hexane and chloroform crude extracts of three species of *Rigidoporus* including R. *microporus, R. ulmarius* and *R. vinctus*. The assessment was based on the Minimal Inhibitory Concentration (MIC) determined by the microdilution method. Eleven species of bacteria of which five gram-positive and six gram-negative as well as three human pathogenic fungi were investigated. Results recorded show an overall weak activity of crude extracts of the three species of *Rigidoporus* on various bacterial species with a MIC of 6.25 mg/ml. More precisely, *Mycobacterium smegmatis, Proteus vulgaris, Klebsiella oxytoca* and *Proteus mirabilis* were sensitive to crude extracts of *R. vinctus*; *Staphylococcus aureus* and *Escherichia coli* to *R. ulmarius* while *R. microporus* was only active against *Proteus vulgaris*. The five remaining species of bacteria including *Bacillus subtilis*, *Enterococcus faecalis*, *Staphlococcus epidermis*, *Escherichia cloacae* and *Klebsiella aerogenes* were resistant to crude extracts of all three species of *Rigidoporus*. In contrast, the inhibition activity was generally higher against fungi with an average activity (MIC = 0.39 mg/ml) of *R. microporus* and *R. vinctus* on *Aspergillus fumageceous*, a very weak activity (MIC = 6.25 mg/ml) of *R. ulmarius* on the same fungus and also an average activity of *R. microporus* and *R. ulmarius* on *A. ochraceus*. The above mentioned figures show that pathogenic fungi are in general much more sensitive to crude extracts of *Rigidoporus* than bacteria.

Keywords: *Rigidoporus*, Polyporaceae, Crude extracts, Hexane, Chloroform, Antifungal, Antibacterial

10.2.4 ASSESSMENT OF BASIDIOCARP VERSUS SCLEROTIUM ANTIFUNGAL AND ANTIBACTERIAL ACTIVITIES OF HEXANE AND CHLOROFORM CRUDE EXTRACTS OF *PLEUROTUS TUBER-REGIUM* (BASIDIOMYCOTA, PLEUROTACEAE)

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Antifungal and antibacterial activities of crude extracts of the basidiocarp compared to that of the sclerotium of *Pleurotus tuber-regium* were investigated on 11 species of bacterial and three of fungal human pathogens. The Minimum Inhibitory Concentration (MIC) of basidiocarp extract was recorded to be 12.5 mg/mL on *Bacillus subtilis, Enterococcus faecalis, Staphylococcus epidermidis, Escherichia cloacae, Proteus mirabilis, P. vulgaris, Klebsiella oxytoca, K. aerogenes* and 6.25 mg/mL on *Staphylococcus aureus, Escherichia coli, Mycobacterium smegmatis* as on all 3 species of fungal pathogens including *Candida albicans, Aspergillus fumigatus* and *Aspergillus ochraceus*. In comparison, the MIC of sclerotium extract was 12,5 mg/mL on *Bacillus subtilis* and *Klebsiella aerogenes*; 6,25 mg/mL on *Enterococcus faecalis*, *Staphylococcus aureus*, S. epidermidis, *Escherichia cloacae, E. coli, Mycobacterium smegmatis*, *Proteus mirabilis, P. vulgaris and Klebsiella oxytoca;* and 3,13 mg/mL on the 3 fungal pathogens. Based on the above mentioned figures, it appears that bacteria are much more resistant to crude extracts than pathogenic fungi. In fact, antimicrobial activities of crude extracts of *Pleurotus tuber-regium*, no matter the part of the carpophore considered, are in general higher on human pathogenic fungi than bacteria. These figures also demonstrate that crude extracts of sclerotium show a higher antimicrobial activity than that of basidiocarp. Carpophores of *Pleurotus tuber-regium* could therefore constitute a new source of natural products potentially more efficient than synthetic products against bacterial and fungal infections.

Keywords: *Pleurotus tuber-regium*, Basidiocarp, Sclerotia, Antimicrobial activity, Bacteria, Pathogenic fungi

10.2.5 FIRST NEW SPECIES OF *FULVIFOMES* (HYMENOCHAETALES, BASIDIOMYCOTA) FROM TROPICAL AFRICA

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Fulvifomes is a hymenochaetoid polypore genus currently undergoing re-estimation of its taxonomic and morphological diversity. Numerous new species were described during the last decade but almost exclusively from Neotropics and Eastern Asia. Here, based on morphological and molecular evidence, we describe a new species of *Fulvifomes* growing on *Pseudocedrela kotschyi* in Benin. The new species named *Fulvifomes yoroui* is characterized by perennial, pileate, ungulate basidiomata and subglobose to globose basidiospores 5.5–6.5 × 4.7–5.6 µm. Analyses of internal transcribed spacer (ITS) and nuclear large subunit rDNA (nLSU) datasets with maximum likelihood and Bayesian phylogenetic inference methods show that *F. yoroui* represents a distinct lineage within *Fulvifomes* clade. It is the first time that a new species of *Fulvifomes* is described based on material from tropical Africa. This finding stimulates further investigations of *Fulvifomes* in tropical Africa.

Keywords: Benin, *Fulvifomes*, Hymenochaetales, New species, Morphological, Molecular,

11. Thematic Area 11: Biodiversity informatics/Databases/DNA Bar-coding

11.1 Oral Presentations

11.1.1 ONLINE FLORA PROJECT OF THE ZAMBEZI CATCHMENT COUNTRIES: PROGRESS AND NEW DEVELOPMENTS SINCE THE PREVIOUS AETFAT CONGRESS OF MAY 2017

MARK HYDE*[1],BART WURSTEN[1],PETRA BALLINGS, MEG COATES PALGRAVE, MIKE BINGHAM, ANNETTE WILLEMEN AND NICK WIGHTMAN
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Work began on an e-flora of Zimbabwe in 2002. The project was expanded to include Mozambique in 2007, Zambia in 2012 and two further countries (Botswana and Malawi) and a region of Namibia (the Caprivi Strip) in 2014. There are now six

separate websites, which use a common database, each covering the separate countries of the Zambezi catchment. The objective of the presentation will be to set out progress on adding content to the site, the impact of including the new countries and region, developments in presentation of information on the website. In addition, an analysis of web traffic to the websites will be presented. The talk will describe the challenges faced by this e-flora project and discuss ways in which they may be overcome.

Keywords: Zambezi catchment countries, e-Flora, websites

11.1.2 THE WORLD FLORA ONLINE SUPPORTING THE GLOBAL STRATEGY FOR PLANT CONSERVATION

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The World Flora Online (WFO) project was initiated in 2012 in response to Target 1 of the CBD Global Strategy for Plant Conservation – "To create an online flora of all known plants by 2020". A WFO Consortium has been formed of 48 international partners to face this huge challenge. The World Flora Online Public Portal (www.worldfloraonline.org) was launched at the International Botanical Congress in Shenzhen, China in July 2017. The portal links taxon information to a managed name list or taxonomic backbone, the WFO Plant List. The latter was initially populated with The Plant List, Version 1.1, now inactive, and is being improved with newer taxonomic data sources like APG4, PPG, Solanaceae Source, World Checklist of Vascular Plants, and others, with additional updates from newly created Taxonomic Expert Networks (TENs). To date, 38 TENs have been formed with many more in the process of creation. Each item of the WFO Plant List is linked to the International Plant Names Index (IPNI) equivalent using the UUIDs in both datasets, and will serve as a source for the Catalogue of Life plant data, feeding into GBIF, IUCN, etc. The World Flora Online aims to include descriptive information for every plant species gathered from digital floras and monographs, and other sources, with clear reference to the origin. Such information can be text descriptions, images, geographic distributions, identification keys, phylogenetic trees, as well as atomized trait data like threat status, life form or habitat. It can come in any language. Digital descriptive datasets have been incorporated from Floras of West, Central and East Tropical Africa, Flora Zambesiaca, South Africa, China, North America,

Mesoamerica, Brazil, and many others. Over 500,000 descriptions are now online for over 120,000 species and the database is growing. Data tools have been created to accomplish the data cleaning, standardization and transformation required to integrate descriptive data from these sources.

Keywords: World Flora Online, Taxonomic backbone, Global Strategy for Plant Conservation, Data cleaning

11.1.3 MOBILIZING PLANT DATA FOR THE TANA RIVER BASIN BIODIVERSITY INFORMATION SYSTEM PROJECT

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Tana River Basin is a biodiversity hotspot of global significance with diverse habitat types and has over twelve protected areas, as well as six IUCN red-listed species including endemic plants such as *Euphorbia tanaensis* and *Cynometra lukei*. The basin covers about 100,000 km^2 which represents about 22% of Kenya's land area. The basin is economically important as it is the main source of drinking water (80%) for Nairobi City and hydroelectricity (40%) for Kenya and supports the livelihoods of about 11 million people. The ecosystem is under increasing environmental pressure mainly due to high population growth, expanding agriculture, deforestation, dam building, invasive species, and excessive water abstraction. A multidisciplinary project funded by the JRS Biodiversity Foundation mobilized biodiversity data that was integrated with environmental geodata layers using GIS tools on a GeoNode instance. Over 11,000 plant species occurrence records representing 2,282 species, accounting for 33% of Kenya's total plant species, were mobilized from herbarium specimens supplemented by fieldwork. Thirty species are classified as either endangered, rare, or endemic. *Prosopis juliflora* is the most important invasive species that is spreading rapidly. The plant records are part of the over 30,000 specimen and human observation records mobilized during the project. The other taxa are invertebrates, birds, mammals, reptiles, amphibians and fish. The data is openly accessible on GBIF portal. We present the results of the plant mobilization efforts and discuss their significance. We also discuss efforts to communicate the project results to the wider population in a simplified way so that it can be easily understood and used by end-users such as policymakers and conservationists.

Keywords: Tana River, Kenya, Biodiversity, Data mobilization, GeoNode, Plants

11.1.4 AFRICAN PLANTS – A PHOTO GUIDE AND IDENTIFICATION TOOL

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The African Plants website (www.africanplants.senckenberg.de) currently containing ca. 80,000 photographs of > 10,000 plant species is an internet photo-archive as well as an identification tool. It aims to illustrate as many African plant species as possible with instructive live images. The photographs can be accessed via free-text searches, browsing a hierarchical list of taxa and/or searching for specific morphological characters. For the latter the user can choose from a total of 18 easy-to-observe characters of flower, fruit, habit and leaf. The search produces a result page with species names and up to three thumbnail images. By clicking on either of them you get to the species page with all available images and some more data plus links to further internet resources, where you can gain more information on the taxon. The digital photographic documentations were contributed by ca. 170 photographers. Georeferenced images are also shown in the Global Biodiversity Information Facility (GBIF) as observation records. We strive to illustrate as many species from the African continent as possible and ask for your help: Check the existing images of plant groups you are familiar with! Contribute your instructive digital plant photographs with locality data.

Keywords: African Plants website, Photo archive, Georeferenced images, Taxonomic hierarchy, Characters, GBIF

11.1.5 POPULATION GENETICS DATA SUGGEST THAT THE SPECIES RICHNESS OF TROPICAL AFRICAN TREES IS LARGELY UNDERESTIMATED DUE TO CRYPTIC SPECIES AND TAXONOMIC OVER-LUMPING

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Tropical forests host a remarkable diversity but the estimation of their species richness depends on how species are delimited. Hence, species richness can be underestimated by the occurrence of cryptic species or overestimated by taxonomical oversplitting. DNA sequencing is increasingly used to guide species delimitation. However, reciprocal monophyly in phylogenetic trees requires that the number of generations since speciation largely exceeds the effective population sizes of the sister species, making it a very conservative criterion in long-living organisms, such as trees. Alternatively, population genetics methods allow assessing reproductive isolation to test the biological species concept (BSC). Using the BSC, we evaluate species delimitation in 25 African tree taxa. For each taxon, samples covering the whole distribution range were genotyped using nuclear microsatellite markers to identify genetic clusters using STRUCTURE software. We considered that distinct species can be recognized when well differentiated genetic clusters occur in sympatry. Chloroplast genes were also sequenced. (i) We found no case of oversplitting: even when phenotypically very similar, species distinguished by taxonomists formed distinct genetic clusters, although hybridization was occasionally detected. (ii) By contrast, in nearly half of the taxonomical species investigated, we found several sympatric genetic clusters, indicating that cryptic species are not uncommon. (iii) A re-examination of morphological traits associated to each genetic cluster often revealed diagnostic characters but some exceptions suggest that truly cryptic species might also occur. (iv) Finally, markers from the chloroplast genome were not always reliable to distinguish closely related species, limiting the usefulness of plastid-based DNA barcodes. According to our results the number of African tropical tree species might in reality be underestimated by a twofold factor due to (near) cryptic species. This could have important consequences for conservation that still need to be assessed.

Keywords: Species richness, Delimitation, Cryptic species, Molecular taxonomy, Tropical African trees

12. Thematic Area 12: Orchid systematics and conservation

12.1 Oral Presentations

12.1.1 NEW INSIGHTS INTO AFRICAN ORCHID CONSERVATION: SYSTEMATICS AND REPRODUCTIVE BIOLOGY OF THE GENUS *CYRTORCHIS* SCHLTR. (ANGRAECINAE, VANDEAE)

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Cyrtorchis, a Tropical African angraecoid orchid genus, is renowned for its showy white stellate long-spurred flowers, which challenge species delimitation and resulting taxonomy. Also, the genus appears sphingophilous, and constitutes a suitable model for studies on reproductive biology of angraecoids, a first step to their conservation. In order to clarify the genus taxonomy, we tested the monophyly of its two sections and of 19 morphospecies through morphological and molecular analyses. We used a representative sampling of 174 specimens belonging to 23 morphospecies for the morphometric analyses, of which 73 specimens were included in the molecular phylogenetic analyses. Based on this taxonomic background, we chose five well resolved species to study, in the living collection in Yaoundé and in two natural populations, their breeding and pollination systems. A protocol involving phenological monitoring of 414 living specimens was implemented

during which 346 hand-controlled pollinations were conducted to assess factors affecting fruit set and seed viability. Pollination efficiency and reproductive success was assessed with fruit set and viable seed production for self- and cross-pollination. Molecular results support the monophyly of the genus with that of one of the sections, *Cyrtorchis* sect. *Cyrtorchis*. Eight morphologically defined taxa and three new taxa are well supported both by molecular and morphological analyses. Flowering period of 13 species occurring in Cameroon occurs from February to November, with a flowering peak during the rainy season. Hand-pollination resulted in 192 fruits with high success rate (53% for self vs 60% for cross) and viable seeds set for cross-pollination. Resulting seeds were used to supply the African orchid seed bank housed at the University of Yaoundé I which currently includes 181 specimens representing 50% of the *Cyrtorchis* species. For the first time in Central Africa, hawkmoths were filmed and confirmed as potential pollinators of three *Cyrtorchis* species.

Keywords: *Cyrtorchis*, Angraecoids, Pollination ecology, Sphingophily, Seed bank, Phylogeny, Taxonomy

12.1.2 THE LAST STAND OF *ANGRAECUM*: UNRAVELING THE EVOLUTIONARY AND BIOGEOGRAPHIC HISTORY OF DARWIN'S MUSES

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Over the past decade, the evolutionary history of Angraecinae (Epidendroideae, Vandae) has been completely re-assessed using a new molecular framework. Two long-accepted subtribes, Aerangidinae and Angraecinae, were both found to be polyphyletic, but together they form a well-supported clade, recircumscribed as a broader Angraecinae. Another major result of these studies was the polyphyly of *Angraecum* Bory, the subtribe's most speciose and widely known genus, which was split into many lineages within the two main clades of Angraecinae, the first principally African, and the second (which includes the type species of *Angraecum*)

principally confined to the West Indian Ocean (i.e., Madagascar and the Mascarenes). While the African species of *Angraecum* have been revised and renamed, the West Indian Ocean group has not been studied as intensively, due to a combination of factors, including a lack of sufficient sampling or of morphological characters supporting phylogenetic hypotheses as well as the paucity of available voucher material. To date, the monophyly of *Angraecum* sensu stricto remains uncertain and relationships between its sections and species are misunderstood.With the help of a new multi-locus dataset collected using target gene capture, augmented by a comprehensive sampling now available through the shade house network of the Missouri Botanical Garden in Madagascar and from extensive field work conducted on the Mascarene islands and East Africa, we aim to revise the genus *Angraecum*, improve its classification and test the following phylogenetic and biogeographic hypotheses: 1) *Angraecum* sensu stricto is a monophyletic group; 2) Morphologically well-defined sections, such as Arachnangraecum, Humblotiangraecum or Perrierangraecum, are monophyletic, while other sections, based on spurious characters such as flower color and plant size, such as *Boryangraecum* and *Nana*, are polyphyletic; 3) *Angraecum* originated in Madagascar and later colonized the Mascarene Islands, Sri Lanka and East Africa through multiple, independent colonization events.

Keywords: Orchidaceae, *Angraecum*, Systematics, Biogeography

12.1.2 COLONIZATION HISTORY AND RAPID DIVERSIFICATION OF THE GENUS *JUMELLEA* (ANGRAECINAE, ORCHIDACEAE) IN THE WESTERN INDIAN OCEAN: PLANT-POLLINATOR INTERACTIONS IMPLICATIONS

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Jumellea is predominantly distributed in the western Indian Ocean region and has its centre of species diversity in Madagascar. The genus provides a good model system for understanding island colonization history and the diversification process in isolated and tropical ecosystems. We performed dating and biogeographic analysis of 53 taxa of *Jumellea* based on combined chloroplast (*matK, trnL-F, rps16*, and *ycf*1) and nuclear (nrITS) DNA data. The genus appeared in the Late Miocene (ca. 6.81 - 6.57 Mya) but began its diversification around 3 Mya. This rapid radiation coincides with the Late Pliocene and Quaternary paleoclimatic changes that have generated the high speciation and diversification in the Malagasy animals and plants.

Jumellea dispersed from Madagascar to the oceanic islands by multiple and independent colonization events. No significant radiation of the genus occurs in the oceanic islands, except the for Mascarene *J. fragrans* and *J. rossii* species. This first dispersal event, the diversifications of *Jumellea* species and their interactions with pollinators occurred during the same period (ca. 3 My). This coincidence reflects the implication of plant pollination interaction in the genus' radiation. The absence of a specific pollinator in the newly colonized habitat does not affect *Jumellea* installation. Patterns of the *Jumellea*-pollinator interactions are highlighted in the context of spur length evolution.

Keywords: *Jumellea*, Orchidaceae, Plant-pollinator interaction, Western Indian Ocean region, Madagascar, Biogeography,

12.1.3 A FIRST PHYLOGENETIC ASSESSMENT OF THE AFRICAN MEMBERS OF THE ANNOYING ORCHID GENUS *NERVILIA*

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The genus *Nervilia* includes 79 species and is distributed in tropical and subtropical parts of Africa, Asia and Australia. Africa harbours 17 species, 15 of which are endemic to the continent. Several species are widespread and occur from West Africa to Madagascar. Pettersson (1990) revised African *Nervilia* based on morphology. He recognised two sections i.e. sect. *Nervilia* and sect. *Linervia*. His conclusions have so far not been tested using molecular data. In this presentation, we will explain why this genus is so annoying to study. We will present a preliminary molecular phylogeny based on material collected in Zambia, Kenya and South Africa. Whereas our study provides some insight into the phylogenetic relationships, it raises several issues that will need to be addressed when engaging in a more extensive investigation.

Keywords: *Nervilia*, Nervilieae, Orchidaceae, Phylogeny, Systematics

12.1.4 CONSERVING ZAMBIA'S EDIBLE ORCHIDS

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Chikanda, also known locally in Zambia as African polony, is a local foodstuff made from edible orchidoid orchid tubers from the genera *Disa, Habenaria* and *Satyrium,* amongst others. The increasing popularity of *chikanda* has put great strain on the wild populations of these orchids in Zambia and the surrounding countries to meet demand. The Darwin Initiative in the UK has funded a three-year project entitled 'Edible Wild Orchid Trade: Sustaining Livelihoods and Biodiversity in Zambia', which started in June 2016 and ended in May 2019. The project aimed to identify those orchid species most at risk from overharvesting for *ex situ* conservation efforts, conduct trials for the commercial production of chikanda orchids in participating rural communities as well as empowering communities to manage the wild populations. A bottleneck in identification of *chikanda* orchids included the lack of a well-sampled DNA reference dataset, particularly for the genus *Habenaria*, indicating the need for continued fieldwork. This presentation will recap the activities undertaken during the project runtime and look at the way forwad in *chikanda* conservation work.

Keywords: Orchids, *Chikanda*, *Disa, Habenaria*, *Satyrium*, conservation, wild populations, *Ex situ*

12.1.5 THE LIVING ORCHID COLLECTION OF THE MISSOURI BOTANICAL GARDEN IN AFRICA & MADAGASCAR

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In order to obtain high quality orchid specimens, a shadehouse cultivation system was established in 1997 in São Tomé and Príncipe, which has been expanded by Missouri Botanical Garden (MBG) into a network across continental Africa and Madagascar, in collaboration with African and international partners. Nine shadehouses are currently active in five African countries; Cameroon, Gabon, Guinea, Madagascar & São Tomé and Príncipe. More than 32,000 living, field-collected orchids have been grown within the network, representing 71 genera and more than 500 species (~20% of the orchid flora of tropical continental Africa and Madagascar), including *Eichlerangraecum infundibulare*, the orchid with the largest flowers in Africa, the only known specimen of *Bulbophyllum pauwelsianum*, the rare *Aeranthes schlechteri*, and the pink *Angraecum* (*A. rubellum*). More than 23,764 herbarium specimens have been prepared from this collection of living plants, mostly associated with silica gel-preserved material and photographs. This material has been used for taxonomic revisions, describing 41 new taxa, assessing the IUCN Red List conservation status of 225 species in West and Central Africa, and Madagascar,

while also contributing to the publication of 44 papers in taxonomy, biogeography, molecular phylogeny, floristics and science communication. The shadehouses also contribute to ex situ conservation of orchids via newly established seed banks in Cameroon and Madagascar, with over 4,700 mature fruits from 169 African orchid species produced to date. The MBG's network of shadehouses also provides valuable educational opportunities to students from Africa and throughout the world and has proven to be a useful tool for training local botanists and improving local capacity, while helping to raise awareness about conservation.

Keywords: Orchidaceae, MBG, Shadehouse, *Ex situ* conservation, Seed bank

12.1.6 LONG-TERM *EX SITU* CONSERVATION OF MALAGASY ORCHIDS

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More than 1,200 orchid species occur in Madagascar, which represent ~ 7% of Malagasy flora, a large part of it threatened due to rapid habitat destruction. Since 2012, field surveys conducted by the Missouri Botanical Garden have brought > 250 orchid species into cultivation using a network of four shade houses, generating flowering material from individuals collected sterile the field, along with photos and DNA samples. Building on these living collections and with support from the National Geographic Society, we propose to develop an integrated approach to long-term conservation of Malagasy orchids involving field surveys, ex situ collection (living plants and material for seed banks) and IUCN Red List assessments. Our project

objectives perfectly align with 6 of the 13 Conservation Plans endorsed by IUCN/SSC Orchid Specialist Group. Specifically, we plan to bank seeds of 15% of Madagascar's orchid diversity (ca. 150 species), focusing on those that are the most threatened. A full set of seeds will be stored in Madagascar, and a duplicate set will be conserved at the Royal Botanic Gardens Kew, UK. Data collected during the project will serve to assess or reassess the risk of extinction of ~200 orchid species and to update the IUCN Red List. The results will be disseminated through popular media and scientific papers, the Catalogue of the Plants of Madagascar, and portals related to orchids (e.g., http://www.osssu.org/).

Keywords: Orchidaceae, *Ex situ* conservation, IUCN Red List, Madagascar, Seed bank, Shadehouse

12.1.7 RESULTS OF THE BOTANICAL INVENTORY AT AMBATOVY MINE SITE AND SURROUNDING AREAS, ALAOTRA-MANGORO REGION, MADAGASCAR, WITH AN EMPHASIS ON ORCHIDS

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The Missouri Botanical Garden has conducted extensive botanical inventory work at the Ambatovy mine site and surrounding areas over a period of more than 20 years in order to document and improve the understanding of the area's flora and to support conservation efforts. In addition, three shade houses have been established on site in order to help identify the orchids present at Ambatovy as well as to ensure the *ex situ* conservation of the most threatened orchid species. To date 19,409 collections have been made of plants and bryophytes, representing 1,705 published plant species belonging to 188 families and 715 genera. Numerous collections have been identified as probable species new to science. To date, the conservation status of 170 species present at Ambatovy has been evaluated according to the IUCN Red List criteria, including 88 orchid species; four have been assessed as Critically Endangered (CR), 68 as Endangered (EN), and 69 as Vulnerable (VU). Management plans will be prepared for each threatened species to guide the mining company's efforts to conserve them. A local seed bank has been established on site to further support conservation efforts for threatened orchid species.

Keywords: Orchidaceae, Madagascar, Ambatovy mine, Shadehouse, IUCN, Seed bank

12.1.8 ADVANCES IN ANGRAECOID SYSTEMATICS IN TROPICAL AFRICA (ORCHIDACEAE, ANGRAECINAE): NEW TAXA, NEW CHARACTERS AND NEW EXPLANATORY MECHANISMS FOR THEIR DIVERSIFICATION

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With approximately 360 species, angraecoids are the most speciose group of epiphytic orchids in Tropical Africa. Molecular phylogenetics combined with a detailed observation of morphological characters have recently uncovered new taxa and phylogenetic relationships within the Afroneotropical clade of Angraecinae, notably resolving the taxonomy of the *Angraecum* alliance in continental Africa. However, the study of evolutionary ecology and macroevolutionary dynamics of Angraecinae in Africa is still in its infancy. Here, based on a set of one nuclear and five plastid DNA markers we have resolved the phylogenetic whereabouts of some still enigmatic angraecoid taxa, including *Angraecum evrardianum, Distylodon, Rangaeris longicaudata* and *R. trilobata, Rhaesteria, Taeniorrhiza* and *Triceratorhynchus*. An overview of new species recently identified in the genera *Diaphananthe, Kylicanthe, Microcoelia* and *Rhipidoglossum* is also presented. Two mechanisms are put forward to partially explain the current diversity of Angraecinae in Tropical Africa: chromosome rearrangements and pollinator shifts. Dysploidy was found to play a key role in cladogenesis within the Afroneotropical clade, contrary to polyploidy which occurs in isolated species lineages, namely within *Ancistrorhynchus*. Hawkmoth-pollination evolved independently in different angraecoid lineages, and is coupled with an overall increase in spur length. So far, no impact on net diversification has been found associated with the shifts to long spurs in angraecoids. The structure and diversity of the gynostemium in angraecoids is analysed, and links between hawkmoth-pollination and gynostemium morphology are discussed.

Keywords: Angraecoid, Tropical Africa, Epiphytic, Dysploidy, Evolution, Pollination, Taxonomy

13. Thematic Area 13: African botanical topics of interest outside the specified themes

13.1 Oral Presentations

13.1.1 *CEROPEGIA* – EVOLUTION AND DEVELOPMENT OF SPECIALIZED FLY POLLINATED PITFALL FLOWERS

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Ceropegia (Apocynaceae-Asclepiadoideae) species are famous for their pitfall flowers which are functionally specialized to trap small flies as pollinators. The deceptive flowers attract their target fly pollinators via chemical mimicry of resources desired by the flies, such as food sources or oviposition sites. *Ceropegia* are an outstanding example of functional floral complexity with high synorganization of floral parts interacting to achieve pollination. The evolutionary origin and development of these complex flowers is unclear, and the genetic background of floral organ formation is unknown. We investigated for the first time MADS-box gene expression during pitfall flower development in a *Ceropegia* species, i.e. *C. sandersonii*. This species is exceptional for its gigantic parachute-shaped flowers which emit honey-bee alarm pheromones to lure scavenger flies to their flowers and trap them for non-rewarded pollination service. We obtained transcriptomes from floral buds and mature flowers of *C. sandersonii* and isolated MADS-box gene homologs. For six homologs (FUL, TM6, GLO, AG, AGL6, SEP) we determined differential expression in various floral organs using RT-PCR. Based on our results, we offer a hypothesis on MADS-box genes involved in *Ceropegia* floral organ identity. Our findings for the corona allow for reconstruction of the evolutionary origin of this highly specialized floral organ. In addition, we investigated floral ontogeny using scanning electron microscopy and defined ten distinct phases during flower development. To further shed light on the evolutionary origin of floral parts, we visualized vascularization using 3D X-ray computer tomography, and reconstructed the first 3D-model of the vascular system of mature pitfall flowers. With our study we laid the foundation to understand extreme floral synorganization in Asclepiadoideae. Fusion of specific floral parts (e.g. the reproductive organs), and highly specialized organs to deceive and trap fly pollinators, were compared with trap flowers that co-evolved in the unrelated plant families Aristolochiaceae and Orchidaceae.

Keywords: *Ceropegia*, Floral mimicry, Fly-pollination, MADS-box genes, Transcriptome, 3D X-ray

13.1.2 TREE SPECIES DIVERSITY OF THE ZAMBEZI TEAK FORESTS ALONG A RAINFALL GRADIENT IN ZAMBIA

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Understanding tree species diversity is important considering the various services trees provide to human society. Trees provide food, fibre, medicine, and other services for subsistence and income generation. Additionally, trees are carbon sinks. They help to prevent and mitigate climate change. We implemented our study at the three sites namely along a rainfall gradient; relativiely dry Sesheke, intermediate Namwala and wet Kabompo to determine the species diversity of the Zambezi teak forests along the gradient in Zambia. Shannon index, Simpson index, species richness, and species abundance were used as indicators of species diversity. We counted the number of tree species to determine species richness. Fisher's log-series was used to determine species abundance. Using the Sørensen index of dissimilarity, the study further determined the degree of dissimilarity of tree species in the surveyed sites. Following the rainfall gradient, we applied the “Space-for-time” substitution approach to establish the trend in species diversity. We recorded 38, 44 and 25 tree species at Kabompo, Namwala and Sesheke respectively, and the species abundance was highest at Namwala (8) compared to Kabompo (7) and Sesheke (5). The high Sørensen index (0.6862) indicates that tree species at these three sites were highly dissimilar. Species richness (Slope = 0.0264, r2 = 0.69, $p < 0.001$), Shannon index (Slope = 0.0051, r2 = 0.85, $p < 0.001$), and Simpson index (Slope = 0.0019, r2 = 0.85, $p < 0.001$) increased with increasing rainfall. Our study demonstrates that species diversity is high in high rainfall receiving areas and low in arid regions.

Keywords: Zambezi Teak forests, Zambia, Africa, Species diversity, Rainfall gradient

13.1.3 AN INVESTIGATION OF THE HIGH-VALUE HARDWOOD TIMBER INDUSTRY IN NORTH-WESTERN ZAMBIA: INSIGHTS FROM MUFUMBWE, MANYINGA AND KABOMPO DISTRICTS

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Forests-derived products and other vegetation resources in the Northwestern Province of Zambia offer diverse products that provide livelihoods for the community. In addition, forests play a very crucial role in ecological service provision. However, there is a rampant increase in deforestation resulting from increased timber logging activities triggered by a high demand for high-value hardwood indigenous timber on the international market. Unfortunately, there is a paucity of information and scarcity of documentation on hardwood timber extraction, timber trade and consumption, timber product value-chains as well as the contribution of timber to household incomes in the province. As a result, information regarding the extraction of timber forest products, their trade and consumption, timber-value chains and how the timber industry contributes to household incomes in the province is required to ensure these resources are sustainably utilized and managed. Therefore, the present study will be carried out to develop a better understanding of the high-value-hardwood timber extraction by identifying and analyzing the value-chains of timber products, the domestic trade and consumption of timber, as well as analyzing the contribution of the timber industry to total household incomes in 3 selected districts (Mufumbwe, Manyinga and Kabompo) in the Northwestern Province of Zambia. Purposive sampling will be used to choose respondents in each of the 3 selected districts. The study will collect primary data using a mixed-methods approach i.e. Key Informant Interviews (KII), Timber Harvest Assessment Survey (HAS), Household Survey (HHS), Focus Group Discussions (FGDs), and direct observations. Secondary data will also be collected to look at the history of the timber industry in terms of trade and consumption, and contribution to rural households. The quantitative data from HHS and HAS will be analyzed using Statistical Package for the Social Sciences (SPSS - 23). The main statistical analyses that will be conducted are frequency analysis and descriptive statistics. Qualitative data from the KII and FGDs will be analyzed using NVivo 11 software to conduct thematic data analysis which will involve the identification of themes or similar patterns in the transcripts. The proposed study will provide useful information critical for guiding decision-making involving the timber value chains as well as the domestic trade and consumption of timber at the community level. The study will also help to provide insight into the contribution of the timber industry to total household income at the community level. The results of this study will further provide vital information relevant to ongoing policy and research development regarding sustainable hardwood timber exploitation and management in timber rich areas of Zambia for the benefit of local communities and the nation as outlined in the Forests Act No. 4 of 2015.

Keywords: Zambia, Northwestern**,** Hardwoods, Value chains, Analysis, Sustainable exploitation,

13.1.3 PROMOTING NEGLECTED AND UNDERUTILIZED PLANT SPECIES IN CZECH ODA PROJECTS IN WESTERN PROVINCE, ZAMBIA

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Today, the world is over-dependent on a few plant species, and a similar situation has been observed in Zambia as well. In contrast to the narrow spectrum of staple food crops, indigenous useful plants are known only regionally and serve a given community or ethnic group that grows and deliberately maintains them within the local food system. These minor crops, partially domesticated species and wild edible plants often have a variety of uses as food, medicinal, cultural, technical, and also economic resources. The importance of plant biodiversity in Zambia is reflected in the Zambian National Biodiversity Conservation Strategy as well as in the conservation of agrobiodiversity described by the National Strategy for Conservation of Plant Genetic Resources for Food and Agriculture. This paper aims to present particular activities and preliminary results of several Czech ODA projects carried out in Western Province, Zambia reflecting the importance of indigenous useful plants so far largely neglected by science and underutilized by society. In cooperation with the University of Barotseland (UBL), Caritas Czech Republic (CCR), ProjectEDUCATE (ProED) and Plant Essentials (PE), the Czech University of Life Sciences Prague (ČZU) coordinates the project activities, which are closely linked to recent development initiatives in Western Province financed by the Czech ODA (Agribusiness4LIFE and Strengthening teaching, research and networking capacities at University of Barotseland in Mongu towards sustainable agricultural development in Western Province, Zambia). Support of neglected and underutilized species could lead to specific actions at the local and national level with maximum impact in securing this unique resource base and improving use, production and marketing options particularly for communities living in marginal and/or poor areas.

Keywords: Czech ODA, Indigenous plants, underutilized, Western Province, Zambia

13.1.4 EXPANDING OUR KNOWLEDGE OF THE COFFEE FAMILY IN CONTINENTAL AFRICA: A SYNOPSIS OF THE GENUS *PYROSTRIA* (RUBIACEAE)

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The genus *Pyrostria* is not well known in mainland Africa; with several taxa not fully described. In this current revision, we present all species from continental Africa, including full descriptions of three new species from Tanzania-Mozambique border forests (Rondo Plateau & Namacubi) and one subspecies from Zambia (Mutinondo Wilderness Area). A species key is given for the 16 *Pyrostria* species occurring in mainland Africa. The Distribution, Phytogeographical linkages, Habitat and Discussion ('Notes') are also provided along with preliminary conservation status assessments for each species based on the IUCN criteria.

Keywords: *Pyrostria*, New species, Species key, Mainland Africa

13.1.5 UTILISATION D'IMAGERIE DRONE POUR LA CARACTERISATION ET LE SUIVI DES FORETS: LE PROJET I-DROP

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La caractérisation et la surveillance des états de la végétation par imagerie spatiale s'est généralisée au cours des décennies passées mais ces outils sont encore

onéreux et pas toujours adaptés à un suivi fin et à fréquence rapide. Une alternative réside dans l'utilisation de nouveaux outils en développement tels que l'imagerie haute résolution acquise avec des drones. Le projet I-DROP a ainsi pour objectifs de tester la faisabilité de nouvelles solutions numériques sur la base de photos aériennes RGB et multi-spectrales prises par des drones légers longue distance dans le cadre de l'exploitation forestière certifiée en Afrique centrale.
Sur la base de ces images aériennes, il s'agit, tout d'abord, de tester la faisabilité d'identification d'un petit nombre d'espèces clefs, permettant de mieux planifier l'exploitation à venir et de favoriser une gestion durable de la ressource. Ces images permettront aussi d'identifier plus précisément les zones sensibles telles que les zones marécageuses ou inondables et de protéger les écosystèmes fragiles. D'autres développement sont aussi à l'étude, en relation avec la caractérisation de l'état de développement et de santé des arbres ou le suivi des états phénologiques. Les premiers résultats de ce projet pilote seront présentés et discutés.

Mots clefs : Imagerie drone, Reconnaissance d'espèces, Phénologie, Forêts tropicales, Afrique centrale

13.1.6 PICT: A LOW COST, MODULAR, OPEN-SOURCE CAMERA TRAP SYSTEM TO STUDY PLANT–INSECT INTERACTIONS

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Commercial camera traps commonly used in wildlife studies have several technical limitations that restrict their scope of application. They are not easily customizable, unit prices sharply increase with image quality and importantly, they are not designed to record the activity of ectotherms such as insects. Those developed for the study of plant–insect interactions are yet to be widely adopted as they rely on expensive and heavy equipment. We developed PICT (plant–insect interactions camera trap), an inexpensive (<100 USD) do-it-yourself camera trap system based on a Raspberry Pi Zero computer designed to continuously film animal activity. The system is particularly well suited for the study of pollination, insect behaviour and predator–prey interactions. The focus distance can be manually adjusted to under 5 cm. In low light conditions, a near-infrared light automatically illuminates the subject. Frame rate, resolution and video compression levels can be set by the user. The

system is remotely controlled using either a smartphone, tablet or laptop via the onboard Wi-Fi. PICT can record up to 72-hr day and night videos at >720p resolution with a 110-Wh power bank (30,000 mAh). Its ultra-portable (<1 kg) waterproof design and modular architecture is practical in diverse field settings. We provide an illustrated technical guide detailing the steps involved in building and operating a PICT and for video post-processing. We successfully field-tested PICT in a Central African rainforest in two contrasting research settings: an insect pollinator survey in the canopy of the African ebony *Diospyros crassiflora* and the observation of rare pollination events of an epiphytic orchid *Cyrtorchis letouzeyi*. PICT overcomes many of the limitations commonly associated with camera trap systems designed to monitor ectotherms. Increased portability and image quality at lower costs allow for large-scale deployment and the acquisition of novel insights into the reproductive biology of plants and their interactions with difficult to observe animals.

Keywords: PICT, DIY camera trap, Plant-insect interaction, Pollination

13.1.7 ANTHROPOGENIC THREATS TO TREE SPECIES VOLUME, DIVERSITY, AND SPECIES RICHNESS, WITHIN THE VEGETATION TYPES OF MRAMBA FOREST RESERVE IN MWANGA DISTRICT, NORTHERN ZONE OF TANZANIA

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Plant species assessment is a panacea for sustainable management of forest reserves. The study was conducted to assess the anthropogenic threats to tree species volume, diversity, and plant species richness, at Mramba Forest Reserve (MRAFR) in Mwanga District, northern zone of Tanzania. This survey involved field work whereby a ground investigation technique was applied to achieve the objectives. Remote Sensing (RS) and Geographical Information System (GIS) were used to mark the plots together with the available shape files to map the study area. Vegetation types were described based on the physiognomic characteristics. Plots of 20 m x 20 m were established, and trees with a diameter ≥ 5cm were measured at 1.3 m from ground, and stems were counted for each tree. Nested plots of 2 m x 5 m were set to determine the individuals of woody non-trees, and 1 m x 1m sub-plots for the non-woody plant species. The observed anthropogenic threats were recorded. The vegetation types were described as; dry montane forest, shrub land with emergent trees, bush land, woodland, and wooded grassland. The calculated volume per diameter class was revealed to be the highest in trees with fewest stems but with the largest trunk diameter sizes. The diameter class of >50 cm got the

largest volume (m^3) of all (36,420 m^3), followed by the diameter class of ≤40 to ≥31 cm (11,617.14 m^3), ≤30 to ≥20 cm (8,448.42m^3), ≤20 to ≥11 cm (3,727.31 m^3), ≤10 to ≥5 (659.617 m^3). The woodland got the largest volume (44,450.85 m^3) with 58 tree species, followed by dry montane forest (11,976.89 m^3) with 29 tree species, bush land (6,430.64 m^3) with 56 species, and wooded grassland got the least volume (153.99 m^3) with 4 species. This implied that that difference in volume was contributed by the differences in the diameter sizes, heights, and the number of stems. A total of 247 plant species were recorded, and of those 103 were trees with H' of 4.0318 implying high tree species diversity for MRAFR. The non-tree woody plants had S value of 70, and for the non-woody plants S was 74. The identified anthropogenic threats to the tree species volume, and plant S of MRAFR were; firewood collection, livestock grazing, charcoal making, poles and rods cutting.

Keywords: Anthropogenic threats, Tree species, Mramba Forest Reserve, Zambia

13.1.8 PLANT HERITAGE NATIONAL COLLECTIONS: CONSERVATION THROUGH CULTIVATION

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Plant Heritage is a UK based Garden charity formed the National Collections in 1978 to conserve the diversity of the British Garden Flora. Presently there are more than 600 National (plant) Collections within the British Isles including 78 plants of African origin. Methods that have been used to achieve conservation through cultivation within the National Collection of *Scadoxus* include micropropagation of meristem material for increasing taxa and safe guarding against pest and diseases along with collection of documented seed from wild populations. Other approaches include observing plants in their habitats to gain knowledge of better cultivation requirements. Conservation of a diverse range of taxa within the National Collection has provided a source of material for researchers to test various hypotheses such as relationships between the diversity and range of plant species.

Keywords: Plant Heritage, UK, Conservation, Micropropagtion, *Scadoxus*, Plants of African Origin

13.1.9 THE ROLE OF LOCAL PEOPLE AND DEDICATED "AMATEURS" IN THE EXPLORATION OF AFRICAN PLANT DIVERSITY

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The role of local people's knowledge should not be underestimated when it comes to the publication of modern taxonomic treatments and floras. These "heroes" in the field have not been acknowledged as deserved. I shall give examples connected to Flora of Ethiopia, Flora of Tropical East Africa and Flora Zambesiaca. This paper gives particular attention to the late Mike Bingham, from Zambia, with whom the author together with students from Africa and Norway, spent five field sessions during the period 2002-2006. These trips led to quite a few new descriptions of plants within petaloid monocots of which one was named after him: *Crinum binghamii* Nordal & Kwembeya and one which was co-published with him: *Gloriosa sessiliflora* Nordal & Bingham.

Keywords: Local knowledge, Mike Bingham, Zambia, New species, *Crinum binghamii*, *Gloriosa sessiliflora*

13.2 Posters

13.12.1 THE GENERA OF VASCULAR PLANTS OF TROPICAL EAST AFRICA

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The *Flora of Tropical East Africa* (FTEA) was published in individual family fascicles between 1952 and 2012 and accounted for 249 families, 2,120 genera, and 12,104 species of vascular plants occurring in Kenya, Tanzania, and Uganda. Well-informed taxonomic treatments, meticulous editing, and a high degree of internal consistency have made it a model tropical flora of great utility over many years. However, the lack of a key to families makes access to FTEA difficult for users not already fully familiar with the regional flora, and changing family and genus circumscriptions and the publication of subsequent species descriptions have complicated the use of many of the earlier family treatments. To address these difficulties, *The Genera of Vascular Plants of Tropical East Africa* is designed as a practical tool to provide access to FTEA and other literature on the regional flora at the generic level. The

primary keys to genera are being constructed independently of family circumscription. For each genus, the place of publication and type species are indicated, generic synonymy relevant to the FTEA area is given, a morphological description is provided, the global number of species and geographic distribution are given, and the number of species in the FTEA area is indicated. Genera are formally grouped into families following the Angiosperm Phylogeny Group IV (APG4) classification, with cross-reference to family placement in FTEA and other relevant systems. A single illustration is provided for each genus. Publication of The Genera of Vascular Plants of Tropical East Africa is anticipated in three hard copy volumes, with dichotomous keys to all genera combined and to genera within each APG family. Multi-access electronic keys will be provided in an online supplement. Completion of the project is anticipated in three to four years.

Keywords: Vascular plants, Genera, Keys, East Africa, APG4

13.2.2 DIVERSITE, LOCALITE ET ECOLOGIE DE CAFEIERS SAUVAGES MALGACHES ENDEMIQUE DE LA COTE OUEST DE MADAGACAR: BARACOFFEA (RUBIACEAE)

DIVERSITY, LOCALITY AND ECOLOGY OF ENDEMIC MALGACHIAN WILD CAFE TREES OF THE WEST COAST OF MADAGACAR: *BARACOFFEA* (RUBIACEAE)

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A Madagascar, près de 75% des espèces de caféiers malgaches sont classées vulnérables, menacées ou fortement menacées de disparition selon la liste de l'UICN. C'est l'une des conséquences directe de la déforestation et d'autres activités anthropiques. Parmi ces espèces de caféier, il y a le groupe des Baracoffea (sous-genre de *Coffea*). *Baracoffea* regroupe 9 espèces endémiques, exclusivement présentes dans les forêts sèches de la côte Ouest de Madagascar, constituent une base importante pour échapper à des problèmes au niveau des caféicultures, puisqu'il comprend des espèces xérophytiques avec des caractéristiques morphologiques d'adaptation à la sécheresse. Cette étude a comme objectif de

caractériser la diversité des espèces du groupe de *Baracoffea* dans la région ouest de Madagascar vu son statut UICN, notamment dans la région Boeny (Parc National Ankarafantsika et la forêt d'Antsanitia) et de caractériser leur exigence écologique afin de pouvoir donner des recommandations pour sa conservation. Une étude écologique a été effectuée, comme l'inventaire floristique; analyse de recouvrement de la végétation; abondance numérique (nombre d'individu et population); et étude de la distribution de ces espèces. Il a été révélé de cette étude que 3 espèces de *Baracoffea* sont présentes près de la ville de Mahajanga, telles que: *Coffea ambongensis*, (forêt d'Antsanitia), Coffea boinensis (forêt du Parc National Ankarafantsika) et C*offea bissetiae* (commune aux deux forêts). Le nombre de population par espèce et par site est en général peu nombreux, pour celui d'Ankarafantsika: 4 populations de *C. boinensis*, 6 populations de *C. bissetiae*; tandis que pour celui d'Antsanitia: 2 populations de *C. ambongensis* et *C. bissetiae*. Nous pouvons en déduire que l'habitat le plus favorable à ces espèces est la forêt protégée dont le Parc National Ankarafantsika, contrairement à la forêt d'Antsanitia qui est une forêt à accès libre, c'est pourquoi on n'y trouve que 2 populations seulement pour chaque espèce localisée. Vu l'état actuel de la forêt d'Antsanitia, ces espèces seront bientôt classées en voie de disparition, ce qui demande une réflexion et prise de responsabilité de notre part, pour leur sauvegarde et protection. Une collection *ex situ* serait une solution primordiale pour la sauvegarde de ces ressources biologiques.

Mots clés: *Baracoffea*, Caféier sauvage, Diversité, Écologie, Distribution, Région Boeny, Madagascar

13.2.3 THE BOTANY OF DAVID LIVINGSTONE'S ZAMBEZI EXPEDITION 1858-1864 AND ASSOCIATED TRAVELS IN TROPICAL AFRICA

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Many volumes have been written on David Livingstone and the government-sponsored Zambezi Expedition. The Expedition mapped the course of the Zambezi River from its delta in central Mozambique to the Victoria Falls that link Zambia and Zimbabwe, and as far upstream as the Linyanti swamps of Botswana. The Shire River and highlands of present-day Malawi were explored together with the lake beyond. The Rovuma River that now forms the border between Mozambique and Tanzania was also investigated. Public interest focused initially on the romance of African exploration – the interior of the continent was largely unknown to Europeans – and of the personalities involved: Livingstone had become a public figure in Victorian Britain through accounts of his earlier missionary travels in the region. More

recent academic works have reassessed the Expedition in the context of natural resources and other more overtly colonial ambitions. But remarkably, despite the fact that the approximately 1,400 herbarium collections from the Expedition underpin innumerable taxonomic and floristic treatments of the region, there has never been a serious attempt to summarise these materials or their significance in a single document. Livingstone made few botanical collections; most were collected by John Kirk who also made detailed field sketches of many species with economic potential. Missionaries Charles Meller and Horace Waller made additional collections from the Shire Highlands. Associated collections came from Anjoan (Johanna) in the Comoros, and from Madagascar. Thomas Baines who left the Expedition in 1859 following a dispute with Livingstone, later travelled with James Chapman from Walvis Bay in Namibia to the Victoria Falls. Baines depicted several landscapes and events on both expeditions in oil paintings. The majority of herbarium collections and around 200 field sketches from the expeditions are at Kew, with additional paintings at the Natural History Museum in London (NHML) and the Royal Geographical Society (RGS).

Keywords: David Livingstone, Zambezi Expedition, Botanical/herbarium collections, Kew, NHML, RGS
