## PROGRAM
### 2 december 2013

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10:30 - 11:00 Coffee break

11:00-11:30 **Plenary 1: Mike Fay**
11:30 - 12:00 **Plenary 2: Orchid conservation in the age of restoration. Kingsley Dixon**, Director, Science, Kings Park and Botanic Garden. Visiting Professor, School of Plant Biology, The University of Western Australia
12:00 - 12h30 **Plenary 3: Transient and Asymptotic Population Dynamics in Orchids: the unpredictable and predictable. Raymond Tremblay**, University of Puerto Rico (UPR) CREST-CATEC UPR- Recinto de Rio Piedras, San Juan, Puerto Rico

12:30 - 14:00 Lunch

### 14:00 - 15:40 Pollination for conservation - Ryan Phillips & Florent Martos

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15:40 - 16:00 Coffee break

### 16:00 - 18:00 Pollination for conservation - Anton Pauw & Claire Micheneau

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<td>Morphological and genetic diversity across an ecological gradient in <em>Jumellea rossii</em>, endemic to Réunion (Mascarenes, Indian Ocean) - Bertrand Mallet, Université De La Réunion - Florent Martos, School of Life Sciences - University of KwaZulu-Natal Pietermaritzburg - Laury Blambert, Université De La Réunion - Thierry Pailler, Université De La Réunion - Laurence Humeau, Université De La Réunion</td>
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<td>Molecular phylogenetic relationships amongst the Southern African members of the subtripe <em>Eulophiinae</em> (Orchidaceae). - Benny Bytebier, School of Life Sciences - University of KwaZulu-Natal Pietermaritzburg</td>
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<td>Improving the efficacy of field collection of orchid seed - Jonathan Kendon, Royal Botanic Gardens, Kew</td>
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<td>The asymbiotic micropropagation, cultivation and re-establishment process of the critically endangered <em>Disa barbata</em>. - Hildegard Crous, Cape Institute of Micropropagation</td>
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15:20 - 15:40  › The international orchid horticultural trade and conservation: the current situation and the potential for future collaborations - Amy Hinsley, Durrell Institute of Conservation and Ecology, University of Kent

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UICN Meeting & Orchid conservation in SWIO round table

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08:30 - 08:50  › Diversity and distribution of mycorrhizal fungi associating with Caladenia in Western Australia. - Nigel Swarts, Royal Tasmanian Botanic Gardens, University of Tasmania

08:50 - 09:10  › Unravelling the functional role of mycelial networks in orchid mineral nutrition - Belinda Newman, School of Plant Biology, University of Western Australia

09:10 - 09:30  › Stable isotope abundance meta data sets as a tool to elucidate the complex nutrition pathways of mycoheterotrophic orchids - Gerhard Gebauer, University of Bayreuth, BayCEER - Laboratory of Isotope Biogeochemistry

09:30 - 09:50  › Mycorrhizal fungi from native and invasive orchids inhabiting a remote, natural area in South Florida - Kavita Patel, Orchid Recovery Program, Illinois College - Lawrence Zettler, Orchid Recovery Program, Illinois College

09:50 - 10:10  › Exploring symbiotic interactions in New Zealand terrestrial orchids to enable their conservation - Jonathan Frericks, Victoria University of Wellington

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10:30 - 12:30 Mycorrhizas for conservation - Florent Martos & Lawrence Zettler

10:30 - 10:50  › Conservation of critically endagered orchids from the central highlands of Madagascar: results from the first of a five year project - Hana Thixton, Orchid Recovery Program- Lawrence Zettler, Orchid Recovery Program, Illinois College

10:50 - 11:10  › Nutrient gains from fungi by adult orchids in temperate montane habitats - Julienne Marie-Isabelle Schiebold, University of Bayreuth, BayCEER - Laboratory of Isotope Biogeochemistry

11:10 - 11:30  › Mycorrhizal fungi from mature roots and young seedlings of critically endangered orchids of Madagascar--first documentation from the Indian Ocean island - Audrey Knight, Orchid Recovery Program, Illinois College - Lawrence Zettler, Orchid Recovery Program, Illinois College

11:30 - 11:50  › Microorganisms associated with orchid roots, and their role in orchid seed propagation. - Elena Tsavkelova, Marija Egorova, Galina Kolomeitseva, Aleksander Netrusov

11:50 - 12:10  › Native Orchids of Singapore - Diversity, Identification and Conservation. - Tim Wing Yam

12:10 - 12:30  › Mauritian forest and orchid status - Bhoyroo Vishwakalyan

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11:10 - 11:30  How to find determinants of species diversity in orchids? Pavel Kindlmann, Department of Theoretical Ecology, Czech Globe AS CR
11:30 - 11:50  Determinants of orchid species diversity in the Caribbean - Iva Traxmandlová, Department of Theoretical Ecology, Czech Globe AS CR
11:50 - 12:10  On the orchid flora of the Seychelles islands - Lindsay Chong-Seng, Plant Conservation Action group
12:10 - 12:30  Orchids of Ngon hills, Kenya: deforestation, species diversity and conservation - Beatrice Khayota,
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14:00 – 16:00  Habitat restoration/translocations - Hanne Rasmussen & Claudia Baider

14:00 - 14:20  Impacts of habitat restoration on the terrestrial orchid community of a tropical island's wet forest. - Claudia Baider, The Mauritius Herbarium
14:20 - 14:40  Orchid Conservation in Australia. Does the integrated conservation approach work? - Nigel Swarts - Royal Tasmanian Botanic Gardens, University of Tasmania
14:40 - 15:00  Where the orchids live - Ventre-Lespiaucq Agustina, Sánchez Andrea, Otero Tupac, Flanagan Nicola
15:00 - 15:20  Orchid conservation by an NGO, the case of Ambodiriana forest in Madagascar - Jean-Michel Hervouet, Société Française d'Orchidophilie, Chantal Misandeau, ADEFA
15:20 - 15:40  A broader perspective on germination site requirements - Hanne N. Rasmussen, Institute of Geosciences and Nature Management
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16:00 - 18:00  Biological invasions - Vincent Florens & Robert Pemberton

16:00 - 16:20  The impact of invasive alien plants on epiphytic orchids of a tropical island's wet forest. - F. B. Vincent Florens, University of Mauritius
16:20 - 16:40  Alien orchids; how are they able to invnde? - Robert Pemberton, Florida Museum of Natural History
16:40 - 17:00  Finding friends in strange lands: contrasting tales of two invasive orchid species - James Ackerman
17:00 - 17:20  Victorian Orchid Conservation - Noushka Reiter
Pollination for conservation
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Specialised pollination systems in the Orchidaceae? challenges for conservation

Phillips Ryan 1,2

1: Botanic Gardens and Parks Authority (BGPA)
Fraser Ave, West Perth

2: The Australian National University
Evolution, Ecology and Genetics, Research School of Biology, The Australian National University, Canberra, ACT 0200, Australia

The Orchidaceae is renowned for its unique and often specialised pollination systems. While specialised pollination systems are predicted to be susceptible to landscape alteration, some meta-analyses suggest they are resilient. However, these analyses have not focused on the cases of extreme specialisation that are prevalent in the Orchidaceae. Here, I present data from sexually deceptive orchids suggesting that rarity of pollinators can contribute to intrinsic species rarity. Further, landscape modification can result in the loss of specific pollinators with detrimental affects for orchids, though the response to fragmentation appears to vary between pollinator functional groups. Specialised pollination systems in orchids also have the additional complexity that pollinators are often attracted using chemical signals? raising the potential for variation in pollinator attraction without concomitant variation in morphology. In sexually deceptive species, this has lead to several cases of potentially cryptic orchid species with different pollinator species and therefore different management requirements. While our understanding of these issues have arisen from increasingly advanced methodology, perhaps the biggest impediment to the conservation of pollination systems are shortages of research in field natural history. A recent example from Australia has revealed sexual deception in one of our most diverse genera, with important conservation consequences for a large number of threatened taxa.
Plant-insect pollinator interactions are believed to be simple in New Zealand and species-specific or highly elaborated pollination mechanisms have not been discovered yet. However, the pollination ecology of the New Zealand flora and orchids, in particular, has remained largely unstudied. Spider orchids are terrestrial, late winter-early spring flowering orchids with nectarless dark-coloured flowers. One of the most widespread and variable species is Nematoceras trilobum. Over eight forms are included under this name, some are uncommon and of conservation concern. Other forms occur sympatrically and flower at the same time. It is unclear whether they are different species or just one variable species. Furthermore, it has been suggested spider orchid flowers mimic mushrooms and attract only female fungus gnats which lay their eggs in the flowers and, by doing so, act as pollinators. To evaluate species boundaries within N. trilobum and uncover its pollination system we have gathered evidence from field observations, pollination experiments, scent analyses, plant morphology, DNA sequences and fingerprinting techniques (AFLP). Morphometric and genetic results indicate that at least three forms should be segregated and described as different species. DNA sequences have confirmed that eggs and larvae found in flowers of these orchids belong to the fungus gnat genus Mycetophila and that different orchid forms are visited by different species of gnats. Contrary to earlier reports, observations indicate both male and female fungus gnats visit these orchids, suggesting a pollination system different to brood site deception. Currently, analyses of fragrance extracted from flowers and co-occurring mushrooms are underway.
The chemical basis of hyper-specialization in an orchid mimicry system

Martos Florent¹, Cariou Marie-Louise², Fournel Jacques³, Bytebier Benny¹, Johnson Steven¹

¹: School of Life Sciences - University of KwaZulu-Natal Pietermaritzburg (UKZN)
   Private Bag X01 Scottsville Pietermaritzburg 3209
   http://lifesciences.ukzn.ac.za/Staff/Biodiversity.aspx
²: Laboratoire Evolution, Génomes et Spéciation (LEGS)
   CNRS : UPR9034
   avenue de la Terrasse Bâtiment 13, Boite Postale 191198 Gif sur Yvette
   http://www.legs.cnrs-gif.fr/
³: Peuplements végétaux et bioagresseurs en milieu tropical (PVBMT)
   Centre de coopération internationale en recherche agronomique pour le développement [CIRAD] : UMR53Université de la Réunion
   Faculté des Sciences et techniques - Université de La Réunion 15 avenue René Cassin CS92003 97744 SAINT DENIS CEDEX 9
   http://umr-pvbmt.cirad.fr

Oviposition site mimicry is an extraordinary phenomenon in which plants dupe insects, typically flies, into responding to their flowers as if they were oviposition sites, and thereby use these insects as pollinators. Decrypting the floral signals through which this form of mimicry is achieved has received much attention in recent years, and has led to identification of olfactory cues emitted by flowers that are signals of mushroom, carrion, dung and urine, or yeast. However, the prevailing view is that oviposition site mimicry tends to exploit rather widespread basal functions in the insect olfactory system and thus does not lead to high levels of specialization. Here, we present a new oviposition site mimicry system in a mycoheterotrophic orchid species (lower Epidendroideae; tribe Gastrodieae) which involves hyper-specialization for a single fly species (Diptera; Drosophilidae) and sex (female). Using bioassays, we furthermore unravel the role of individual floral volatiles in mediating the specialized attraction of female fruit flies. This is the first evidence of hyper-specialization for a single pollinator species in oviposition site mimicry and of its chemical basis. These findings are of seminal importance for understanding the role of olfactory signalling in plant-insect specialization and raise interesting new questions about odorant receptors and underlying genes in Drosophila.
Pollination success is independent of population size in a temperate deceptive orchid

Peter Craig ¹, Johnson Steven ²

¹ : Rhodes University (RU)
PO Box 94 Grahamstown 6140
² : University of KwaZulu-Natal (UKZN)
Durban, 4041
http://www.ukzn.ac.za/

Small populations of plants in transformed and fragmented landscapes can experience component Allee effects in terms of reduced fecundity, and this is often attributed to these small populations being insufficiently attractive to pollinators. Conversely, plants that offer no rewards can experience competition for pollinators in large populations and perform best when surrounded by fewer conspecifics. We examined the effects of population size on pollination success of the temperate deceptive orchid, Orchis militaris on the Swedish island of Öland in the Baltic Sea. Orchids are ideal experimental subjects for such studies as their discrete pollen packages allow pollination success to be measured directly. In each population, we recorded the number of flowering individuals, made pollinator observations, and scored between one and five flowers per inflorescence for pollinia removal and massulae deposition on stigmas. We show that rates of pollinia removal, massulae deposition and flower visitation were independent of population size, although pollen transfer efficiency (PTE) was depressed in small populations. This suggests that small populations may have some conservation value provided the habitat fragments can also support pollinators.
Floral colour variation in a mimetic orchid is driven by pollinator preference

Anderson Bruce 1, Johnson Steven 2, Newman Ethan 1

1 : Université de Stellenbosch
   Victoria Street, Stellenbosch, 7600 Stellenbosch, Cap occidental
   http://www.sun.ac.za

2 : University of KwaZulu-Natal (UKZN)
   Durban, 4041
   http://www.ukzn.ac.za/

Orchids display tremendous variability in floral colour within and between species. Although much of this variability is attributed to divergent selection by pollinators, processes unrelated to pollinators may also play a role in determining floral colour. Here, we examine the role of pollinators in driving floral colour variation in Disa ferruginea, a non-rewarding orchid that is thought to attract its butterfly pollinator by mimicking the flowers of sympatric nectar-producing species. Disa ferruginea has red flowers in the western part of its range and orange flowers in the eastern part. We hypothesized that this colour shift is the outcome of selection to match the geographic variability of nectar-producing plants. Populations of red Disa ferruginea tended to occur among populations of red nectar producing flowers whereas orange population of Disa ferruginea were associated with orange nectar producing flowers. Disa ferruginea was only pollinated by the butterfly Aeropetes tulbaghia, but this butterfly had geographically variable colour preferences. When offered a choice of orange versus red Disa ferruginea inflorescences, butterflies displayed a preference for the colour which matched that of the co-occurring nectar flowers. In a population of red Disa ferruginea with red nectar producing flowers, butterflies preferred red colours. However, orange colours were preferred where orchids and their model flowers were orange. This demonstrates that intra-specific geographic variability in orchid morphology can be adaptive. The divergent selective pressures faced by different populations suggest that conservation efforts need to take population variation into account in order to conserve the evolutionary potential of a species.
The geographical extent to which a mimetic orchid relies on its model

Duffy Karl ¹, Johnson Steven ²

¹ : University of KwaZulu-Natal (UKZN)
   School of Life Sciences, University of KwaZulu-Natal, Scottsville, Private Bag X01, Pietermaritzburg 3209
   http://www.ukzn.ac.za/

² : School of Life Sciences - University of KwaZulu-Natal Pietermaritzburg (UKZN)
   Private Bag X01 Scottsville Pietermaritzburg 3209
   http://lifesciences.ukzn.ac.za/Staff/Biodiversity.aspx

For Batesian mimics, theory predicts that both their occurrence and fitness is directly dependent on their distance from a model. We tested this hypothesis using a well-documented Batesian mimic, the nectarless orchid Disa pulchra, and its model Watsonia lepida. For this, we quantified the potential null distribution of D. pulchra by constructing the range of environmental conditions using occurrence records for all taxa within the clade containing D. pulchra and analysed these according to the distribution of W. lepida. To test whether fitness of D. pulchra is related to distance from W. lepida we; (i) quantified rates of pollination and fecundity of D. pulchra individuals and related these to distance from W. lepida individuals, and (ii) translocated pairs of D. pulchra inflorescences at different distances and directions from the W. lepida population and quantified their pollination success. Disa pulchra has a geographically non-random distribution and is more likely to occur where W. lepida is present than when it is not present. Pollination and fecundity of D. pulchra increases with decreasing distance from W. lepida and that, controlling for direction and distance from W. lepida, there was an overall decrease in pollination with increasing distance from W. lepida. These results highlight the dependency of a Batesian mimic on its model and suggest that fitness and population expansion of D. pulchra is constrained by its reliance on W. lepida.
Reproductive isolation in morphologically cryptic, sympatric taxa of Australian orchids.

Whitehead Michael 1,2, Peakall Rod 1

1 : Research School of Biology, The Australian National University
   Research School of Biology 116 Daley Rd The Australian National University Acton 0200 ACT
2 : School of Life Sciences, University of KwaZulu-Natal
   Life Sciences Campus Carbis Road Scottsville Pietermaritzburg 3209

Understanding reproductive boundaries between incipient taxa is of fundamental importance for delineation of species and understanding speciation. Despite this, few studies have quantified the full range of pre- and post-zygotic barriers that limit introgression between closely related species. Chiloglottis orchids sexually attract their specific male wasp pollinator species by emission of semiochemicals. We present a multidisciplinary study of reproductive barriers among several taxa within this genus of Australian orchids. We show that sympatric, morphologically cryptic taxa are interfertile, in some cases producing offspring with hybrid vigour. Population genetic analysis however shows these entities to be genetically differentiated and this genetic differentiation correlates to differences in the floral volatile chemistry responsible for pollinator attraction. Floral chemistry thus underpins reproductive isolation and is largely responsible for initiating speciation and maintaining species boundaries. Cryptic orchid and pollinator taxa present special conservation challenges due to the difficulty of identifying them in the field. This study shows that when such taxa are suspected, integrated ecological, genetic and chemical research is critical for resolving taxonomic ambiguity.
Mutualisms matter: linked declines of pollinators and orchids in the Cape Floristic Region of South Africa.

Pauw Anton

1 Université de Stellenbosch
Victoria Street, Stellenbosch, 7600 Stellenbosch, Cap occidental
http://www.sun.ac.za

There are at least two immediate reasons why it is important to determine the role of biotic interactions, such as pollination, in limiting species distribution ranges. Firstly, if range limits are imposed by biotic factors, current and future distribution ranges might not be constrained by climate. Secondly, if biotic interactions limit the distribution ranges of species, anthropogenic impacts on these interactions are likely to have a major effect on biodiversity. Here we test the role of pollination in limiting plant distributions by studying plant community assembly in a guild of 15 oil-secreting orchids (Coryciinae) along a pollination gradient. In all the members of the guild, seed production depends on pollination by the oil-collecting bee, Rediviva peringueyi (Melittidae). While the mode of aboveground reproduction is uniform across the guild, the orchid species differ widely in their capacity for belowground clonal reproduction through the formation of bulbils, and hence span a range of predicted dependence on pollination (and subsequent seed set) for population persistence. Pollination rate by R. peringueyi varied across the landscape from 0 to 98% of flowers pollinated. Degree of urbanization was a major contributor to this variation in pollination rate. With decreasing pollination, species richness of the orchid guild declined, and species were lost by the successive deletion of the least clonal species. Thus, pollination is shown to act as a biotic filter, excluding non-clonal species from pollinator poor communities. The findings are consistent with the idea that pollination mutualisms matter ecologically by limiting the distribution of non-clonal plants.
Many angraecoid orchids naturally occur in limited areas of Madagascar and tropical Africa. Unfortunately, these habitats have suffered extensive destruction and fragmentation. To date, conservation efforts have been unable to substantially diminish the destruction of angraecoid-rich habitats. The future of these habitats is grim. Both in-situ and ex-situ conservation are necessary for species survival.

Seeking to increase the number of angraecoid species in ex-situ conservation, plants already in cultivation are being used to propagate genetically diverse populations for ex-situ conservation. A large number of angraecoid species—some exceedingly rare—are cultivated in private collections around the world by botanical gardens and hobbyists with a passion for angraecoid orchids. The Angraecoid Alliance has recruited (and continues to seek out) individuals and organizations interested in angraecoids and ex-situ species conservation. Members of The Angraecoid Alliance donate pollen, seed and/or flasking services. As of July 2013, members of The Angraecoid Alliance have pollinated (or attempted pollination) on multiple species: Aerangis umbonata (syn fuscata); Angraecum conchoglossum; Angraecum curnowianum; Angraecum dollii; Angraecum pinifolium; Angraecum rynchoglossum and Cryptopus elatus. Seed of several additional species has been donated to The Alliance's efforts: Aeranthes peyrotii; Angraecum birrimense; and Cryptopus paniculatum. The Angraecoid Alliance's objective is to harness previously unused resources and methods to effectuate both ex-situ and in-situ conservation of angraecoid species.
Conservation genetics

Phylogenetic relationships

Propagation technology
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<td>08:30 - 10:30</td>
<td>Conservation genetics - Mike Fay &amp; Barbara Gravendeel</td>
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<td>08:30 - 08:50</td>
<td>› Morphological and genetic diversity across an ecological gradient in <em>Jumellea rossii</em>, endemic to Réunion (Mascarenes, Indian Ocean) - Bertrand Mallet, Université De La Réunion - Florent Martos, School of Life Sciences - University of KwaZulu-Natal Pietermaritzburg - Laury Blambert, Université De La Réunion - Thierry Pailler, Université De La Réunion - Laurence Humeau, Université De La Réunion</td>
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<td>08:50 - 09:10</td>
<td>› Transcriptomic and epigenetic alterations after recurrent allopolyploidization triggers adaptive diffusion in <em>Dactylorhiza</em> (Orchidaceae) - Mark Chase, Royal Botanic Gardens, Kew</td>
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<td>09:10 - 09:30</td>
<td>› New possibilities for orchid conservation genetics from next-generation sequencing: are we finally getting somewhere with <em>Cypripedium calceolus</em>? - Michael Fay, Jodrell Laboratory</td>
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<td>09:30 - 09:50</td>
<td>› DNA barcoding helps monitoring illegal trade in African and Asian orchids - Barbara Gravendeel, Naturalis Biodiversity Center - Hugo de Boer, Uppsala University - Ghorbani Abdolbaset, Uppsala University - Youri Lammers, Naturalis Biodiversity Center - Joseph Otieno, Department of Medical Botany, Plant Breeding and Agronomy, Institute of Traditional Medicine, Muhimbili University of Health and Allied Sciences - Tamara Peelen, Dutch Customs Laboratory - Sarina Veldman, Uppsala University - Rogier van Vugt, Hortus botanicus of Leiden University</td>
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<tr>
<td>09:50 - 10:10</td>
<td>› DNA barcoding of illegally traded Tanzanian orchids - Joseph Otieno, Department of Medical Botany, Plant Breeding and Agronomy, Institute of Traditional Medicine, Muhimbili University of Health and Allied Sciences</td>
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Identifying factors that promote population differentiation is of interest for understanding the early stages of speciation. Gene flow among populations inhabiting different environments can be reduced by geographical distance (isolation-by-distance) or by divergent selection resulting from resource use (isolation-by-ecology). Few studies have investigated the influence of these factors in small-elevated oceanic islands where the influence of geographic distance is expected to be null but where habitat diversity could have a strong effect on population differentiation. In this study, we tested for the spatial divergence of phenotypes (fitness-related traits) and genotypes (neutral markers) among ten populations of an epiphytic orchid endemic to Réunion growing in three different habitats, Jumellea rossii. Floral scent compounds are not significantly different between populations or between habitats. Floral morphology and microsatellite genotypes are both significantly differentiated between populations and are structured by habitat type. However, both climatic and geographical distances influence genetic differentiation while only geographic distance influence morphological differentiation. These results suggest that although orchids have high seed dispersal ability, ecological factors might reduce gene flow among populations located in different habitats. This ecological divergence does not seem to be driven by the plant-pollinator interaction in J. rossii but by other factors.
Transcriptomic and epigenetic alterations after recurrent allopolyploidization triggers adaptive diffusion in Dactylorhiza (Orchidaceae)

Paun Ovidiu 1*, Chase Mark 2*

1: University of Vienna (UV)
   Rennweg 14 A-1030 Vienna
2: Royal Botanic Gardens, Kew (RBGK)
   Richmond, Surrey TW9 3DS
* : Corresponding author

We have studied gene expression and genome-wide DNA methylation alterations in three sibling allotetraploid lineages of Dactylorhiza, an evolutionarily complex genus of temperate terrestrial orchids. Dactylorhiza majalis s.str., D. traunsteineri and D. ebudensis have formed independently through recurrent but unidirectional hybridization between the widespread diploids D. fuchsii and D. incarnata at different times during the last part of the Quaternary, but they differ in range, morphology and ecological preferences. Analyses of cDNA-AFLPs show a significant increase in the range of gene expression in the allopolyploid lineages, demonstrating a higher potential for phenotypic plasticity compared to either parent. Moreover, allopolyploid individuals express significantly more gene variants (including novel ones) than the parents, providing clear evidence for an increase in biological complexity. Significantly more genetic mutations have accumulated in the older D. majalis compared with the younger D. traunsteineri since their respective formations, but the opposite trend is visible in DNA methylation data. Multiple origins of each tetraploid taxon (except D. ebudensis) contribute to differential patterns of gene expression with a geographic structure. However, several transcripts and epialleles are conserved within each allopolyploid taxon but differ between taxa, indicating that habitat preferences shape similar expression patterns in independently formed allopolyploids. Water availability and temperature appear to be the relevant factors correlated with these altered patterns of expression. In addition to stabilizing the allopolyploid genome, genetic and epigenetic alterations are key determinants of the adaptive success of the new polyploid species, potentially triggering reproductive isolation between the resulting lineages.
New possibilities for orchid conservation genetics from next-generation sequencing: are we finally getting somewhere with Cypripedium calceolus?

Fay Michael 1*, Sanchez Michele 1, Chochai Araya 1, Kahandawala Imalka 1, Cowan Robyn 1

1 : Jodrell Laboratory
Royal Botanic Gardens, Kew, TW9 3DS Richmond, Surrey
* : Corresponding author

Since the early 1990s there has been a rapid development of molecular technology for DNA sequencing and genetic fingerprinting; most recently, new high-throughput sequencing technologies (next-generation sequencing; NGS) have dramatically increased the ease of data production, at the same time as reducing costs. In addition to the large-scale genomics studies that these technologies allow, it is also possible to use the resulting data to streamline the development of population genetic markers, notably plastid and nuclear microsatellites (simple sequence repeats; SSR). Previously, the development time for microsatellite markers has been a severely limiting factor in conservation genetics studies, and the large genome size of some orchids (notably members of Cypripedioideae and some terrestrial Orchidoideae) has been a source of problems associated with development and use of these markers. Genetic studies of the European lady's slipper orchid, Cypripedium calceolus, conducted over the last 20 years (using sequencing and various fingerprinting techniques) will be used to demonstrate the problems associated with some of the earlier techniques and illustrate how the newer techniques are being used to overcome, or at least ameliorate, some of the problems.
DNA barcoding helps monitoring illegal trade in African and Asian orchids

Gravendeel Barbara 1, De Boer Hugo 2, Abdolbaset Ghorbani 2, Lammers Youri 1, Otieno Joseph 3, Peelen Tamara 4, Veldman Sarina 2, Van Vugt Rogier 5

1 : Naturalis Biodiversity Center
Sylviusweg 72, Leiden, The Netherlands
www.naturalis.nl

2 : Uppsala University
Box 256, SE-751 05 Uppsala
http://www.uu.se/en/

3 : Department of Medical Botany, Plant Breeding and Agronomy, Institute of Traditional Medicine, Muhimbili University of Health and Allied Sciences (ITM-MUHAS)
P.O. BOX 65001 Dar es Salaam
http://www.muhas.ac.tz

4 : Dutch Customs Laboratory
Kingsfordweg 1, 1043 GN Amsterdam
www.belastingdienst.nl

5 : Hortus botanicus of Leiden University
Rapenburg 73, 2311 GJ, Leiden
www.hortusleiden.nl

An increasing number of orchids are illegally collected worldwide for incorporation in traditional products. In Africa, underground tubers of species of Disa, Habenaria and Satyrium are used for the production of Chikanda, a vegetarian snack. In Asia, leaves and stems of species of Dendrobium are harvested for the production of Dendrobii Herba, medicinal teas. And in Greece, Iran, Turkey, underground tubers of Anacamptis, Orchis and Platanthera are used to make Salep, a nutritive tonic or elastic ice cream. Prices of traditional orchid products keep increasing year-on-year which boosts illegal collecting. To put a stop to this, conventional morphology-based methods cannot be used to identify species processed in these products due to degradation of leaves and tubers by heating, treatment with chemicals and mixing with other species. Next Generation Sequencing (NGS) enables sequencing of multiple samples in parallel to assess the presence of orchid species in chikanda, salep and herbal teas by comparison of the reads obtained with reference DNA barcode databases. Results obtained will be discussed in terms of (1) monitoring and controlling illegal trade, (2) identification of smuggling routes and (3) reduction of health risks to consumers of these products.
DNA barcoding of illegally traded Tanzanian orchids

Otieno Joseph

1 : Department of Medical Botany, Plant Breeding and Agronomy, Institute of Traditional Medicine, Muhimbili University of Health and Allied Sciences (ITM-MUHAS)
P.O. BOX 65001 Dar es Salaam
http://www.muhas.ac.tz

Introduction
Chikanda is a traditional vegetarian snack consisting mainly of processed orchid tubers commonly eaten in Zambia and Southern Tanzania. Orchid tubers are wild-harvested and traded through local markets. Part of the tubers originates from Tanzania where they are in some cases poached from protected areas.

Objectives
This project aims to map harvesting and trade of Tanzanian orchids, and to investigate which species are traded on local markets to produce chikanda.

Methods
Market surveys were conducted and orchid tubers and chikanda were purchased. Informants were interviewed. In parallel, herbarium vouchers of 47 wild orchid species were made and identified using morphology. DNA barcodes of these collections were generated to function as a reference database. Chikanda was prepared experimentally.

Preliminary results
Illegal collection in protected areas and their surroundings was observed, and was reported to have increased recently. Tanzanian informants reported tuber harvesting was traditionally done for subsistence use, but that commercialization had become more lucrative due to increasing demand and market value in Zambia. The first DNA barcodes were generated from chikanda.

Future directions
The next step is to attempt identification of all species traded on the markets and in prepared chikanda by matching DNA barcodes generated, and to trace traded species back to collection sites. Once the main illegally traded species are identified, and a reproducible recipe of chikanda is obtained, we will attempt to develop sustainable production of these orchids in Tanzania as alternative to wild harvesting to enhance local orchid protection and generate alternative income in Tanzania.
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<td>10:30 - 10:50</td>
<td>› Phylogeny and evolution of Australasian <em>Dendrobium</em> (Epidendroideae: Orchidaceae) - Claire Micheneau, Centre for Tropical Biodiversity and Climate Change, Australian Tropical Herbarium</td>
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<td>› Molecular systematics and evolutionary trends and relationships in the genus <em>Jumellea</em> (Orchidaceae): Implications for its species limits - Fanny Rakotoarivelo, Université d'Antananarivo</td>
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<td>› Systematics and conservation of <em>Angraecum</em> (Orchidaceae, Angraecinae) in Madagascar - Herinandrianina Notahianjanahary ANDRIANANJAMANANTSOA, Université de Montréal - UdeM (CANADA)</td>
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<td>› Molecular phylogenetic relationships amongst the Southern African members of the subtribe <em>Eulophiinae</em> (Orchidaceae). - Benny Bytebier, School of Life Sciences - University of KwaZulu-Natal Pietermaritzburg</td>
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<td>11:50 - 12:10</td>
<td>› Refinements in DNA sequencing protocols for applications in orchid conservation - Dirk Bellstedt, Université de Stellenbosch</td>
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With more than 1200 species distributed across the Indo-Malayan, Australasian and Pacific regions, the genus Dendrobium s.l. (Epidendroideae: Orchidaceae) is one of the most taxonomically challenging groups of epiphytic orchids, with complex patterns of morphological variation. Several classification systems have been proposed, with different morphological groups treated at different taxonomic levels. Previous molecular phylogenetic analyses showed that Dendrobium s.l. is divided into two well supported clades, one centred in Asia and the other in Australasia (i.e. Australia, New Zealand, New Guinea, and the neighbouring islands of the Pacific Ocean, including New Caledonia). However, the monophyly of most taxonomic entities within these clades remains to be tested.

In this study, we generated a broad scale molecular phylogeny of Australasian Dendrobium based on plastid and nuclear markers (ycf1, matK, ITS, Xdh). Our results support the monophyly of many previously recognized taxonomic groups within the Australasian clade (e.g. sections Dendrocoryne, Phalaenanthe, and Spatulata), and provide insights into the evolution of the group. This study is an important step forward in reconciling taxonomic concepts within Dendrobium s.l.
Molecular systematics and evolutionary trends and relationships in the genus Jumellea (Orchidaceae): Implications for its species limits

Rakotoarivelono Fanny

1 : Université d'Antananarivo
BP 906, Ankatso Antananarivo 101- MADAGASCAR

Jumellea is an orchid genus centered on Madagascar but also occurs on some of the neighboring oceanic islands (the Mascarenes and Comoros) and in southern and eastern Africa. Prior to our study the genus contained ca. 55 morphologically distinct species, of which six are found in the Comoros, nine in the Mascarenes, two in southern and eastern Africa, and 41 species endemic to Madagascar. We perform Bayesian and parsimony phylogenetic analyses of Jumellea based on combined chloroplast (matK, trnL-F, rps16, ycf1) and nuclear (nrITS) data from 60 specimens representing 47 species, four subspecies, and two varieties of Jumellea: to assess the phylogenetic value of growth form, leaf, bract and lip shape, and spur length, presently used for recognizing informal groups within the genus; and to test the monophyly of some variable species. We find no support for the informal groups of Jumellea, as all the characters tested are evolutionarily labile. Jumellea lignosa is not monophyletic unless subsp. tenuibracteata is excluded. Jumellea gracilipes is polyphyletic. As a result, we resurrect three species, and recognize J. lignosa subsp. tenuibracteata at species level. Furthermore, we propose new circumscriptions for the following species: J. arachnantha; J. exilis; J. recta; J. recurva; and J. stenophylla. Finally, Jumellea arborescens and J. maxillarioides are recorded from Madagascar and the Comoros. Finally, the number of species of Jumellea has now increased from 55 to 57: seven species in the Comoros, nine species in the Mascarenes, two species in Africa, and 39 species, three subspecies, and two varieties restricted to Madagascar.
Systematics and conservation of Angraecum (Orchidaceae, Angraecinae) in Madagascar

Andriananjamanantsoa Herinandrianina Notahianjanahary

1 : Université de Montréal - UdeM (CANADA) (IRBV)
4101 Sherbrooke Est, Montreal (QC) H1X 2B2
http://www.irbv.umontreal.ca/

The paleotropical genus Angraecum (Orchidaceae) includes more than 220 species; 80% of which are present in Madagascar. With more than 100 endemic species, this amazing group of orchids greatly contributes to this island nation's biodiversity. The remaining Angraecum species are found in mainland Africa, Asia, and on Atlantic and Pacific islands. Due to a lack of collections and information about Madagascan Angraecum, there is a real danger that species may be lost before being fully described and studied. The famous A. longicalcar with its 16 inch long spur is already extirpated from its native environment. Systematic relationships within Angraecum need a major revision as the currently used classification is based solely on morphology, which is inadequate for this morphologically complex genus. The most recent molecular phylogeny suggests a polyphyletic origin for this group, but lacks any Madagascan species despite the country representing the center of diversity for this group. A preliminary study of 90 Madagascan species of Angraecum proved that DNA barcodes are an important source of phylogenetic information for this group. The combination of rbcL and matK genes was useful in delimiting major lineages within the genus, while matK and ITS were informative in discrimination among species. This research project aims to complete the investigation of Madagascan species of Angraecum, yielding more evidence on the phylogeny, taxonomy, biogeography and conservation status of this morphologically diverse genus.
Molecular phylogenetic relationships amongst the Southern African members of the subtribe Eulophiinae (Orchidaceae).

Bytebier Benny 1*, Martos Florent 1, Craig Peter 2, Johnson Steven 1

1 : School of Life Sciences - University of KwaZulu-Natal Pietermaritzburg (UKZN)
Private Bag X01 Scottsville Pietermaritzburg 3209
http://lifesciences.ukzn.ac.za/Staff/Biodiversity.aspx
2 : Department of Botany, Rhodes University
PO Box 94, Grahamstown 6140
* : Corresponding author

Phylogenetic relationships were inferred for the African-centred orchid subtribe Eulophiinae, which includes the large genus Eulophia and three closely related genera, Oeceoclades, Pteroglossaspis and Acrolophia. We sequenced one nuclear (ITS) and four chloroplast (rbcL, trnK-matK, rpl32-trnL, and trnQ-5' rps16) markers for 86 samples, representing 58 species (62 taxa) and one outgroup. The combined sequence matrix had 6,525 characters and was analysed using parsimony and Bayesian criteria. Our results show that Acrolophia and Oeceoclades are monophyletic but are nested in Eulophia as currently circumscribed. Our analysis and its taxonomic implications will be presented.
Refinements in DNA sequencing protocols for applications in orchid conservation

Bellstedt Dirk 1*, Le Maitre Nicolas 1

1 : Université de Stellenbosch
   Victoria Street, Stellenbosch, 7600 Stellenbosch, Cap occidental
   http://www.sun.ac.za
* : Corresponding author

In orchid conservation, use is frequently made of DNA based methods to establish the phylogenetic relationships of species or to assess the variability within a species. Over the past 10-15 years, a more or less standard protocol for DNA sequence determination has been developed. This includes DNA isolation, polymerase chain reaction amplification of a target gene, the purification of the amplified gene fragment and a cycle sequencing reaction. These more or less standard procedures can take up to five days to complete. We have developed procedures which shorten this process to one day from plant sample to completion of the cycle sequencing reaction. We have developed a procedure in which a plant homogenate is used for direct amplification by means of the polymerase chain reaction. The use of improved thermostable DNA polymerases give better amplification product yields and can be completed in a shorter period of time. Amplification product cleanup can be speeded up and made cheaper with newer procedures. Finally, a new cycle sequencing protocol requiring dramatically shortened run times without compromising sequence quality has been developed. These refined procedures will be presented.
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Ex situ conservation of orchid germplasm: where are we after 100 years of research?

David Merritt

1 : Kings Park and Botanic Garden (KPBG)
Kings Park and Botanic Garden Fraser Avenue West Perth WA 6005
www.bgpa.wa.gov.au

Ex situ conservation of wild plant germplasm is fundamental to the increasingly co-ordinated and global-scale actions underway to conserve the world's declining biodiversity. Seed banking is the most widely adopted method of conserving orchid biodiversity. This paper reviews the approaches and techniques used for the ex situ conservation of orchids, with a focus on seed banking and cryopreservation techniques to improve the longevity of germplasm. Orchid seeds are usually desiccation tolerant, leading to the assumption that seeds are easily stored following international standards (i.e. storage at -18 °C and 5 ± 7% seed moisture content), or under the more specialised conditions of cryopreservation. Yet seed desiccation tolerance does not guarantee survival of sub-zero temperatures, and there is longstanding evidence of poor germination of orchid seeds following storage at sub-temperatures. A renewed focus on describing the low-temperature storage physiology of orchid seeds is clearly required. Data on storage behaviour remains sorely limited for orchid seeds; published data is available for perhaps 0.5% of all orchid species. Phylogenetic coverage of the Orchidaceae is also poor, with data almost entirely absent for the Apostasioideae, Cypripedioideae, and Vanilloideae. And with recent research pointing to orchid seeds as being perilously short-lived relative to other desiccation tolerant seeds, there is clearly much to be done to scientifically define storage procedures. This research, coupled with development of improved methods of seed viability testing, will support the growing work of seed banks to protect orchid biodiversity in the face of habitat loss and potential species extinction.
As in other plant groups, collecting mature seeds is the preferred approach when seeds have to be stored for more than a couple of days before germination in vitro. As seed maturation can be affected by fluctuating weather conditions every year, assessing seed maturity is a difficult task. On dehiscing of the fruit, seeds of some species can lose viability rapidly. Additionally, other species may have dormancy mechanisms conferred late in the seeds’ development that are difficult to overcome. These are important obstacles to conventional ex situ orchid conservation. They can be surmounted by the collecting of green pods and the immediate culturing of ‘immature’ seeds. Although the green pod method has been successful for some orchids, the process is reliant on culturing seeds within 1-2 days of harvesting the fruit. In scenarios where remoteness of field sites increases this delay, tools need to be employed to prevent deterioration of the immature seeds before they can be cultured. This would increase numbers of collections possible per trip since pods normally overlooked can be collected. Seeds that have been collected in this way can be used for ex situ conservation using techniques other than conventional seed banking, and will also provide propagules rapidly for reintroduction. Seeds at their peak viability period can be collected and used for rescue and other conservation studies. Importance of collecting material in the wild in an in vitro medium and its use later on after weeks of collecting in the wild is discussed in detail.
The asymbiotic micropropagation, cultivation and re-establishment process of the critically endangered Disa barbata.

Crous Hildegard 1

1 : Cape Institute of Micropropagation (CIM)
PO Box 105, Barrydale, 6750,
www.saorchids.co.za

Last sightings of this exceptionally beautiful orchid around the Cape Town area was in the 1950’s. Over the last 11 years Dr Benny Bytebier has organised a yearly count of the only existing colony, in order to assess and document the dynamics of this deciduous disa, sect. Herschelianthe. As part of this project, a cultivation protocol is being developed. The protocol includes the process of seed harvesting, establishment of seedlings in vitro, and cultivation of Disa barbata ex-situ, culminating in a process of re-establishment at a locality where it had once occurred. Deciduous disas are particularly difficult to propagate and maintain in cultivation; this report reflects on the difficulties that have been overcome, and the challenges that still lie ahead. The horticultural information from this project will then be applied to other disas of section Herschelianthe, many of which are also endangered as well as having tremendous horticultural potential.
Promotion of aromatic orchids endemic to the Mascarene Islands within a framework of sustainable development.

Blambert Laury 1, Mallet Bertrand 1, Palama Tony 1, Couprie Joël 2, Shum Cheong Sing Alain 3, Suzanne Willy 4, Grisoni Michel 5, Humeau Laurence 1, Chatel Alain 6, Pailler Thierry 1

1 : Université De La Réunion
   Université de la Réunion : UMRPVBMT
   15 rue rené Cassin
2 : Université De La Réunion
   Laboratoire de Biochimie et Génétique Moléculaire
   15 rue rené Cassin
3 : Université De La Réunion
   Laboratoire de Chimie des Substances Naturelles et des Sciences des Aliments
   15 rue rené Cassin
4 : VitroRun
   VitroRun
   Pôle de Protection des Plantes, Ligne Paradis, 7 chemin de l'Irat, 97410 Saint-Pierre
5 : Cirad
   CIRAD de La Réunion, Pôle de Protection des Plantes, Ligne Paradis, 7 chemin de l'Irat, 97410 Saint-Pierre
6 : SARL J. Chatel
   SARL J. Chatel
   80 rue Adolphe Pégoud, 97438 Sainte-Marie,

Jumellea fragrans and Jumellea rossii, both named « Faham », are two epiphytic orchids endemic to the Mascarene Islands (Reunion, Mauritius) widely used for their aromatic and medicinal properties. Cultivation of these orchids is currently non-existent, so gathering and poaching in natural populations provide the supply. Continued use of this resource and the reduction of its natural habitat now result in a drastic decline of its natural populations. In order to prevent the decline of these taxa, to preserve its natural evolution in the wild, and to answer to the local consumers demand, we initiate a multidisciplinary project. The main aim of the so-called « ORCHIFAH» project is to provide the scientific background requisite for the production of Faham at an industrial level. An ecological approach is set to characterise the environmental conditions (light, temperature, watering) for an optimal biomass production. In vitro conditions of asymbiotic germination are currently determined. The biochemical components variation of populations of the two species are analysed by RMN spectrometry. The development of an appropriated extractive mode of volatile compounds is planned. All this information will help us to accurately characterise the biology of Faham and the conditions of its production, essential prerequisites for the development of an agricultural production chain. The results will also allow us to determine the conservation status of the species and recommendations for the management of wild populations. The poster will explicit the different steps of the implementation of an agricultural production chain. The first results in each field will be presented.
The international orchid horticultural trade and conservation: the current situation and the potential for future collaborations

Hinsley Amy ¹, Roberts David ¹

¹ : Durrell Institute of Conservation and Ecology, University of Kent (DICE)
Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Marlowe Building, Canterbury, Kent, CT2 7NR
http://www.kent.ac.uk/dice/

Demand from the orchid horticultural trade is often implicated as a driver of wild orchid collection and has been linked to species extinction in the wild. However, horticulture also contributes a great deal to orchid conservation, whether it is providing seedlings for reintroduction projects, creating an alternative livelihood for people who may otherwise collect from the wild, or reducing the demand for wild plants by flooding the market with nursery-grown alternatives. For example, Orchid Seed Stores for Sustainable Use (OSSSU) collect seed from pollinations made in private and garden collections, which is then used for conservation work and seed banking. This paper presents an overview of the current relationship between horticulture and orchid conservation and explores ways to strengthen the links between the two in the future. Data on sales trends and buyer preferences were collected using surveys and interviews with hobbyists and professional growers online and at major international shows. In addition, the existing capacity of different countries to grow their own native orchids for the international market was mapped, allowing priority areas for the future development of orchid horticulture to be identified. We believe that by encouraging the view of the horticultural trade as an ally, orchid conservation could be greatly enhanced.
5 December 2013

Mycorrhizas for conservation

Vanilla

Conservation
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Diversity and distribution of mycorrhizal fungi associating with Caladenia in Western Australia.

Swarts Nigel 1,* , Phillips Ryan 3, Barrett Matthew 3, Dixon Kingsley 3

1 : University of Tasmania (UTAS)
Sandy Bay, Tasmania, 7005
http://www.utas.edu.au/
2 : Royal Tasmanian Botanic Gardens (RTBG)
Queens Domain, Hobart, Tasmania
3 : Botanic Gardens and Parks Authority (BGPA)
Fraser Ave, West Perth
* : Corresponding author

Caladenia is a diverse and widespread terrestrial orchid genus with over 100 species occurring in the global biodiversity hotspot of the south west Australian floristic region (SWAFR). Caladenia is known to be associated exclusively with the Sebacinaceae and is colonised in a highly localised position of the under-ground stem. The species richness of the genus and its distribution across a wide variety of habitats, soils and climatic regions provides a powerful opportunity to consider the influence of these factors on the diversity and distribution of its mycorrhizal associates. Using ITS DNA sequencing we assessed orchid mycorrhizal isolates of over 50 Caladenia species comprising four of the six subgenera, sampled from a wide variety of locations, habitats and climate regions. Phylogenetic analysis supported the presence of approximately 8 fungal species, with the more frequently detected species occurring across a wide range of habitats and climatic regions. A phylogenetic pattern of fungal use was detected, with some fungal species primarily associating with one orchid subgenus. Our results show that while some Caladenia are highly specific, the widespread distribution of the fungi suggests that the broad-scale distribution of mycorrhizal fungi is unlikely to be responsible for the pattern of short range endemism seen in many Caladenia.
Unravelling the functional role of mycelial networks in orchid mineral nutrition

Newman Belinda 1, Dixon Kingsley 1,2, Read David 1,3, Lambers Hans 1

1 : School of Plant Biology, University of Western Australia
   35 Stirling Hwy, Crawley, WA 6009, Australia
2 : Botanic Gardens and Parks Authority (BGPA)
   Fraser Ave, West Perth
3 : Department of Animal and Plant Sciences, University of Sheffield
   Department of Animal and Plant Sciences, The University of Sheffield, UK

The Orchidaceae is the largest plant family on earth, currently estimated at c. 25,000 species distributed globally. With a fascinating array of evolutionary and morphological quirks, they have been the focus of scientific research for over 150 years. However, orchid research focused on below-ground interactions has only occurred in the last fifty years, and it is surrounding the role of the orchid-mycorrhizal link that the greatest knowledge gaps still exist. There has been a long-held assumption, that due to the greatly reduced root system in many orchids, they are highly dependent on mycorrhizal fungi for mineral nutrition, however this has rarely been tested experimentally. Pioneering work on a handful of European orchid species has provided insights into the function of mycelial networks in capturing and transport nutrients to orchids. Work is now being completed on a range of terrestrial orchids from Australia that cover the spectrum of common to rare, all major infection patterns and four of the major orchid fungal associates. We hypothesise that orchid mycorrhizal fungi behave in a similar manner to other mycorrhizal symbioses, by supplying phosphorus to the plant in return for carbon. We also investigate the ability of OM fungi to forage preferentially for different sources of phosphorus. We present preliminary findings and discuss how unravelling the function of the orchid-fungus relationship should help develop improved outcomes for orchid conservation.
Within the Orchidaceae the usually mutualistic mycorrhizal symbiosis has been modified in different directions. Orchid dust seeds require fungal carbon and nutrient supply for germination and development in the early seedling stage without any obvious reward. This kind of nutrition is called initial mycoheterotrophy. About 200 orchid species have entirely lost the ability to photosynthesize and therefore are dependent on fungal supply throughout their life cycle. Their nutrition is known as full mycoheterotrophy. In addition, some green orchids have been identified as gaining carbon and nitrogen by autotrophic means and simultaneously by feeding on the fungal source. The nutrition of this group of orchids is called partial mycoheterotrophy. The fungus-plant interaction in carbon and nutrient exchange becomes even more complicated by the fact that different fungal groups are involved in orchid mycorrhiza. Partners of orchids can be ubiquitary saprotrophic fungi, wood-decay fungi or fungi that simultaneously form ectomycorrhizas with trees.

This presentation reports on a stable isotope meta data set collected over the last years that includes all orchid carbon and nitrogen isotope abundance data from the literature suited for distinction of different nutrition types. Based on their carbon and nitrogen isotope abundance patterns fully mycoheterotrophic orchids and partially mycoheterotrophic orchids associated with ectomycorrhizal fungi or fully mycoheterotrophic orchids associated with wood-decay fungi can nicely be distinguished. In addition, hydrogen isotope abundance data provide evidence that partial mycoheterotrophy can also be found among green orchids associated with saprotrophic fungi.
Located in remote South Florida within the Big Cypress Basin eco-region lies the 10,684 hectare Florida Panther National Wildlife Refuge (FPNWR). Many types of natural communities are present within the refuge ranging from hardwood (tropical) hammocks, wet prairies, and swamps that harbor considerable plant and animal diversity including 27 species of orchids. During the past 10 years, several orchid taxa have been studied there with respect to their ecological needs, including the recovery and use of mycorrhizal fungi to facilitate seed germination for conservation. As many ecosystems worldwide are being invaded by exotic (pest) species on an increasing scale, biological inventories of the native flora and fauna are urgently needed before these ecosystems become permanently altered. For example, within the FPNWR, at least two non-native orchids have appeared with increasing frequency - Oeceoclades maculata and Eulophia graminea, from Africa and Asia, respectively. We report the isolation and tentative identification of mycorrhizal fungi from six orchid species acquired from the FPNWR in 2013. Four of these species are well-known native epiphytes (Dendrophylax lindenii, Epidendrum amphistomum, E. rigidum, Prosthechea cochleata), and two are terrestrial exotics (E. graminea, O. maculata). These fungal isolates have tentatively been identified as common basidiomycete associates (e.g., Ceratobasidium and Tulasnella). Efforts are underway to confirm their identity using ITS sequencing followed by permanent deposition into UAMH (Canada) for safekeeping and future use. This talk will present an overview of these new mycorrhizal strains, as include a synopsis of the previous isolates secured from the FPNWR over the decade.
Exploring symbiotic interactions in New Zealand terrestrial orchids to enable their conservation

Frericks Jonathan 1*, Munkacsi Andrew 1, Ritchie Peter 1, Lehnebach Carlos 2

1 : Victoria University of Wellington
PO Box 600 Wellington 6140 NEW ZEALAND
http://www.victoria.ac.nz/home/default
2 : Museum of New Zealand Te Papa Tongarewa
PO BOX 467 Wellington
* : Corresponding author

The Orchidaceae family in New Zealand (NZ) has >39 species on the list of Threatened and Uncommon Plants of NZ. Little work has been conducted on the mycorrhizal partners they required for their recruitment. This study aims to implement and develop methods used overseas to discover mycorrhizae of a range of NZ orchids. Fungi were isolated and cultured from roots of Microtis unifolia, Pterostylis patens, Simpleglottis cornuta, Simpleglottis valida, Spiranthes novae-zelandiae and Thelymitra longifolia. The diversity of recovered fungi was revealed using ribosomal DNA markers (ITS1?5.8S?ITS2 and 28S) using the primer pairs ITS1F?ITS4, ITS1a? ITS4-Tul, ITS1-OF?ITS4-OF, LR0R?LR7. These fungi belong to three phyla: Ascomycota, Basidiomycota and Zygomycota. An in vitro experiment was prepared to demonstrate the ability of 36 identified fungal isolates to facilitate germination of M. unifolia, P. patens, S. novae-zelandiae, and T. longifolia. Germination of inoculated and uninoculated seed will be scored after 12 weeks, currently at 5 weeks. An in situ experiment was prepared to demonstrate the germination success of M. unifolia and T. longifolia seeds at varying distances from established plants of each species. Permeable (pore size 90µm) seed packets were buried at 0cm, 25cm, 50cm and 100cm along transects originating from established plants. Germination will be scored after 12 weeks, currently at 6 weeks. FDA staining was used to assess seed viability before germination experiments were set up. The outcome of this study will contribute to orchid conservation efforts by enabling propagation and translocation of endangered NZ orchids.
Conservation of critically endangered orchids from the central highlands of Madagascar: results from the first of a five year project

Thixton Hana 1*, Edwards Korrie 1, Sandford Helen 2, Kendon Jonathan 2, Stice Andrew 1, Rajaovelona Landy 3, Cable Stewart 2, Zettler Lawrence 1*, Sarasan Viswambharan 2

1 : Orchid Recovery Program, Illinois College
   1101 West College Ave, Jacksonville, IL 62650
   http://www.ic.edu/default.aspx?RelID=618786&issearch=orchid%20recovery%20program#item618939

2 : Royal Botanic Gardens, Kew
   Richmond, London, Surrey TW9 3AB
   http://www.kew.org/index.htm

3 : Kew Madagascar Conservation Centre (KMCC)
   Antananarivo
   http://www.kew.org/science-research-data/directory/teams/madagascar/

* : Corresponding author

Few regions harbor more endemic species than Madagascar. Of the island’s 12,000 vascular plant species, 80% are found nowhere else on earth, and among the Orchidaceae, 90% of the family’s 1,000 species are endemic. In the central highlands, a number of critically rare orchids have been the subject of interest in recent years by conservationists. These orchids consist of epiphytes in forest remnants, terrestrials near standing water, and lithophytes on sun-exposed rocks. In 2012, a collaborative 5-year research project was initiated between Illinois College and the Royal Botanic Gardens, Kew, aimed at studying selected critically endangered orchids from the region. Among the aspects investigated include: 1) isolation and use of mycorrhizal fungi to augment orchid population size, 2) the use of seeds as fungus «baits» to acquire fungi that facilitate germination in situ, and 3) development of seed germination protocols leading to seedling reintroduction. Approximately 75 taxa were targeted for study the first year, including several noteworthy Angraecum species (e.g., A. longicalcar, A. protensum, A. magdalenae), as well as species of Aerangis, Bulbophyllum, Cynorkis, Eulophia, Habenaria, Jumellea, and Polystachya, among others. In June (2012), root segments and/or mature seeds from 19 taxa spanning 6 genera were collected for mycorrhizal fungus isolations, seed viability assessment, and seed germination on asymbiotic media: Angraecum (8 spp.), Bulbophyllum (2), Cynorkis (1), Eulophia (1), Jumellea (4), Polystachya (3). This talk will present an overview of some of the results we acquired the first year.
Mountain regions with high plant diversity are particularly rich in orchids, but the dominant trophic strategies (e.g. autotrophy, partial, or full mycoheterotrophy) of montane orchids are not known. We screened orchids in the Northern Limestone Alps of the Austrian province of Vorarlberg for their nutrient gains and fungal partners across habitats. Leaf samples and root fragments of 15 orchid species from 13 genera in the subfamilies Epidendroideae and Orchidoideae, and accompanying autotrophic non-orchid plants as references for site conditions, were collected at 11 locations ranging from closed forests to open meadows. Stable isotope natural abundance analyses were conducted to test whether carbon (C), nitrogen (N) and hydrogen (H) are gained through autotrophic means or via mycorrhizal fungi. Mycorrhizal fungi from the orchid roots were identified by molecular methods. As expected, our results show that full mycoheterotrophy occurs only in the light-limited forest dweller dependent on ectomycorrhizal fungi (Neottia nidus-avis, Epidendroideae). In contrast, most green meadow orchids mycorrhizal with saprotrophic rhizoctonias have low N gains and apparently no C gains from fungi. Nonetheless, multi-element isotope signatures including H isotope composition indicate that some green meadow orchids rely on partial mycoheterotrophy. Thus, adding H isotopes to C and N isotope signatures provides a higher resolution in assorting trophic strategies in adult orchids.
Mycorrhizal fungi from mature roots and young seedlings of critically endangered orchids of Madagascar--first documentation from the Indian Ocean island

Knight Audrey 1*, Kendon Jonathan 2, Stice Andrew 1, Yokoya Kazutomo 2, Rajaovelona Landy 3, Ratovonirina Gaëtan 3, Corey Laura 1, Zettler Lawrence 1*, Sarasan Viswambharan 2

1 : Orchid Recovery Program, Illinois College
   1101 West College Ave, Jacksonville, IL 62650
   http://www.ic.edu/orchidrecoveryprogram

2 : Royal Botanic Gardens, Kew
   Richmond, London, Surrey TW9 3AB
   http://www.kew.org/index.htm

3 : Kew Madagascar Conservation Centre (KMCC)
   Antananarivo
   http://www.kew.org/science-research-data/directory/teams/madagascar/

* : Corresponding author

In the second year (2013) of a five-year collaborative project aimed at recovering critically endangered orchids in Madagascar, a vigorous attempt was made to isolate and identify mycorrhizal fungi, with emphasis on peloton-forming fungi from small seedlings. More than 100 taxa were targeted, ranging from epiphytes, terrestrials, and lithophytes collected from seven different regions and habitats in the central highlands. During April and May (2013), shortly after the rainy season, orchid-rich substrates were closely inspected for young seedlings and root pieces were detached, placed into vials, and promptly returned to labs at Kew and Illinois for fungal isolations. Root pieces from mature orchids (n = 3 per species) were also obtained for this purpose. Mature and unripe capsules were also collected for long-term experiments, namely involving symbiotic and asymbiotic seed germination, respectively. Our combined efforts yielded (so far) several promising strains of orchid mycorrhizal fungi tentatively assignable to common basidiomycete genera Ceratobasidium and Tulasnella, primarily the latter. The orchids that yielded these fungi include terrestrials, epiphytes, and lithophytes, among others. Of particular interest was the prevalence of active pelotons in seedlings of at least one epiphytic species, lending support to the hypothesis that tree-dwelling orchids continue to utilize mycotrophy after initiating leaves. Efforts are underway to verify the identification of these isolates using ITS sequencing. To our knowledge, this is the first report that documents orchid mycorrhizal fungi from Madagascar.
Microorganisms associated with orchid roots, and their role in orchid seed propagation

Tsavkelova Elena 1*, Egorova Marija 1, Kolomeitseva Galina 2, Netrusov Aleksander 1

1 : Moscow State University, Faculty of Biology, Department of Microbiology
   1-12 Leninskie Gory, 119991, Moscow
2 : Main Botanical Garden of the Russian Academy of Sciences
   Botanitcheskaya ul. 4, 127276, Moscow
* : Corresponding author

Understanding of interactions between the host-plant and its associated microorganisms is of special importance, particularly in orchid cultivation under the artificial conditions of greenhouses. Interactions between orchids and mycorrhizal fungi have been studied for a long time, although little is known about orchid «satellite» bacteria and their role in plant development. We showed the abundance and difference in composition of microbial communities inhabiting epiphytic and terrestrial plants, depending on the root type (aerial/substrate) and environmental surroundings. Velamen is a comfortable econiche for autotrophic and diazotrophic cyanobacteria: isolated strains of Anabaena, Nostoc, Scytonema and Calothrix revealed their high nitrogen fixing capacity that is essential for epiphytic plants. Among Fusarium strains, F. proliferatum was active in production of plant growth stimulators - auxin and gibberellins. Interestingly, the ways of their biosynthesis differs from those known for pathogenic strains, indicating a possible connection to its endophytic lifestyle. Among several investigated orchids (genera of Calanthe, Dendrobium, Acampe, Phalenopsis, Pholidota, Paphiopedilum) the most often isolated heterotrophic bacteria were Arthrobacter, Bacillus, Caulobacter, Flavobacterium, Microbacterium, Mycobacterium, Paenibacillus, Pseudomonas, Rhizobium, Rhodococcus, Sphingomonas, Streptomyces. DGGE (denaturating gradient gel electrophoresis) allows detecting more rare species: Erythrobacter, Dokdonella, Telluria, Dyella, Ohtaekwangia. Some of isolated bacteria were shown to produce high amounts of indolil-3-acetic acid. Bacillus sp., Sphingomonas sp. and Mycobacterium sp. were active in stimulating orchid seed germination, which took place in the absence of mycorrhizal fungus or any of plant growth regulators. Treatment of the orchid seeds with IAA-producing microbial cultures is helpful and advantageous for orchid propagation and conservation.
More than 220 species of native orchids have been found in Singapore. Many have since disappeared because of habitat destruction. Fortunately, some 60 species can still be found in the country. Most of them grow in nature areas such as the primary and secondary forests of the Central Catchment Nature Reserve. The Orchid Conservation Programme, which started in 1995, aims to monitor existing species, explore ways to conserve their germplasm, and increase their numbers through reintroduction into appropriate habitats, including roadside trees, in parks and nature areas. Planting native orchids in both nature and urban areas helps to enrich the biodiversity in our island-state. We are also in the process of learning how to use native orchids to landscape our parks and gardens, and to study which species are suitable for specific environments. To date, our repopulation and reintroduction efforts have been largely successful. Several reintroduced species have produced seed capsules naturally. We hope that once these seeds are mature, the wind will disperse them successfully into environments where the seeds can germinate, the seedlings can develop and the plants can grow. If that happens, it means our native orchids are able to grow without our help, and natural populations will take root again! Singapore's natural biodiversity will thus be richer for it. In this talk, you will be introduced to the beautiful orchids of Singapore, how the conservation work is carried out, and some of the horticultural considerations and challenges involved in the reintroduction efforts.
Mauritian Forests and Orchid Status

Bhoyroo Vishwakalyan

**Institution:** University of Mauritius

Following colonization by man, mainland Mauritius has gone through a rapid decline in forest cover, to about only 2% left within four centuries. Consequently, this led to rapid extinction of several plant and animal species. Colonisation had two main impacts on the forest: 1) depletion in forest cover for agriculture and urbanization and 2) introduction of invasive plants species and wild animals. Of the 89 orchid species recorded in Mauritian forests, nine species are endemic and mostly restricted to few forest areas in the humid zones and isolated mountain peaks which still harbor some of the forest patches. Some threatened orchid species like *Angraecum cadetti* and *Angraecum eberneum* have been successfully mass-propagated and re-introduced to the wild. Wild guava (*Psidium cattleianum*), a fruit that is enjoyed by Mauritians, is the most dominant plant species in Mauritius, though exotic. Recent survey carried out revealed a density of more than 20 wild guava individuals per m² in some forest areas. Wild guava invasiveness was mainly enhanced by animal vectors such as wild boars. Indigenous tree species struggle to propagate through the densely occupied guava trees. This lack of indigenous tree species, lead to a reduced availability of host plants and contributed to the decline of orchid species. With the government’s vision to restore and protect our biodiversity, a “*National Biodiversity Strategic and Action Plan (NBSAP)*” was developed for the conservation of our endemic flora. Some forest areas were cleared off of all wild guava species and indigenous species re-introduced. These areas were fenced and monitored daily to minimize of invasion by exotic plants species and will also inhabit endemic orchid species.
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The past two decades have seen a significant increase in the number of systematic studies focused on Vanilloideae, a subfamily that represents one of the earliest diverging lineages of Orchidaceae. The fourteen recognized genera are members of two tribes: Pogonieae (Duckeella, Cleistes, Cleistesiopsis, Isotria, Pogonia) and Vanilleae (Epistephium, Éraxios, Clemeniptephium, Lecanorchis, Galeola, Cyrtosia, Erythrorchis, Pseudovanilla, Vanilla). Attempts to reconstruct the phylogeny of the subfamily using molecular data and to estimate the age and historical biogeography of the lineages has been a challenge because of high levels of sequence divergence, reduction of the plastome within mycoheterotrophic taxa, rarity of plant material, and discordance among gene trees. Some age estimates indicate that Vanilloideae is younger than previously hypothesized, but this claim and the problem of working with widespread, but rare and relictual species continue to shroud Vanilloideae in mystery. Nevertheless, appreciation for vanilloid diversity, especially within the larger genera (e.g., Vanilla, Cleistes, and Epistephium) has grown and has important implications for conservation. In particular, the recent taxonomic treatment by the late Mexican botanist Miguel Soto has done much to advance the systematics of Vanilla. Vanilloideae may be best known as the subfamily within which Vanilla is classified, but several of the other lesser-known vanilloid genera are equally interesting and in need of conservation priority efforts, especially as researchers begin to take phylogenetic diversity, not only species richness, into account when mapping biodiversity hotspots.
Vanilla is an emblematic patrimonial and endemic resource for tropical EU regions, combining high socio-economic value with a natural image due to its traditional and sustainable mode of production and processing. Tropical EU regions offer a unique opportunity to study the genus in its global biodiversity. The challenge of vanilla sustainability relies on three capacities: protecting wild Vanilla through conservation and study, using our knowledge of this biodiversity to diversify the quality of the vanilla product, and improving cultivated vanilla (aroma, disease resistance, agronomy). The five partners involved in VaBiome share Vanilla genetic resources, biodiversity management and development skills as well as scientific expertise to attain two objectives: scientifically-sound actions for the preservation of vanilla wild genetic resources in tropical EU (ex situ and in situ) and identification of traits wild species may offer for improving cultivated species and the sustainability of vanilla production.

We are inventorying and characterising (genetic, phenotypic, mechanisms of evolution and diversification) the wide range of cultivated and natural Vanilla genetic resources in tropical EU. We also assess important agronomical traits in these species (aroma, resistance to viruses and fusarioses), and how these traits can be combined through hybrid breeding (V. xtahitensis x V. pompona). Novel candidate-gene markers are developed for improvement strategies. In each region, the stakeholders of biodiversity management and sustainable development are present as partners, key to implementation of these two aspects.

VaBiome will contribute to structuring long-term international conservation of this diversity as well as the exploitation of this beloved aromatic product.
The genus Vanilla Plum. ex Mill. (Orchidaceae) is represented in South Asia (India, Bangladesh and Sri Lanka) by 6 species: V. albida Blume, V. moonii Thwaites, V. parishii Rchb. f., V. sanjappae Rasingam, R.P. Pandey, J.J. Wood & S.K. Srivast., V. walkeriae Wight and V. wightii Lindl. ex Wight. Of this, two (V. walkeriae and V. wightii) are leafless forms and the rest are leafy forms. V. andamanica Rolfe is here understood to be a synonym of V. albida Blume, while V. parishii Rchb. f. is reconsidered here as a good species and very different from V. aphylla Blume to which it has been, of late, synonymised. Both V. walkeriae and V. wightii occur in two states in South India and Sri Lanka. V. moonii is a very rare species, endemic to Sri Lanka, while V. parishii occurs in India, Bangladesh and Myanmar. V. albida spreads from the Andaman Islands to Sumatra and Java. A key to the South Asian species is provided with status, descriptions and sketches and the orchid conservation efforts at JNTBGRI are highlighted with special emphasis on the Vanilla farm which has many accessions of germplasm including Vanilla pompona subsp. grandiflora (Lindl.) Soto Arenas and variegated forms for breeding and other studies. Commercial cultivation of Vanilla planifolia in South India and its problems and prospects are also described.
Endophytes are ubiquitous and have been found in all plant species. However, the fungal endophytes present and their diversity in Vanilla planifolia have not been characterized before. As such, seven regions under vanilla culture in Réunion Island were chosen. Organs were then sampled from the seven regions such as eight months old pods, leaves at ranks 1, 3, 5 and 15. Pods from shade houses and on the field were collected from two zones. Scalded pods coming from two regions of Réunion Island were also sampled. From all the sampled organs, fungal endophytes were isolated, identified and their distribution and diversity evaluated. Results indicate that the most represented fungal class was Sordariomycetes. Moreover the fungal transmission method was established to be horizontal. Fusarium proliferatum was ubiquitously present (40% of total isolated strains) across regions and organs. Leaf age largely affected the fungal population encountered. From all organs assessed, the pods had the highest fungal diversity. The endosymbiont community of pods was modified in favor of thermophiles due to post-harvest processing (scalding). However, plants under shade house conditions at St. André harbored a greater diversity of endophytes than those cultivated in the field. Such an empirical observation was attributed to a higher wetting frequency under shade house conditions. As a consequence, this work shows that several fungal endophyte species inhabit vanilla plants and may be involved in biochemical reactions of the plant.
Assessment of genetic and pathogenic diversity of Fusarium isolates from the Indian Ocean area for the screening of resistance to root and stem rot in vanilla germplasm.

Koyyappurath Sayuj 1, Le Guen Roxane 1, Le Squin Sandrine 1, Gauheron Nadine 2, Hermann Véronique Edel 2, Peribe Jimmy 3, Steinberg Christian 2, Liew Edward C.y 4, Alabouvette Claude 5, Besse Pascale 6, Grisoni Michel 1*

1 : Peuplements végétaux et bioagresseurs en milieu tropical (CIRAD UMR-PVBMT)
7 Chemin de l'IRAT, 97410 St . Pierre
http://umr-pvbm.cirad.fr
2 : UMR Agroécologie, INRA
Institut national de la recherche agronomique (INRA)
17 rue Sully, 21065 Dijon
3 : Provanille
21 RN 2, 97412, Bras Panon.
4 : The Royal Botanic Gardens and Domain Trust
Mrs Macquaries Road, Sydney NSW 2000
5 : ARGENE
ARGENE
47 Rue Constant Pierrot, 21000 Dijon
6 : Peuplements végétaux et bioagresseurs en milieu tropical (PVBMT)
Faculté des Sciences et techniques - Université de La Réunion 15 avenue René Cassin CS92003 97744 SAINT DENIS CEDEX 9
http://umr-pvbm.cirad.fr
* : Corresponding author

Root and stem rot of vanilla caused by Fusarium oxysporum f. sp. vanillae (FOV) is one of the most important constraints to vanilla cultivation all over the world. Breeding for resistance is considered the best approach to control Fusarium diseases, but until now, very few sources of resistance to FOV have been identified in the vanilla genetic pool. With the aim of screening vanilla germplasm for resistance to FOV, the two crucial factors, i.e. the choice of challenge isolates and the inoculation procedure, were investigated. In the present study, 118 Fusarium isolates collected from diseased vanilla plants in the Reunion Island (108), Madagascar (6) and Indonesia (4) were genotyped by elongation factor1-? gene and intergenic spacer region sequencing, and evaluated for pathogenicity using V. planifolia (CR001) as susceptible host. The majority of the isolates belonged to F. oxysporum (78%) and F. solani (10%). Among the various inoculation methods tested, root dipping of in vitro plants in a 10 6 conidia/ml suspension of the fungal isolate proved to be fast and reproducible. For the pathogenic isolates, symptoms appeared on the 4th day post inoculation and the plantlet was necrotic on the 14th day. The isolates were differentiated into highly pathogenic (16%), moderately pathogenic (22%), slightly pathogenic (19%) and non-pathogenic (43%), according to the area under the disease progress curve calculated on four replicates. The procedure used in this study is fast and robust for assessing the pathogenicity of Fusarium isolates and will enhance the search for FOV resistant vanilla.
What provide the low-copy nuclear genes to the phylogeny of the Vanilla genus.

Gigant Rodolphe 1*, Ahmed Ibrahim 2, Grisoni Michel 3*, Besse Pascale 2*

1 : Université de La Réunion (UR)
    7 ch. Irat, Ligne Paradis, 97410 Saint-Pierre, île de La Réunion
2 : Université de La Réunion (UR)
    15 av. René Cassin B.P. 7151 97715 St Denis Messageries cedex 9
3 : Cirad
    7 ch Irat, Ligne Paradis, 97410 Saint-Pierre, île de La Réunion
* : Corresponding author

The limitations previously encountered to resolve the phylogeny of closely related species of the genus Vanilla with chloroplast and nuclear ribosomal sequences led us to turn to low-copy nuclear genes. Several candidate genes involved in the phenylpropanoid pathway were integrated in the analysis and we focused particularly on their introns. We selected the main American, African and Asian Vanilla clades to cover the genus diversity and we included a large set of African leafless species, poorly resolved in previous phylogenies. The phylogenetic reconstructions were performed using maximum parsimony and Bayesian inference methods, then the tree topologies were compared to that obtained previously with chloroplast rbcL phylogenies. The results showed congruent phylogenies and the main taxonomic entities were robust, but the phylogenetic signal remained confused in recent genetic differentiations. Nevertheless, a careful examination of the alignments focusing on the introns gave us key elements for the selection of characteristic sequences which may enter into a barcoding strategy, to improve the identification of the wild Vanilla species particularly threatened in the Indian ocean sub-region.
A VpPAL-1 gene is positively correlated to maturation and vanillin accumulation during Vanilla planifolia pod maturation

Fock-Bastide Isabelle ¹, Palama Tony ¹, Bory Séverine ¹, Noirot Michel ², Joet Thierry ³

¹ : Université de La Réunion - UMR Peuplements Végétaux et Bioagresseurs en Milieu Tropical (UMR PVBMT)
Pôle de protection des plantes - 7 chemin de l'IRAT - 97410 St Pierre

² : UMR Peuplements Végétaux et Bioagresseurs en Milieu Tropical (UMR PVBMT)
Pôle de protection des plantes - 7 chemin de l'IRAT - 97410 St Pierre
http://umr-pvbmt.cirad.fr/

³ : IRD - UMR Diversité et Adaptation et Développement des Plantes (UMR DIADE)
Institut de Recherche pour le Développement
911 Av Agropolis BP64501 - 34394 Montpellier, FRANCE
http://www.ird.fr/

Numerous compounds related to the phenylpropanoid pathway constitute the so typical aroma of Vanilla planifolia. With its massive accumulation during maturation of the pod, vanillin is the major flavor precursor and the most popular flavors coming from the phenylpropanoid pathway. Because of its wide economic importance, its biosynthetic routes have been intensively studied but definitive evidence is still lacking. In order to explore the early steps of phenolic compounds biosynthesis, a few key phenylpropanoid genes expressed during pod development were identified and their mRNA accumulation profiles were evaluated from green to mature pods using real-time RT-PCR. As a prerequisite for expression analysis using qRT-PCR, the identification of reliable reference genes with stable expression during pod maturation was performed. Differential pattern of expression was observed between 3 to 8 months after pollination. A gene encoding a phenylalanine ammonia-lyase (VpPAL-1) was gradually up-regulated, reaching the maximum expression level at mature stage. Interestingly, this PAL isoform is strongly correlated with vanillin levels in pods, suggesting its direct involvement in vanillin biosynthesis in pod.
Vanilla, Vanilla planifolia Andrews., the source of natural vanilla, and native to Mexico and Central America. Cultivated vanilla outside Mexico has a narrow genetic base. The natural populations of vanilla species are declining making them endangered. Susceptibility to diseases is resulting in decline in productivity. The Linear Dependence of Stability on Diversity indicates that reduction in the number of species will result in lower stability of the genus. Many important agronomic characters are present in wild species. V.aphylla and V.andamanica has tolerance to Fusarium and Phytophthora. V.pilifera flowers were fragrant, V. wightiana and V.andamanica showed signs of natural pollination. The species of Orchidaceae are highly amenable to inter specific / generic hybridization. This gives us avenues for converging the useful genes from wild species into cultivated vanilla. The advances made using in vitro technology for multiplication, conservation and utilization of Vanilla and its related species are presented in this paper. Techniques like micropropagation, synthetic seed, slow growth and cryopreservation, helped in the conservation of vanilla germplasm. Pollen from two asynchronously flowering species of Vanilla viz., cultivated V. planifolia and its wild relative V. aphylla, were cryopreserved, retrieved and successfully used in inter specific hybridization. This system is can be used for conserving the haploid gene pool of Vanilla in cryobanks. DNA markers helped in better understanding of the genetic diversity and species inter relationships. The in vitro techniques standardized open up new vistas in the improvement an important orchid of vanilla
Among orchids, the Vanilla genus is of special interest because several species bearing aromatic fruits are highly demanded by the food and perfume industries. About one hundred species are currently recognized in this genus that has evolved in the tropical regions of America, Africa and Asia. A number of these species are presently threatened in their native area because of the destruction of their habitats. This is especially the case for V. planifolia, the economically most valued species, whose resources are very scarce in the wild, and diversity in the cultivated plots, in addition to be very limited, is often overlooked.

In 2003, the CIRAD engaged a program with partners aimed at gathering, characterizing, and making available to the community, the diversity of the vanilla resources. Those were the premises of the Biological Resources Center named VATEL which was established in Saint Pierre (La Réunion).

Here, we will review the methods and technologies that are continuously developed at the BRC VATEL in order to improve the preservation of the vanilla genetic resources and facilitate their exchange, dealing with cultivation procedures, taxonomic identification, conservation biotechnologies, sanitation practices, data management, and quality insurance.
6 december 2013

Population dynamics

Biogeography

Habitat restoration/translocations

Biological invasions
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<td>› In plain sight: Using herbaria and entomological collections to establish host range of herbivores associated with wild orchids. - Marilyn H. S. Light, Retired</td>
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We have been monitoring a population of several hundred plants of Cypripedium reginae (Walter) in a 10 ha densely wooded complex wetland in Gatineau Park, Québec, Canada for the last 11 years. The majority of the plants found were within 30 m of the wet edge: on searching deeper into the wetland, the habitat became clearly inappropriate for this species. Within the peripheral band, the distribution of plants was highly heterogenous: close-packed assemblages were separated by sparser distributions and extended empty stretches. Plant locations were mapped by GPS, local clusters being further delineated by distance and bearing surveys. Patches were initially identified as clearly separated geographic blocks, and further refined and subdivided based on distributions of inter-plant distances between near-neighbours. Twelve major patches were so circumscribed, with a further seven sub-patches of locally contiguous plants being evident within five of these. Inter- and intra-patch comparisons of vegetative, flowering and fruiting behaviours, and of infestation by two phytophagous insects, showed significant heterogenities. The parameters examined included stems per plant, proportions of stems flowering and of double flowering, capsule set from matured flowers, and insect infestation rates. This study suggests that it is important to consider the effect of local hot-spots in developing models of population forecasting.
Contrasted responses of orchid occurrence between community and species level to the vegetation dynamics in Mediterranean region: first lessons from a 30 year long sampling interval using a Site-Occupancy Model

Vogt-Schilb Hélène 1*, Geniez Philippe 2, Pradel Roger 1, Richard Franck 1, Schatz Bertrand 1

1: Centre d’écologie fonctionnelle et évolutive (CEFE)
CNRS : UMR5175
Campus CNRS - 1919 route de Mende - 34293 Montpellier cedex 5
http://www.cefe.cnrs.fr/

2: Centre d’écologie fonctionnelle et évolutive (CEFE)
École Pratique des Hautes Études [EPHE]
Campus CNRS - 1919 route de Mende - 34293 Montpellier cedex 5
http://www.cefe.cnrs.fr/

*: Corresponding author

There is an increasing interest in understanding and evaluating shifts in biodiversity induced by the ongoing global change. Orchids are particularly relevant organisms to investigate diachronic variations because they respond to anthropic pressure (land-use change, habitat fragmentation, etc.). Here we used a Site-Occupancy Model in order to describe the dynamics of orchid occurrence in Corsica at community and species level, and evaluate the influence of land-use change on orchid occurrence. We compared the occurrence of 45 orchid species at 62 locations in Corsica between 1982-1984 and 2009-2011. Data were collected by the same observer during the two sampling periods applying the same protocol of species inventories. We considered environmental factors and species biological traits as co-factors in the Site-Occupancy Model to estimate the probability of species detection. At community level, we found no significant difference in orchid occurrence between the two sampling periods, in contrast to the species level. Species responded differently to the increase of vegetation cover. We concluded that (i) conservation strategies should be species-dependent, as we observed contrasted responses to the land-use change between species, and (ii) that the use of Site-Occupancy Models is an appropriate way to analyze temporal dynamics of orchids and to investigate the ecological processes underlying these dynamics.
In plain sight: Using herbaria and entomological collections to establish host range of herbivores associated with wild orchids.

Light Marilyn H. S. 1*, Macconaill Michael 1

1 : Retired
174, rue Jolicoeur, Gatineau QC J8Z 1C9
* : Corresponding author

Long term study of terrestrial orchids in Gatineau Park, Québec, Canada, has provided insight into the diversity and incidence of insect herbivores including a leafminer, Parallelomma vittatum. Infestations can easily be missed given their irregular presence and patchy distribution. While an occasional blotch mine within one large leaf of Cypripedium reginae might not be cause for concern, a mine occupying one of the two smaller leaves of Listera (syn. Neottia) spp. could limit the plant’s photosynthetic potential. Reared adult insect specimen data led to the identification of Neottia cordata as a possible host. Herbarium and entomological specimens together have provided biological and historical evidence of leafminer incidence and range: herbarium specimens of Neottia have revealed a further three species as hosts. Once insect biology has been established, herbarium specimens could be used to identify additional hosts in both a geographic and an historic context.
KwaZulu-Natal (KZN) is a small province (92,100 km²) but diverse province situated in the south east of South Africa. There are 289 species of orchids known to occur in KwaZulu-Natal of which one is listed on the National Red List (IUCN) as critically endangered, four are listed as endangered and eight are listed as vulnerable. Listing is based on the available data mostly derived from herbarium specimens which in most instances, refer only to the location of a plant with very little information on population size and extent. These data are therefore insufficient to understand status and trend in orchid populations and from this prioritise species for conservation action.

To address this, the approach developed and implemented for surveillance and monitoring comprises three levels of intensity:

1. Known common wide spread species of little conservation concern - on-going collection and collation of sighting and specimen records with visual estimates of local abundance.
2. Restricted distribution but locally common species - 'random meander' sampling, recording distribution and abundance at known localities.
3. Highly restricted rare species - intensive and frequent sampling (normally annual) of known localities to assess changes in the number of sub-populations, area of occupancy and abundance.

Once enough information is available to set conservation targets and develop management interventions to improve the status of the species a monitoring plan is developed to evaluate progress towards meeting the management objective or target.
The role of seed dispersal and colonization in orchid conservation

Trapnell Dorset 1

1 : University of Georgia, Plant Biology Department (UGA)
2502 Miller Plant Sciences Bldg. Athens, Georgia 30602
http://www.plantbio.uga.edu/about/botinfo/

Orchids are increasingly threatened by various factors not least of which is anthropogenic habitat disturbance. Even in pristine habitats orchids experience considerable spatial heterogeneity of substrates suitable for colonization and establishment, which renders them potentially more vulnerable to habitat disturbance. Understanding factors that effect and limit colonization by orchids can have important conservation implications. Considering the long distance dispersal potential of the dust-like wind-dispersed seeds characteristic of orchids, the expectation is that as long as suitable substrate and appropriate mycorrhizal fungi are available, long distance dispersal and effective colonization by multiple genetically varied seeds should be common. To test this we use genetic analyses to discern the prevailing pattern of colonization by four Neotropical species of orchids: two epiphytic and two terrestrial species. Leaf samples from multiple populations were assayed for their neutral multi-locus allozyme genotypes. Spatial autocorrelation analyses and a hierarchical analysis of molecular variance were used to assess the relatedness of individuals within and among populations. Results show that there are often significant levels of relatedness within populations and much lower values among populations in relatively close proximity (e.g., the same pasture). Our data suggest that colonization of new populations is often by few individuals with subsequent in situ population expansion and that colonists within a population are not a random sample of the regional seed pool. These results have important ramifications for understanding the conservation measures needed for these species as well as other orchid taxa.
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Orchid tubers harvested from the wild in Turkey are used as both a food in the form of salep; a hot drink, and mara? dondurma; a chewy ice cream, and medicine. At least 30 different species of orchid are collected for consumption and the flour produced by grinding the tubers is called salep. The orchid family is listed on CITES (Convention on Trade in Endangered Species) and harvesting tubers from the wild in this region is considered unsustainable. With no current wide scale cultivation of the orchids used to make salep, trade relies on collection of tubers from the wild. There is a role for horticulture to develop the infrastructure and knowledge required for propagation of terrestrial orchids via seed within Turkey, in order to support orchid conservation. However cultivation of plants does not always reduce pressure on populations of wild plants that are collected. and people who harvest wild orchids may not be in a position to cultivate orchids, so cultivation may not be a viable alternative to the collection of wild plants. In south west Turkey most of the orchids used to make salep grow as wild plants within an agro-pastoral landscape of olive groves and grazed pine forests, which is threatened by development. Orchid conservation can be supported by conserving traditional use and management of orchid rich landscapes in Turkey.
Strengthening the taxonomic backbone of Thai orchid conservation: challenges and strategies

Pedersen Henrik ærenlund 1*, Watthana Santi 2, Bunpha Kanok-On 3, Srimuang Kanok-Orn 4, Suddee Somran 5

1 : Botanical Garden, Natural History Museum of Denmark, University of Copenhagen
Øster Farimagsgade 2C; DK-1353 Copenhagen K
2 : Queen Sirikit Botanic Garden
P.O. Box 7, Mae Rim; Chiang Mai 50180
3 : Department of Biology, Faculty of Science, Prince of Songkla University
Hat Yai; Songkhla 90112
4 : School of Agriculture and Natural Resources, University of Phayao
Phayao Province 56000
5 : Forest Herbarium; Department of National Parks, Wildlife and Plant Conservation
Chatuchak; Bangkok 10900
* : Corresponding author

An informative, transparent and operational classification is crucial for any red-listing activity or science-based conservation strategy. The ongoing preparation of the Orchidaceae for Flora of Thailand constitutes the third complete revision of this family in Thailand (the previous works dating back to 1959?1965 and 1977?1988). Comparison of the three revisions of subfamily Orchidoideae (the Flora of Thailand account was published in 2011) confirms that both the second and the third revision were indeed worthwhile, as both of them provided comprehensive changes ? arguably improvements ? compared to the latest previous revision. Besides the high number of species in itself (c. 1200), the major challenges in the current project are: (1) large and geographically widespread genera that are difficult to survey; (2) poorly known species of doubtful taxonomic validity; (3) intricate species complexes that cannot be resolved through conventional revisions. Using examples, the strategies applied to address these challenges are presented. They all involve studies and publications prior to the flora account itself and include, in corresponding order: (1) preparation of national revisions with emphasis on supplementary field work and a geographically broad search for matching taxa; (2) mapping the range of morphological variation in natural populations, followed by comparison with the range of variation recorded for putatively distinct relatives; (3) multivariate morphometric analysis and genetic fingerprinting. It is discussed how the new insights concerning species delimitations, range sizes and patterns of occurrence should influence conservation priorities; and a plea is made for expanded collaboration with flora projects in adjoining areas.
How to find determinants of species diversity in orchids?

Pavel Kindlmann

Department of Theoretical Ecology, Global Change Research Centre AS CR, and Institute for Environmental Studies, Faculty of Science, Charles University, Prague, Czech Republic

Efficient allocation of conservation resources will be achieved only if the priorities for biodiversity conservation – the “hotspots” – are correctly defined. To achieve this we need to pinpoint the main determinants of species diversity. The number of orchid species in a location depends mainly on its area, latitude, habitat heterogeneity and connectivity with other potential orchid habitats with area being the most important. It is well known that the number of orchid species is a power function of area (species-area relation), while the number of orchid species may depend linearly on the latter factors. I will explain methods, how to evaluate the importance of all the above-mentioned factors and how to calculate connectivity. The gist is that the influence of area is first factored out and the residuals correlated with the other factors using a stepwise linear regression.
Determinants of orchid species diversity in the Caribbean

Traxmandlová Iva 1*, Ackerman James 2, Tremblay Raymond 2, Kindlmann Pavel 1,3

1 : Department of Theoretical Ecology, Czech Globe AS CR
   Na Sadkach 7, 37005 Ceske Budejovice
2 : Department of Biology, University of Puerto Rico
   100 Carr. 908, Humacao, Puerto Rico, 00791-4300
3 : Institute for Environmental Studies, Faculty of Science, Charles University
   Benatska 2, 128 01 Praha
* : Corresponding author

The dependence of the number of orchid species in a location on its area, and habitat heterogeneity has been studied previously by Ackerman on a data set from the Caribbean archipelago. The relative importance of latitude and that of the total size of a location vs. the size of protected areas in the location as factors determining the number of orchid species in that location was studied by Schödelbauerová et al. The importance of connectivity with other habitats for determination of the number of orchid species in a location was, however, never tested. Here we reanalyze the dataset on the numbers of orchid species in the Caribbean archipelago that was previously used by Ackerman and add the connectivity to the analysis. We first fit the relationship between the number of orchid species in each island and the area of this island by a power function. Then we correlate the residuals with habitat heterogeneity and negative exponential connectivity with other potential orchid habitats using a stepwise linear regression. Habitat heterogeneity is measured (i) as the altitude of the highest point in the island, (ii) as the mean slope in the island, measured on 1x1km pixel scale. We then discuss the relative importance of individual factors.
On the orchid flora of the Seychelles islands

Chong-Seng Lindsay 1*, Senterre Bruno 1,2

1 : Plant Conservation Action group (PCA)
P O Box 392 Victoria
www.pcaseychelles.org
2 : Université Libre de Bruxelles (ULB)
50 Avenue F.D. Roosevelt, B-1050 Brussels
* : Corresponding author

The last comprehensive account on the Seychelles orchids dates from 1989, by Robertson, and was mostly based on literature synthesis. This document recorded 33 taxa: 20 natives and 13 introduced. The Seychelles orchids remain poorly studied and poorly collected. There is a need for more taxonomic studies, and more collections associated with cultivation in a nursery dedicated to the taxonomy of orchids. Here, we present a synthesis of the existing specimens (ca. 150) and sight records (ca. 500) of Orchidaceae in the Seychelles and we analyze their distribution within ecological groups and biological types. We also present the most problematic taxa needing more careful study.
The diversity of orchids in Ngong Hills has been monitored over the last 15 years where at least seven major exploration trips were accomplished. This paper describes the general vegetation of the forest and presents taxonomic descriptions, ecology and conservation status of its orchid flora. To date a total of 25 species of orchids in 13 genera have been recorded in the Ngong Hills. This includes Aerangis confusa J. Stewart, a new record for the area. The studies vary in the numbers of species recorded. Specific activities that may decimate the species were assessed and are presented. The decreasing frequency of recording certain species of orchids may indicate loss of habitat due to anthropogenic effects such as deforestation and forest encroachment. It may also indicate sensitivity of orchids to habitat changes, especially changes in their microclimate. Given the high diversity of orchid species, Ngong Hills forest is an important forest reserve for orchid conservation in Kenya. This forest should therefore be managed and protected preferably only for non-extractive use, such as ecotourism within it and its environs.
6 december 2013

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<td>14:00 - 16:00</td>
<td>Habitat restoration/translocations - Hanne Rasmussen &amp; Claudia Baider</td>
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14:00 - 14:20  › Impacts of habitat restoration on the terrestrial orchid community of a tropical island's wet forest. - Claudia Baider, The Mauritius Herbarium

14:20 - 14:40  › Orchid Conservation in Australia. Does the integrated conservation approach work? - Nigel Swarts - Royal Tasmanian Botanic Gardens, University of Tasmania

14:40 - 15:00  › Where the orchids live - Ventre-Lespiaucq Agustina, Sánchez Andrea, Otero Tupac, Flanagan Nicola

15:00 - 15:20  › Orchid conservation by an NGO, the case of Ambodiriana forest in Madagascar - Jean-Michel Hervouet, Société Française d'Orchidophilie, Chantal Misandeau, ADEFA

15:20 - 15:40  › A broader perspective on germination site requirements - Hanne N. Rasmussen, Institute of Geosciences and Nature Management
Impacts of habitat restoration on the terrestrial orchid community of a tropical island's wet forest.

Baider Claudia 1*, Mawlah Umar 2*, Florens F. B. Vincent 2*

1 : The Mauritius Herbarium (MAU)
RE Vaughan Building, MSIRI Compound, Reduit
http://agriculture.gov.mu/English/Pages/Agronomy/The-Mauritius-Herbarium.aspx
2 : University of Mauritius (UoM)
Department of Biosciences, Reduit
http://www.uom.ac.mu/faculties/fos/biosciences/
* : Corresponding author

Within the global effort to conserve biodiversity, habitat restoration is poised to progressively increase in importance owing to both the wide scale of habitat degradation and the benefits that restoring habitats are seen to bring in the recovery of threatened species. In this context, it is however important to carefully document the influence of restoration activities on different groups because these may not all respond in the same way. An understanding of the variety of these responses would help inform improvements through minimising detrimental impacts or maximising beneficial ones. We studied the influence that habitat restoration, in the form of control of invasive alien plants and fencing out of alien deer and feral pigs have on the guild of native terrestrial orchids in the best preserved wet native forests on the tropical island of Mauritius. This was done through random and replicated sampling in three adjacent zones of forest that were respectively not managed (the control), fenced only, and both fenced and weeded of invasive alien plants. The efficacy of the fencing in excluding large hoofed mammals was also assessed. The results did not show any tangible positive effect of the fencing on the ground orchids contrary to what was expected. Furthermore, the weeding appeared to be generally detrimental to the guild of ground orchids. This was linked to direct damage caused by the weeders but was also likely caused by indirect negative impacts linked to severe microclimatic changes following weeding. These results opened the way to test possible improvements.
Orchid Conservation in Australia. Does the integrated conservation approach work?

Swarts Nigel ¹,²*, Dixon Kingsley ³

¹ : University of Tasmania (UTAS) 
Sandy Bay, Tasmania, 7005 
http://www.utas.edu.au/

² : Royal Tasmanian Botanic Gardens (RTBG) 
Queens Domain, Hobart, Tasmania

³ : Botanic Gardens and Parks Authority (BGPA) 
Fraser Ave, West Perth, Western Australia

* : Corresponding author

Since the first IOCC in Perth, orchid conservation in Australia has made significant inroads. Where 10 years ago, we were contemplating the contents of a conservation program, today we are applying knowledge gained from a burgeoning global research into orchid biology to the process of orchid recovery. In an earlier review, we proposed an integrated approach to terrestrial orchid conservation incorporating research into key aspects of orchid biology with in situ and ex situ methods to ensure the long term preservation of orchids in their local habitat and an insurance bank of germplasm. In this presentation, we will review the success or failure of this approach, what we have achieved, lessons learnt and next steps. Integrated conservation approaches have been adopted in orchid conservation programs in each of the southern Australian states which contain predominantly terrestrial species, many of which are highly threatened. These programs generally contain the in situ monitoring and ex situ germplasm components, as these are usually the first to be funded and prioritized in threatened species recovery plans, however often the science to underpin the understanding of rarity or limitations to population recruitment and expansion are omitted. Here we demonstrate the advantage of adopting a complete integrated approach and the opportunities it presents to long-term species preservation. The programs in Australia provide potential road maps for engaging in conservation of terrestrial orchids globally.
Tropical twig-epiphytic orchids experience high exposure to light, wind, pollinators, predators, parasites and seed dispersal. Abiotic and biotic factors play crucial roles in orchid survival and reproduction, and sustained human intervention may alter energy fluxes and ecosystem structure and composition. The degree of canopy cover determines the amount of radiation available for epiphytes. Therefore, established, adult orchids may develop strategies at the leaf and individual level for maximizing light interception. We have studied leaf light-responsive traits of a tropical twig epiphyte, Rodriguezia granadensis (Oncidiinae), in response to local light environment, in two populations growing on Psidium guajava trees in an intervened zone of the Yotoco Forest Reserve, Valle del Cauca, Colombia. One population was growing on isolated trees in a cattle farm and the other in a south-facing forest edge with 15 years of no intervention since forest fragmentation. Additionally, we censed fruit presence as a proxy of reproductive success. The study was conducted during the wet season to minimize the impact of water stress. In both populations we found that leaf area and orientation locally maximized light interception. Orchids had more pseudobulbs and leaves in the forest edge, but this did not translate into increased reproductive effort. Overall, 15% of censed individuals had fruit, and surprisingly, 90% of them were hosts of a parasitic wasp. These orchids seem to find suitable abiotic conditions in these habitats, but sexual reproductive success might be seriously compromised by biotic factors. Further research would clarify whether these interactions occur in non-intervened habitats.
Ambodiriana’s forest is located on the North East coast of Madagascar, near the village of Manompana. Once sacred, it was eventually threatened by slash and burn agriculture (tavy). Since 1996, it has been protected by the «Association de Défense de la Forêt d’Ambodiriana » (ADEFA), under an agreement with the Malagasy Government (Ministère des Eaux et Forêts, de l'Environnement et du Tourisme). The agreement includes the forest corridors along River Manompana and its tributaries. A special care has been paid to the involvement of local communities and as a whole about 12 persons of Manompana are employed by the association. 25% of the income of the city municipality stems from ADEFA royalties generated by ecotourism and research activities. It is the key concept for a sustainable management. Though relatively small (230 km²), the forest boasts an amazing biodiversity, including a rich fauna of lemurs, amphibians, reptiles, insects and birds, and for plants palms, ferns, trees and orchids. Besides ecotourism, researchers regularly visit and study the forest. More than 85 species of orchids have been identified, and at least 3 others, a Gastrodia and 2 Bulbophyllum, are new to Science. The steady presence of local guides and rangers equipped with cameras and GPS help determine the flowering seasons. It becomes more and more blatant that protecting the small patch of Ambodiriana provides a sanctuary for a very large number of species. An overview of the orchid flora will be given in the presentation, e.g. Cynorkis lowiana Rchb.f., regular dweller of Ambodiriana cascades.
A broader perspective on germination site requirements

Rasmussen Hanne N. 1

1 : Institute of Geosciences and Nature Management (IGN)
Rolighedsvej 23, 1958 Frederiksberg C
www.science.ku.dk

Rasmussen HN1*, Dixon KW2, Jersakova J3, Tesitelova T4
1Forest & Landscape, Denmark, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg
C, Denmark. 2 The University of Western Australia and Kings Park and Botanic Garden, 3 Faculty
of Science, University of South Bohemia, Brani?ovska 31, 37005 ?eske Bud??jovice, Czech
Republic, 4 Department of Biodiversity Research, Global change Centre AS CR, Brno, Czech
Republic
*hnr@life.ku.dk

Seedling recruitment is essential to the sustainability of orchid populations. In conservation work,
attribution should be given to identifying all essential germination site requirements. During the
twenty years since seed packet techniques were introduced, more than hundred studies have been
carried out on orchid seed germination and seedling development in situ. We have carried out a
review of the results obtained so far. A great achievement has been the unequivocal identification,
for many orchid species, of their specific mycobionts during germination. It can thus also be
ascertained that relevant mycobionts may be available without necessarily leading to seedling
recruitment, which means that less obvious limiting factors need to be identified. The published
seed packet observations implicate both abiotic and biotic factors of possible importance: light/
shade, humidity, substrate, antagonistic fungi, seed predators and so forth. The overall picture
developing from the studies reviewed is one of extreme bottlenecks in life stage transitions, not
only from seed to seedling, but also during seedling development towards established plant.
Thus, a broad perspective on germination requirements needs to be taken in species conservation.
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<td>17:00 - 17:20</td>
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The impact of invasive alien plants on epiphytic orchids of a tropical island's wet forest.

Florens F. B. Vincent 1*, Mawlah Umar 1*, Baider Claudia 2*

1: University of Mauritius (UoM)
Department of Biosciences, Reduit
http://www.uom.ac.mu/faculties/fos/biosciences/

2: The Mauritius Herbarium (MAU)
RE Vaughan Building, MSIRI Compound, Reduit
http://agriculture.gov.mu/English/Pages/Agronomy/The-Mauritius-Herbarium.aspx

*: Corresponding author

The impact of invasive alien species is one of the major threats to plant biodiversity. Because alien plant invasion is progressing worldwide, highly invaded natural habitats like those on the oceanic island of Mauritius, might offer useful insights into what likely awaits other relatively less invaded areas. Furthermore, few studies have investigated the influence of invasive alien plants on native epiphytic orchids. We surveyed native epiphytic orchids within the best preserved tropical forest of Mauritius, located in the Black River Gorges National Park, to assess the influence that invasive alien plants (which comprised mainly of the strawberry guava Psidium cattleianum), had on these orchids. We compared the species richness, population density and structure, and spatial distribution of epiphytic orchids between adjacent native forest areas, which were in all respect similar to each other except for the presence or absence of invasive alien plants (that were controlled about a decade earlier). Areas weeded of invasive alien plants had more species and 20 times higher density of native orchids. The structure of populations in the weeded areas was indicative of strong regeneration, while those in the non-weeded areas were typically ageing. Epiphytic orchids could also grow closer to the ground in weeded forest. Despite presenting an abundant surface area of bark, invasive alien plants, were found to be virtually devoid of epiphytic orchids. Therefore, weeding of invasive alien plants did not represent any substantial loss of substrate to the orchids but has major positive effects on the native orchid community.
Alien orchids; how are they able to invade?

Pemberton Robert

1 : Florida Museum of Natural History
Atlanta, Georgia, USA U.S.D.A. Agricultural Research Service (retired) Courtesy Curator Florida Museum of Natural History

Invasive plants comprise 50% of Hawaii's flora and 30% of Florida's. Naturalized orchids, however, are a tiny portion of these invaders. Extremely low orchid naturalization occurs despite the Orchidaceae being the most speciose plant family, with great numbers or horticultural plants, particularly in tropical and subtropical areas such as Hawaii and Florida. Orchids are self-compatible and produce enormous numbers of seed, characteristics that can promote naturalization. The lack of appropriate pollinators and suitable mycorrhizae required for seed germination limit orchid naturalization. Examining the histories and characteristics of orchids that have naturalized in Florida suggest how, at least, some orchids species can invade. First, most all are horticultural escapes. Second, all are terrestrial, probably increasing the likelihood of encountering suitable mycorrhizae. Zeuxine strateumatica is apomitic and Oecoclades maculata has rain assisted self pollination, so neither need pollinators. Cyrtopodium flavum grows in rocklands, similar to its isoberg rock habitat in its native Brazil. C. flavum also has oil reward flowers pollinated by a naturalized Centris, an oil collecting bee congeneric with the orchid's Centris bee pollinators in Brazil. Phausis tankervilliae propagates vegetatively, is probably pollinated by Xylocopa bees, as it is in its native Asia, and might produce cliestogamious flowers. Bletilla striata is most likely pollinated by the ubiquitous honey bee as it is in Asia. The newly naturalized Eulophia graminea, whose pollinator(s) are unknown, produces fruit, propagates vegetatively, and colonizes exceptionally diverse habitats as it does its native Asia. None of these alien orchids cause significant environmental harm in Florida.
Finding friends in strange lands: contrasting tales of two invasive orchid species

Ackerman James 1*, Falcón Wilfredo 2, Recart Wilnelia 3, Hernández Pablo 4

1 : Department of Biology, University of Puerto Rico (UPRRP)
   Department of Biology, University of Puerto Rico, PO Box 23360, San Juan PR 00931-3360
   http://herbario.uprrp.edu
2 : Institute of Evolutionary Biology and Environmental Studies, University of Zurich
   Institute of Evolutionary and Biology and Environmental Studies, University of Zurich, Winterthurerstrasse 190, 8057 Zurich
3 : Department of Ecology and Evolutionary Biology, University of California, Irvine (UCI)
   Department of Ecology and Evolutionary Biology, University of California, Irvine CA 92697
4 : Department of Biology, University of Puerto Rico (UPRRP)
   Department of Biology, University of Puerto Rico, PO Box 23360, San Juan PR 00931-3360
* : Corresponding author

Floras have never been static, but shifts in the structure and composition of many regions of the world has progressed at an unprecedented pace, facilitated by human activities, intentional or not. The success of invaders is often attributed to acquired interactions, both native and invasive, and this applies to a small phylogenetically diverse group of invasive orchids. The family is grossly underrepresented among invasive species, and as orchid dogma dictates, perhaps constrained by specialization in mycorrhizal associations and/or pollinator interactions. We contrast the above-ground life histories of two pollinator-dependent invasives, terrestrial Arundina graminifolia (bamboo orchid) and epiphytic Dendrobium crumenatum (pigeon orchid), in Hawaii and Puerto Rico. While A. graminifolia is food-deceptive and self-compatible, D. crumenatum offers nectar and is self-incompatible. The pigeon orchid is pollinated by native Apis in its home range, and by invasive Apis in both Hawaii and Puerto Rico. But pollination of the bamboo orchid varies across and within islands in reproductive success, effective pollinator visitation, and pollinators, and the differences may be attributed to variation in bee faunas and flower size. Thus, we find acquired interactions are context dependent reflecting a hidden flexibility that facilitates colonization by these orchids in novel regions.
Victoria is home to almost 400 predominately terrestrial orchids, half of these are considered threatened. Australian orchids form a web of interdependence between mycorrhizal fungi, pollinators, and the surrounding vegetation. To conduct successful reintroductions an understanding of all these interdependent processes is required. The importance of an integrated approach to conserving south eastern Australia's threatened orchids was recognised in Victoria by the early 1990's. The Threatened Orchid Recovery Team (TORT) formed around this time and eventually consisted of many organisations including the Royal Botanic Gardens Melbourne (RBGM), Melbourne Zoo, Melbourne University, Victoria University, RMIT University, local governments, Catchment Management Authorities (CMA), the Department of Sustainability and Environment (DSE) and 40 community groups.

A backbone to the program is the ongoing enthusiasm of community groups which provide consistency through government funding cycles. The Australasian Native Orchid Society (ANOS) take part in all aspects of the program in Victoria ANOS have been directly involved with the reintroduction of at least 20 species of orchid in Victoria in the last 6 years.

Research is the key to conducting successful orchid conservation projects within Victoria. The RBGM in conjunction with several Universities and project partners has hosted many postgraduate projects on orchid conservation. Recently collaborations between Melbourne University, RMIT University, the Wimmera CMA (WCMA) and the RBGM have explored taxonomic relationships of some of the orchid mycorrhiza.

This paper highlights five of many reintroductions from the first official reintroduction in 2005 to the most recent in 2013, each reintroduction increasing our knowledge.
POSTER LIST

Pollination for conservation

Znaniecka Joanna(1), Minasiewicz Julita(2), Wiczkowska Emilia(2)
1 - Department of Plant Protection and Biotechnology, Intercollegiate Faculty of Biotechnology, University of Gda?sk & Medical University of Gda?sk (Poland), 2 - Department of Plant Taxonomy and Nature Conservation, University of Gda?sk (Poland)
Long-term storage of temperate orchid seeds employing cryopreservation.

Peter Craig(1), Shuttleworth Adam(2), Johnson Steven(2)
1 - Rhodes University (South Africa), 2 - University of KwaZulu-Natal (South Africa)
Divergent scent chemistry in two pollination ecotypes of Eulophia parvi flora

Buyun Lyudmyla(1), Cherevchenko Tetiana(1), Kovalska Lyudmyla(1), Ivannikov Roman(1)
1 - M.M. Grishko National Botanic Garden, NAS of Ukraine (Ukraine)
Reproductive biology of Angraecum eburneum Bory under glasshouse conditions

Biogeography

Chong-Seng Lindsay(1), Senterre Bruno(1)(2)
1 - Plant Conservation Action group (Seychelles), 2 - Université Libre de Bruxelles (Belgium)
On the orchid flora of the Seychelles islands

Simpson Lalita(1)(2), Clements Mark(3), Crayn Darren(1)(2), Schulte Katharina(1)(2)
1 - Australian Tropical Herbarium (Australia), 2 - James Cook University (Australia), 3 - Centre for Australian National Biodiversity Research (Australia)
Disentangling the Dendrobium speciosum complex: a phylogeographic approach to resolving taxonomic limits within Australia's King Orchid

Conservation genetics

Almeida Paulo(1), Gões-Neto Aristóteles(1), Van Den Berg Cassio(1)
1 - Universidade Estadual de Feira de Santana (Brazil)
Population genetics of Cattleya warneri (Laeliinae, Orchidaceae) populations: Delimitation between Brazilian sister species C. labiata and implications for its conservation

Salazar-Rojas Victor Manuel(1), Herrera-Cabrera Braulio Edgar(2), Campos Jorge E.(1)
1 - Facultad de Estudios Superiores-Iztacala UNAM (Mexico), 2 - Colegio de Postgraduados Campus Puebla (Mexico)
WOMEN, HOMEGARDEN AND "CALAVERITA": A CIRCA SITUM CONSERVATION EXPERIENCE OF AN ENDANGERED MEXICAN ORCHID

Sharma Jyotsna(1)
1 - Texas Tech University (United States)
Overview of multiple, multifaceted orchid conservation projects

Habitat restoration/translocations

Verlynde Simon(1), Ramandimbisoa Brigitte(2), Andriatsiferana Félix(3), Rajaonarivelo Nirina(3), Andriamahefarivo Lalao(1), Phillipson Peter(1), Stévart Tariq(1)(4)
1 - Missouri Botanical Garden (United States), 2 - Missouri Botanical Garden, Madagascar (Madagascar), 3 - Ambatovy S.A. (Madagascar), 4 - National Botanic Garden of Belgium (Belgium)
Orchid Conservation at Ambatovy, Madagascar
Ibrahim Yahaya(1)
1 - Centre national de documentation et de recherche scientifique (Comoros)
Les orchidées du massif de la Grille aux Comores: Inventaire, menaces et perspective de conservation.

Gale Stephan(1), Kumar Pankaj(1), Hu Ai-Qun(1), Li Jihong(1), Zhang Huarong(1), Yang Feng(1), Fischer Gunter(1)
1 - Kadoorie Farm & Botanic Garden (Hong Kong SAR China)
Integrated Research for the Conservation of Hong Kong's Threatened Orchids: Case Study of the Near Endemic Bulbophyllum bicolor

Mycorrhizas for conservation

Serivichyaswat Phanu(1), Thongthod Nattawan(2), Nontachaiyapoom Sureeporn(1)
1 - School of Science, Mae Fah Luang University (Thailand), 2 - Scientific and Technological Instruments Center, Mae Fah Luang University (Thailand)
Expression study of selected genes potentially associated with orchid-mycorrhiza interaction and development in Dendrobium Burana Charming

Aewsakul Natdanai(1), Watthana Santi(2), Nontachaiyapoom Sureeporn(1)
1 - School of Science, Mae Fah Luang University (Thailand), 2 - Queen Sirikit Botanical Garden (Thailand)
Ex vitro symbiotic seed germination of Paphiopedilum barbigerum var. sulivongii Schuit. & P.Bonnet

Buyun Lyudmyla(1), Grakhov Vladimir(1)
1 - M.M.Grishko National Botanic Garden of NAS, Ukraine (Ukraine)
Bioactivity and HPLC metabolites profiling of some orchid seeds relating to interaction with mycobiont

Phylogenetic relationships

Stévart Tariq(1)(2), Micheneau Claire(3)(4), Simo-Droissart Murielle(5), Droissart Vincent(6), Lowry Ii Porter(1)(7), Verlynde Simon(1), Geerinck Daniel(8), Descouvières Pascal(9), Sonké Bonaventure(10)(1)(6)(11), Hardy Olivier(11), Edwards Molly(12), Carlsward Barbara(13), Plunkett Gregory(12)(2)
1 - Missouri Botanical Garden (United States), 2 - National Botanic Garden of Belgium (Belgium), 3 - Australian Tropical Herbarium (Australia), 4 - Centre for Tropical Biodiversity and Climate Change (Australia), 5 - University of Yaoundé I (Cameroon), 6 - Institut de Recherche pour le Développement (France), 7 - Muséum National d'Histoire Naturelle (France), 8 - Université Libre de Bruxelles (Belgium), 9 - UMR 7207 CNRS-MNHN-UPMC (France), 10 - University of Yaoundé I (Cameroon), 11 - Université Libre de Bruxelles (Belgium), 12 - The New York Botanical Garden (United States), 13 - Eastern Illinois University (United States)
New insights into developing a natural generic taxonomy of the Continental African angraecoid orchids

Ngugi Grace(1), Martos Florent(1), Bellstedt Dirk(2), Linder H. P.(3), Pailler Thierry(4), Bytebier Benny(1)
1 - School of Life Sciences - University of KwaZulu-Natal Pietermaritzburg (South Africa), 2 - Université de Stellenbosch (South Africa), 3 - Institute of Systematic Botany, University of Zurich (Switzerland), 4 - Université De La Réunion (France)
Phylogenetic relationships amongst the African taxa of the orchid tribe Orchideae (Orchidoideae, Orchidaceae)
Phylogeny of *Dendrobium* sect. Spatulata based on plastid and nuclear data sheds light on the evolution of the Antelope orchids

Population dynamics

Comparative study on populations of *Epipogium aphyllum* (Ghost Orchid): analysis of selected aspects of biology and ecology.

Changes in distribution range of French orchid species: a study based on a large-scale survey conducted in France over 28 years.

Propagation technology

An integrated approach for ex situ and in vitro conservation of orchids at Institute of Ecology, Mexico

Which countries lack the capacity to produce their native orchids for the international trade?: A gap analysis of South East Asian countries

Biochemical analysis during adventitious shoot formation in embryogenic callus of *Vanilla planifolia*

CONSERVATION THROUGH IN VITRO PROPAGATION AND GREENHOUSE CULTIVATION OF *BLETILLA STRIATA* (THUNB.) RCHB. F.
Vanilla conservation

M’sa Tachirifa(1), Gigant Rodolphe(1), Guiot Valérie(2), Viscardi Guillaume(3), Gigord Luc(3), Grisoni Michel(4), Besse Pascale(1)

1 - Université de La Réunion (Réunion), 2 - Conservatoire Botanique National Mascarin (France), 3 - Conservatoire Botanique National Mascarin (France), 4 - Cirad (Réunion)

Conservation strategies of V. humblotii (Orchidaceae), the endemic vanilla of the Comoros Archipelago: review and prospects

Besse Pascale(1)(2), Atuahiva Timeri(3), Bourge Michaël(4), Brown Spencer(4), Da Silva Denis(5), Dijoux Jean Bernard(6), Dron Michel(7), Fock-Bastide Isabelle(8), Gigant Rodolphe(9), Gigord Luc(10), Grisoni Michel(6), Jade Katia(6), Kodja Hippolyte(11)(5), Koyyappurath Sayuj(12), Lepers-Andrzejewski Sandra(3), Magnin Hervé(13), M’sa Tachirifa(10), Pailler Thierry(14), Palama Tony(15), Pelissier Chloé(3), Robin Odile(16), Siljak-Yakovlev Sonja(16), Silvestre Daniel(13), Viscardi Guillaume(10)

1 - Université de La Réunion, UMR PVBMT Univ. Réunion-Cirad (Réunion), 2 - UMR Peuplements végétaux et bioagresseurs en milieu tropical (France), 3 - Etablissement Vanille de Tahiti (France), 4 - Institut de Sciences du Végétal (France), 5 - UMR PVBM T (Réunion), 6 - Cirad (Réunion), 7 - UMR 8618 UPSud1-CNRS IBP (France), 8 - Université de La Réunion - UMR Peuplements Végétaux et Bioagresseurs en Milieu Tropical (Réunion), 9 - Université de La Réunion (Réunion), 10 - Conservatoire Botanique National Mascarin (France), 11 - UMR PVBM T (Réunion), 12 - Peuplements végétaux et bioagresseurs en milieu tropical (Réunion), 13 - Parc National (France), 14 - Université De La Réunion (France), 15 - Université de La Réunion (Réunion), 16 - UMR 8079 CNRS-UP Sud11 ESE (France)

Characterisation, Protection, Sustainable use and Valorisation of Vanilla Biodiversity in Tropical EU (VaBiome project)

Salazar-Rojas Victor Manuel(1), Campos Jorge E.(1), Herrera-Cabrera Braulio Edgar(2)

1 - Facultad de Estudios Superiores-Iztacala UNAM (Mexico), 2 - Colegio de Postgraduados Campus Puebla (Mexico)

Is Vanilla insignis Ames a species? or is it floral morphological variation of Vanilla planifolia G. Jack.?

Gonzalez Robertulio(1), Molineros-Hurtado Francisco(2), Otero J. Tupac(1), Flanagan Nicola(3)

1 - Universidad Nacional de Colombia (COLOMBIA) (Colombia), 2 - Universidad del Pacífico (Colombia), 3 - Ph.D. Professor (Colombia)

COLOMBIAN CHOCÓ WILD VANILLA SPECIES

Alomia Jazmin(1), Flanagan Nicola(2), Mosquera-Espinosa Ana(3), Otero Joel(4)

1 - B. Sc. Masters Student (Colombia), 2 - Ph.D. Professor (Colombia), 3 - Ph. D. (Colombia), 4 - Ph. D. Professor (Colombia)

MYCORRHIZAL DIVERSITY AND SEED GERMINATION IN Vanilla spp. (ORCHIDACEAE) NATIVE TO COLOMBIA

Alomia Jazmin(1), Muñoz Efren(2), Otero Joel(3), Acosta Aleyda(4)

1 - Masters St (Colombia), 2 - PhD St (Colombia), 3 - Professor (Colombia), 4 - Master Biological Sciences (Colombia)

Seeds of Vanilla spp. (Orchidaceae) native to Colombia: Morphometry and Fine structure by SEM (Scanning Electron Microscopy)

Besse Pascale(1)(2), Hoarau Julie(2), Mattoir Jasmine(2), Gassman Maud(3), Gigant Rodolphe(4)(2), Grisoni Michel(5)(2), Bialecki Anne(6)

1 - Université de La Réunion, UMR PVBM T Univ. Réunion-Cirad (Réunion), 2 - UMR Peuplements végétaux et bioagresseurs en milieu tropical (France), 3 - Laboratoire de Chimie des Substances Naturelles et des Sciences des Aliments (France), 4 - Université de La Réunion (Réunion), 5 - Cirad (Réunion), 6 - Laboratoire de Chimie des Substances Naturelles et de Science des Aliments (France)

Diversity and evolution of floral scent in the genus Vanilla