

PLANT CONSERVATION IN THAILAND: DOKMAI GARDEN AND THE ORCHID ARK

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ABSTRACT

Thailand's diverse flora is under threat from extensive habitat degradation and illegal plant collection. The activities of botanic gardens, in cooperation with other organisations and authorities at regional and national levels, are vital for *in situ* and *ex situ* conservation of threatened plant taxa as well as habitat restoration. Additionally, participatory educational outreach strategies increase awareness of the importance of plants and support for their conservation. This paper reports on a botanic garden which has been established recently in northern Thailand, and the far-sighted vision of its Director. Orchids are particularly vulnerable due to their widespread appeal, and so, the creation of a regional 'Orchid Ark' has formed a significant step towards maintenance of an *ex situ* gene pool. Reliance on biodiversity preservation in organisations which are spatially distant from regions of conservation concern inevitably correlates negatively with geographical and taxonomic coverage within living collections. The establishment of Arks (not exclusively for orchids) in the floristic regions to which their taxa are native would present a valuable asset, as each would serve as a repository for genetic conservation in the short term and a proximate source of material reintroductions and restoration once appropriate land had been secured.

Key words: conservation, education, *ex situ*, orchid, repository, threat

INTRODUCTION

Thailand is floristically very rich, numbering more than 10,000 vascular plant species (recent estimates include: 10,000 [SANTISUK *ET AL.*, 2006], 10,250 [MIDDLETON, 2003] and 12,500 [PARNELL, 2000]), and is placed centrally within the Indo-Burma Biodiversity Hotspot, one of 25 regions recognised as global conservation priorities (e.g. MYERS *ET AL.*, 2000; CONSERVATION INTERNATIONAL, 2012). Historically, the flora of Thailand has been under-collected (scientifically) and insufficiently documented, whilst habitat loss and risk of extinctions have exacerbated the situation—traits shared by the country's Indo-Burmese neighbours: Burma, Cambodia, PDR Lao and Vietnam (WILLIAMS, 2011). The ongoing Flora of Thailand project (1970 to present) is redressing this deficit—196 families having been covered so far in 34 parts of the Flora within 12 volumes—the first part of the largest family, the Orchidaceae, having been completed most recently (PEDERSEN *ET AL.*, 2011), building on significant work by Gunnar Seidenfaden (e.g. SEIDENFADEN, 1977) and others. Progress has been advanced significantly by international collaboration, encouragement of students and local engagement (MIDDLETON, 2003).

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Queen Sirikit Botanic Garden in Chiang Mai Province has made an outstanding contribution to Thai plant conservation and research for many years. Recently, a new botanic garden named 'Dokmai Garden' was established in the province. The creators of this new garden aim to play a substantial role in conservation and education, as well as expanding botanical networks within and outside Thailand, particularly for the preservation of threatened orchids. The Director of Dokmai Garden initiated contact with the first author two years ago and this article has been created following their discussions.

Two major challenges for Thai botany lie ahead. The first—cataloguing of extant plant diversity—is now ca. 57% complete (including completed, unpublished accounts (D. Middleton, pers. comm.), based on the total species estimate in MIDDLETON [2003]). We may be only a little over half way along the road to knowing the diversity but the project has provided grounds for optimism, having already yielded much information on local hotspots and future targets for research and conservation, alongside 40+ years of establishing collaborative networks, which will enhance future outputs. Additionally, consideration of endemic, rare and endangered taxa has led to the production of red lists of threatened plants in Thailand (POOMA *ET AL.*, 2005; SANTISUK *ET AL.*, 2006), forming pioneering first steps towards comprehensive IUCN assessments, and which will be expanded as the Flora project moves forward. High biodiversity, although often positively correlated with the level of threat to an ecosystem (especially in the Asian tropics), always needs to be assessed on a case-by-case basis because species richness, as a single index, is insufficient to identify areas of conservation priority (ORME *ET AL.*, 2005). Careful consideration of endemism and threats is required for the preparation of accurate geographical and taxonomic assessments.

The second challenge is the application of knowledge obtained during the completion of the first: conservation and sustainable use of the flora that remains. The changing role of botanic gardens has been documented recently (MAUNDER *ET AL.*, 2004; DONALDSON, 2009; AKOPIAN, 2010; HARDWICK *ET AL.*, 2011; MABBERLEY, 2011), and the essential strategic focuses for the twenty-first century are conservation, habitat restoration, and leadership in public engagement, in addition to the more traditional recreational and pure scientific research directions. However, the significance of botanic gardens has often been overlooked (CRANE *ET AL.*, 2009).

There is a clear discrepancy between the localities of the major botanic gardens and those of the majority of endangered taxa. FRANKEL *ET AL.* (1995) inferred that this situation places most of the 'burden' of preservation on *ex situ* conservation in greenhouses and seed banks. However, the development of new centres together with increased support for the few which have already been established, in close proximity to where they can most efficiently carry out *in situ* as well as *ex situ* conservation actions, presents a logical way forward. Costs of logistics (transportation, export), maintenance (specially designed and constructed buildings, heating) and so on, associated with biodiversity preservation in organisations which are spatially distant from regions of conservation concern, inevitably increase with more comprehensive geographical and taxonomic coverage within living collections. On the one hand these, often long established, botanic gardens are well placed to exert influence through outreach activities to 'inform and inspire' (MABBERLEY, 2011), educating and motivating the general public, political bodies, commercial enterprises, and so forth (in addition to their significant contributions to core scientific research and derivative outputs, see HARDWICK *ET AL.*, 2003), capitalising on their longstanding expertise and global recognition. On the other, botanic gardens suitably placed within regions of conservation concern are ideally located

to be efficient repositories of local and regional floras, and to exert influence for *in situ* conservation at these scales (CHEN *ET AL.*, 2009). In addition, certain scientific studies, such as observations on pollination ecology, may well be feasible in botanic gardens situated within the natural range of occurrence of plants and their pollinators, but are almost impossible to carry out in botanic gardens elsewhere. Nevertheless, it has to be acknowledged that there are often prominent political and financial hurdles to overcome in order to ensure stabilisation of 'local' conservation/restoration centres—hence, the need for a cohesive network with multidirectional interactions.

DOKMAI GARDEN'S CONTRIBUTION TO THAI PLANT CONSERVATION AND PUBLIC EDUCATION

Unambiguously named, Thailand's Dokmai Garden ('Dokmai' is Thai for 'flower'), is a newly established botanic garden which opened to the general public in January 2009 (www.dokmaigarden.co.th). The Garden is located in Chiang Mai Province, ca. 16 km south-west of Chiang Mai (18°40.634'N, 98°52.749'E). It is currently a relatively small site, of approximately 10 acres (4 ha), though more than 1,300 species have been recorded there (including plants, fungi, birds, reptiles, etc.). The Garden is privately managed, with six full-time staff supported by additional human resources, dependent on project requirements.

The Garden's Director, Dr. Eric Danell, is a plant physiologist and Associate Professor in Forest Microbiology from Uppsala University, Sweden, though his concerns extend from botany to entomology, ornithology and mycology, giving Dokmai a 'whole ecosystem' approach. Currently, he is the only academically trained biologist at the site, but he and his team are rapidly developing networks to reinforce the ecological and horticultural and conservation activities taking place as well as engaging, and helping to train, new generations of botanists.

The living collection at Dokmai currently numbers more than 1,200 plant taxa (a figure which is continually increasing as the team extend their activities), with a particular focus on the native flora of Thailand, though also representing many other tropical to temperate floras. Between 2009 and 2011, the Garden received ca. 3,000 visitors from around the world, and this is increasing as publicity is being widened. Public education is a key component of Dokmai's outreach strategy, both locally and internationally. Accordingly, the Garden is arranged in ecologically and ethnobotanically themed zones (including monsoon woodland, wet forest, dry grassland, timber sources, food plants, poisonous plants, and so on), and 500 of the plant species are accompanied by high quality aluminium sign posts, bearing scientific names and trilingual (English, Thai and Japanese) information. Educational tours and activities embrace a wide range of groups. For example, children from local schools are inspired to care for the flora and fauna on which they depend greatly, and international horticulture and ecology students are able to learn, first hand, how to identify tropical plants in the field and to experiment with propagation techniques which will advance conservation and community restoration. Dokmai also hosts a 'Tropical Gardening School' for farmers, gardening amateurs, university student and professionals; running a six-day set program as well as a tailor-made option (up to two weeks in duration) with excursions.

Scientific endeavours are aided by a new laboratory for identification and propagation of plants and fungi, as well as a growing library. Further funds are being sought to enhance this facility. Mycorrhizal fungi are a prominent focus of Dr. Danell's research as these

symbionts are critical to the survival of many tropical plants, especially under conditions of stress (including pest attacks and water deprivation, which are being altered by climate change and habitat degradation). They also constitute many edible species of which one, the mango bolete (*Phlebopus portentosus* [Berk. & Broome] Boedijn), has been cultivated in a joint project with Chiang Mai University (KUMLA *ET AL.*, 2011).

Since its inception, Dokmai has received interest and support from several major botanic gardens and other institutions (including Queen Sirikit Botanic Garden, Chiang Mai University, Singapore Botanic Gardens, Royal Botanic Gardens Melbourne, New Brunswick Botanical Garden and Royal Botanic Gardens, Kew) as well as botanical and orchid societies in Asia, Australasia and Europe. The Garden has also been invited to join the Southeast Asian Botanical Gardens Network (SEABG).

THE ORCHID ARK

The popularity of orchids is widely known but was perhaps captured best by ATTENBOROUGH (2003), who wrote simply ‘orchids attract superlatives.’ Their appeal is largely visual, the flowers often being described as ‘enchanting’, though orchids are also widely used in traditional medicine in Thailand, China and other countries in eastern Asia (several *Dendrobium* species, for example, are supposed to strengthen the human immune system and infusions or decoctions of some *Bulbophyllum* species are used to treat tuberculosis). Their popularity has contributed in no small way to their endangerment within natural habitats—but this same allure ‘may also be their redemption’ (DIXON *ET AL.*, 2003) and has endowed them with the potential to achieve much as flagship taxa for conservational motivation. Many wild orchid populations are now imperilled due to widespread habitat loss as natural vegetation has been cleared or degraded (PEDERSEN, 2010; threats are listed in DIXON *ET AL.*, 2003) but their fate has, in particular, been directed by illegal collection to fuel a demanding and often unscrupulous consumer market.

Orchidaceae are the largest family of vascular plants. Species richness of this single family represents about 8% of all plant species and so, in addition to their taxonomically specific threats, orchids present valuable targets in the quest to address broader issues relating to destruction of the natural world as they are good environmental indicators. Thailand’s ca. 1,200 orchid species (PEDERSEN, 2010) form a particularly significant portion of the global diversity (estimates of the number of total orchid species vary, including: 22,500 [MABBERLEY, 2009]; 25,000 [CAMERON, 2010]; and 26,567 species [GOVAERTS, 2011]). Although one instalment of Orchidaceae for the Flora of Thailand has been published, five more are planned (the second instalment is in an advanced state) and new national records of orchids and taxa new to science are being described regularly from Thailand (e.g. PEDERSEN & ORMEROD, 2009; PEDERSEN & SUKSATHAN, 2009; SUDDEE & PEDERSEN, 2011). Moreover, about 10 orchid genera (including *Bulbophyllum*, *Cleisostoma*, *Crepidium*, *Dendrobium*, *Eria* s.l., *Geodorum*, *Gastrochilus*, *Liparis*, *Luisia* and *Oberonia*), which include species in Thailand, require molecular and morphological reassessment to resolve current shortfalls in species delimitation before their treatments can be completed. Orchid sales form a multi-million dollar industry and Thailand is one of the top exporters of orchid plants (ANON., 1999; SUMANONTA & KULASABJIRA, 2010). Although the majority are commercially propagated hybrids, illegally wild-collected species still constitute an alarming proportion of sales (MAXWELL *ET AL.*, 1995; SEATON & PRITCHARD, 2003).

Successful orchid conservation demands a multidimensional approach, from habitat protection and management to preservation of genetic diversity and enforcement of legislation. Salvation of those orchid plants which remain extant in the wild has therefore become increasingly vital to their conservation. Dokmai's Orchid Ark, launched on 3 April 2011, is intentionally 'a non-profit entity to avoid any conflicts between business and conservation' (E. Danell, pers. comm.). Two months after its launch, the Ark was invited to join the Orchid Conservation Coalition (OCC), an organisation which has been promoting orchid conservation internationally for eight years. The Orchid Ark already houses 196 named taxa, of which 192 (98%) are indigenous Thai species, including 36 species which are listed as threatened in Thailand, and several unidentified specimens, some of which are likely to belong to undescribed taxa. *Vanda coerulea* Griff. ex Lindl., a CITES Appendix I listed species; *Vanda coerulescens* Griff., a species which is thought to be extinct in the wild in Thailand; and the threatened *Vanda denisoniana* Benson & Rehb.f. (Fig. 1), are just some of the important taxa in this growing repository. Plants of the genus *Vanda* are showy and have therefore suffered much from illegal collection. Many plants have been accessioned following donations from reputable benefactors, CITES registered where appropriate.

The challenges of *ex situ* conservation of orchids, which have been discussed at some length by SULLIVAN (2010) and previously in DIXON *ET AL.* (2003), include issues of hybridity, niche habitat occupation, and the need for co-ordination of efforts and a clear long-term strategy—the last of which was also highlighted by PEDERSEN (2010) when performing a SWOT analysis of the Queen Sirikit Botanic Garden's orchid conservation activities. Seed banking is an important component of orchid conservation (SWARTS & DIXON, 2009) and the Dokmai team have had recent successes with pollination of several orchid species (e.g. the endemic and endangered species *Kingidium minus* Seidenf. [now called *Phalaenopsis finleyi* Christenson]) and is now producing a large collection of seeds. The benefits of seed banking and shortcomings of reliance solely on propagated living collections have been discussed by SEATON *ET AL.* (2010) and principally concern greater coverage of genetic diversity within taxa and within populations, so as to avoid artificial selection of forms due to low numbers of individuals representing each taxon in cultivation. The Orchid Seed Stores for Sustainable Use (OSSSU) partnership is a major step towards securing the future of orchid biodiversity. Currently, OSSSU links 32 organisations in 23 countries (H. Pritchard, pers. comm.). Expansion of risk assessments, of habitats and taxa, is greatly needed and additional network partners will aid the achievement of this pressing objective.

Creation of *ex situ* stocks is a back-up tool to supplement *in situ* activities but conservation of wild plant populations and ecosystems *in situ* is critical to their future because organisms never occur in isolation. This is especially true of orchids, which depend on an insufficiently known suite of, often highly specific, pollinators, as well as plant-fungal interactions. The Dokmai team are undertaking investigations to discover specific pollination mechanisms and to find out more about the optimal habitats for some of the less well known taxa. BERNHARDT & EDENS-MEIER (2010) suggested a way forward with respect to investigation of pollination ecology, which should combine traditional field data with information on orchid flower demography, genetic variation and temporal climatic factors. Capitalisation on the proximity to wild populations of botanic gardens like Dokmai and on local knowledge facilitates regular and long-term *in situ* observations which, in coalition with technologically advanced institutional facilities, will greatly enhance our understanding of the highly specific ecology of these orchids.

Dokmai's staff and associates have also found new localities of species such as *Vanilla siamensis* Rolfe ex Downie and *Vanda denisoniana* Benson & Rchb.f. but are naturally cautious regarding the sharing of locality data, for fear of exploitation. Negotiations are currently underway between Dokmai and the Department of National Parks, Wildlife and Plant Conservation in Thailand with a view to the attainment by the Garden of a 'salvation picking' permit. Such a license will allow the preservation of far more specimens and, importantly, conservation of a wider gene pool within the Ark, as well as providing material for replanting into secure natural habitats. Dr. Danell is also keen to complement conservation with a plant translocation programme. For example, the replacement of rescued indigenous epiphytic orchids (e.g. ones that have fallen to forest floor, whether naturally when a senesced branch falls or due to logging, see Fig. 2) onto trees which are in secure localities outside the Garden. A notable, somewhat similar project, involving orchid propagation, translocation and re-introduction to street trees and green areas in Singapore, has been undertaken by Singapore Botanic Gardens (YAM *ET AL.*, 2010).

CONCLUSIONS

Although Dokmai Garden is relatively new when compared with its illustrious counterparts across the world, its Director has a clear vision for the future. 'Formation of a network of regional Arks in different climates will help to preserve genetic diversity within species and allow natural pollination, at first in the different floristic regions of Thailand and, in time, expanded across Indo-Burma and beyond, will enhance the security of regional floras close to where indigenous. This will streamline conservation and restoration actions, and allow broader combined taxonomic coverage within global repositories' says Dr. Danell. He is also keen to develop protocols for ensuring the security of the collections within such a network of Arks, especially those under private ownership, because, without legal protection, their futures would be subject to personal and political disruption. The 'Land for Wildlife' program, which currently operates in the states of Victoria and Queensland in Australia, is perhaps a useful model which could be developed in other countries such as Thailand for securing protection. The program helps landowners (with land over 1 hectare in size) to improve wildlife habitats on their properties and advice is offered regarding the protection of native flora and fauna on their properties. Therefore, landowners are able to contribute securely to the maintenance and restoration of native biodiversity with the knowledge that their efforts will be supported at state level.

PARMENTIER & PAUTASSO (2010) pointed out that the majority of botanic gardens, especially older gardens, do not coincide spatially with hotspots of plant diversity. Dokmai is one of a new wave of establishments which will help to address this issue, developing *in situ* and *ex situ* conservation facilities in close proximity to where these resources are needed. A network of regional organisations would have the potential to secure a much greater proportion of the national biodiversity through pinpointed assessment effort.

Dr. Danell is clearly ambitious in his plans to advance and expand plant (especially orchid) conservation, not only in Thailand but also across other countries in eastern Asia. Whilst acknowledging the constraints to progress that currently exist both nationally and internationally, as well as the need for consideration of social factors such as livelihoods, he remains undeterred and strongly believes that perseverance and collaborative efforts will



Figure 1. *Vanda denisoniana* Benson & Rehb.f. is a favourite among buyers and has, consequently, been subjected to much illegal collection (Credit: E. Danell).



Figure 2. An epiphytic *Luisia* or *Cleisostoma* orchid remains attached to a fallen branch—doomed to die on the dark forest floor unless salvation permits are issued to allow such specimens to be rescued. Chiang Mai Province, 2011 (Credit: J. Wearn).



Figure 3. The front gates of Dokmai Garden, behind which is a hive of botanical activity (Credit: E. Danell).

make valuable contributions to saving threatened floras. The plan for widespread Orchid Ark establishment is gaining momentum, and a similar project is now underway in Queensland, Australia. Significant interest has also been shown by the Luang Prabang Botanical Garden in Laos (www.pha-tad-ke.com). This Garden is being newly created with a view to opening to the general public in 2014, and has already sought international collaboration on fieldwork, *in situ* conservation and ethnobotanical studies.

Dokmai Garden and the Orchid Ark are private initiatives, which affords an independent approach to conservation strategy. Admittedly, this mode of governance can increase threats to its perpetuity; a factor that has been acknowledged by its Director. As a precaution, in the case of the unexpected death of the owners within the next 10–20 years, Dokmai's plant collections will be shared between the Queen Sirikit Botanic Garden and Singapore Botanic Gardens, together with any other orchid arks present at that time. Dr. Danell also seeks share holders with commitments to botanical preservation, to increase Dokmai's future protection (Dutch and Australian share holders have already been forthcoming). Profits are used for the running costs to perpetuate Dokmai Garden and its aims, and additional funds will be directed towards activities and displays to increase public outreach. Consideration of long-term development of the Garden and increased workloads has revealed that volunteers will be a significant resource (indeed, voluntary helpers contribute to many of the major botanic gardens worldwide). Experience gained from the Tropical Gardening School at Dokmai has already shown this to be true, and further engagement is predicted to increase this beneficial trend.

Queen Sirikit Botanic Garden and Dokmai Garden both currently lack CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) registration. This makes international collaboration much more difficult, as foreign researchers are discouraged to share their expertise due to lack of access to Thai specimens for their studies. CITES is an agreement between governments to ensure that international trade or other anthropocentric movement of

specimens of wild plants and animals does not threaten their survival. Therefore, registration aids the preservation of these species and facilitates scientific exchange of material. CITES registration is still an impediment which must be broached in Thailand, and this is something which the authors have begun discussing with the Director of Dokmai and Thai authorities.

SCHATZ (2009) stated directly that ‘the continuing decline of plant diversity will have a greater impact on human society than any other type of biodiversity loss’. Plant conservation would not be possible without the world’s botanic gardens, but PARMENTIER & PAUTASSO (2010) noted that ‘there is a need for an increased co-ordination in the conservation activities of the various botanic gardens’. As members of a global social and scientific community, we must, therefore, constantly embrace new endeavours which will widen the global network of support for conservation activities and habitat restoration, and strengthen the links between its collaborative entities to create an effective synergy.

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