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Multiscale action for medicinal plants:

implementing the Global Strategy for Plant Conservation on a human dimension

By Gary Martin (Director, Global Diversity Foundation)

Almond seed (*Prunus dulcis*) germinating PHOTO: M. EL HAOUZI

Aloe vera gel for burns. Aspirin for fever and pain relief. Quinine for malaria. All around the world – and on a daily basis – people continue to take plant-derived remedies for what ails them. With the growing popularity of herbal medicine and a global human population that has breached the 7 billion mark, it is inevitable that we are putting increasing pressure on medicinal plants and the world's floristic resources in general.

When a group of plant conservation specialists gathered in Dublin, Ireland in late May 2009, this reality was very much on our minds. As members of the Liaison Group of the Global Strategy for Plant Conservation (GSPC), we had come together to respond to a request from the Conference of Parties of the Convention on Biological Diversity (CBD) to update the strategy, which had been adopted in 2002.

One small group, in which I was fortunate to participate, focussed on GSPC targets that explore the relationship between the conservation of useful plants and the knowledge, practices and innovations of indigenous peoples and local communities (including targets 9 and 13).

Five years on, the time has come to assess the impact of our recommendations and more importantly our actions. Representatives of the Parties to the Convention and other concerned individuals will be gathering in Montreal in June for the 18th meeting of the CBD's Subsidiary Body on Scientific, Technical and Technological Advice. Among other activities, this event will allow countries to showcase their efforts to conserve plant resources towards implementing the GSPC. Because of the specific mention of botanical resources used for health care in target 13, the customary use, wild harvesting and international trade of medicinal plants should figure prominently in these case studies.

Taking action at a national level

In Morocco, the Global Diversity Foundation is working with diverse partners to ensure that medicinal plant conservation has the prominence it deserves. The 12th largest exporter of medicinal and aromatic plants in the world, Morocco faces the challenge of conserving biodiversity while encouraging rural peoples to benefit economically from wild-crafting and value-adding activities. Morocco is keen to expand its share of a $15 billion global market while mainstreaming biodiversity conservation throughout the value chain.

With funding from the UK Darwin Initiative and the Critical Ecosystems Partnership Fund, we are addressing trade in medicinal roots and its impact on plant conservation and local livelihoods in the Middle and High Atlas mountains. In May 2014, we joined forces with our partners in this venture – the Moroccan Ministry of Energy, Mines, Water and Environment, Cadi Ayyad University in Marrakech, the Scientific Institute in Rabat and High Atlas Foundation – to convene a workshop on implementing the GSPC in Morocco organised with Botanic Gardens Conservation International. This meeting provided an opportunity to review case studies of medicinal plant conservation in Morocco.

The most ambitious of these projects is the UNDP/GEF Medicinal and Aromatic Plants Programme, which aims to integrate biodiversity in the value chains of medicinal and aromatic plants in Morocco. Four of

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ROYAL BOTANIC GARDENS

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Morocco's most commercialised plants in diverse regions are the focus of the three-year project: oregano (*Origanum elongatum*) in the Rif Mountains, pellitory (*Anacyclus pyrethrum*) in the Middle Atlas, thyme (*Thymus saturejoides*) in the High Atlas, and rosemary (*Romarinus officinalis*) in the eastern part of the country.

Practicing plant conservation at a local level

As the sun rises over Imegdale, an Amazigh community in the High Atlas mountains south of Marrakech, there is a new feature on the landscape. A two hectare plant nursery is starting to green the arid lands surrounding the village, with a water basin, drip irrigation system, greenhouse and sprouting almond and walnut seedlings. Imegdale is home to hundreds of seasonal collectors of medicinal and aromatic plants, especially local species of artemisia, lavender and thyme. They are keen to explore cultivation of these wild-harvested species as well as domesticated medicinal and aromatic plants. Along with the almond and walnut trees, plants produced in the community plant nursery will be distributed in coming years to many families who live in the dispersed villages that make up Imegdale.

Some 300 km to the northeast, a plant nursery in Ait M'hamed will have another story to tell. Amazigh plant harvesters in this Middle Atlas community seek pellitory (*Anacyclus pyrethrum*) root above all other medicinal plants. The region witnessed yields that declined by more than 75% over the last decade as commercial value and harvesting pressure soared. A small plot of 10,000 almond and 10,000 walnut seedlings for distribution in the community promises some economic relief in coming years, but there is even greater enthusiasm for a planned half hectare nursery that will be dedicated to pellitory and other medicinal plants. An enrichment planting scheme for private lands and well-managed commons will hopefully restore the *Anacyclus* population while continuing to support livelihoods based on customary harvest.

Global Diversity Foundation and High Atlas Foundation are collaborating on the creation of these nurseries, which are part of a broader development and research initiative that blends agroforestry, biodiversity and hydrology. Learning techniques of seed saving and germination, whether for wild or domesticated species, is part of the capacity building programme for the community researchers who also tend the community nurseries.

Conserving plants on a global scale

Local initiatives and national programmes, such as the ones in Morocco that I have briefly described, are the lifeblood of the GSPC. They ensure it will be implemented in harmony with the Strategic Plan for Biodiversity 2011-2020 and with other relevant programmes of work of the CBD.

Conducting research on medicinal plants and promoting their conservation have become more complex over the past decades. Concerns about improper use of both local knowledge and sovereign botanical resources permeated debate on plant-derived pharmaceutical products and generated a notable side effect – a dampening of international collaboration on medicinal plant research.

One sign of this new era of medicinal plant study is the emergence of innovative research paradigms – such as one being developed by MedPlant, a research project exploring the evolution and sustainable use of medicinal plant diversity – which bring together research institutions, private companies and non-profit organisations to explore new interdisciplinary approaches and technologies.

The process of developing best practices, which may have seemed slow and tortuous at times, has yielded new initiatives that hold the promise of achieving the conservation, sustainable use and equitable trade of plants and animals as proposed by the CBD. The vision of the GSPC – to promote human activities that support the diversity of plant life, which in turn nurtures and improves our livelihoods and well-being – is what we must all keep in mind as we contemplate the future of medicinal plants.

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Gary Martin has been involved in conservation and ethnobotanical work for over 30 years and in more than 45 countries. After studying botany as an undergraduate, he received his MA and PhD in anthropology from the University of California at Berkeley. From 1998 – 2011, he was a research fellow and lecturer at the School of Anthropology and Conservation of the University of Kent in Canterbury, UK. Since 2011, he has been the Director of the Global Environments Summer Academy.

Young Amazigh women filling planting bags in the community nursery PHOTO: I. TEKGUC

Hassan Ait Ba, community researcher from Imegdale, showing the plant nursery he helped create to Hassan Rankou of Kew
PHOTO: I. TEKGUC

A **message** from Paul Smith

Millennium Seed Bank Partnership Leader

Understanding the role that botanical science can play in improving people's livelihoods is not always easy, partly because there are so many other variables involved. For example, if we apply our scientific knowledge to help communities grow a medicinal plant species that has previously been collected from the wild, does this reduce its efficacy and therefore its value? Also, if we solve a technical problem at one point in the value chain, there may still be other impediments related to getting that plant product to a market – for example obtaining a licence to operate from the authorities. Even where there is a ready market, with a well-defined value chain, the people we have trained with the technical skills they need to grow plants may not have the basic business skills they need to make money from the plants they grow. These are all challenges that we have encountered through the Useful Plants Project (UPP) and, through this process, we have learned a great deal. Firstly, it is essential that local communities and individuals identify needs and opportunities themselves. This has been a feature of the UPP programme in all of the countries we have worked in, and the result has been enthusiastic participation. Secondly, it helps enormously if markets and value chains for particular products already exist. This is the case with traditional medicine in Mali (see below) where the value chain was in place but particular technical impediments matching the MSB Partnership's expertise were identified. Finally, understanding and helping to solve other constraints outside our comfort zone through partnership. A good example of this is the Citi entrepreneurs training we have supported in Kenya (see *Samara* 25), through which nurserymen growing indigenous tree seedlings have been trained in accounting and business skills. While we may not always have immediate impact on improving people's livelihoods, we are gradually learning how we can get better at this. I hope the articles in this issue enable us to share what we have learnt.

Conservation of medicinal plants with local communities in Mali

By Kader Sanogo and Sidi Sanogo,
(Institut d'Economie Rurale)

Like other countries of the Sahelian zone, rural populations of Mali still depend on plants to satisfy their primary needs for medication, food, fuel wood and construction. Despite the dependence of the local communities on natural resources, climate change combined with over-exploitation mean that ecosystems are weakened and biodiversity reduced. Since 2007, seed conservation and propagation, reforestation and sustainable management of plants which are useful to the rural communities have been introduced through the MSB Partnership between Kew and the Institut d'Economie Rurale (IER) of Mali, as part of Project MGU-the Useful Plants Project (UPP).

Main representatives of the Ifola medicinal plants community garden with Kader Sanogo (UPP Coordinator Mali) on the right and Moctar Sacande, second on the left (MSB International Coordinator- Mali) PHOTO: UPP TEAM MALI

Aim of the Useful Plants Project

The Useful Plants Project aims for the sustainable management of plants by local communities and the preservation of biodiversity. The objectives of the project are to:

- Identify useful and/or threatened plants, according to the desires and needs of local communities;
- Collect and conserve plant material (seeds, plants, cuttings, bulbs) of those useful plants;
- Install and maintain arboreta containing medicinal plants, food plants and plants used to produce plant products;
- Restore and enrich natural habitats with the support and the participation of local communities and organisations;
- Determine the chemical constituents of the medicinal plants and study their biological activity in order to improve harvesting practices.

Project activities and achievements in Mali

Survey and identification of medicinal plants

An ethnobotanical survey has been carried out with several socio-professional organisations (therapists, herbalists, nurserymen, gardeners, artisans, farmers, etc.) to produce a target list of species important for the local communities. The data from this survey have been compiled into a bibliographic review. In total, 323 species (woody and herbaceous) have been listed: 98% are medicinal and food plants, 2% are fodder species and 26% are craft plants (dyeing, sculpture and carpentry). Among medicinal plants the most used plant parts are the leaves, roots and bark.

Establishment of medicinal plant gardens in the communities

The medicinal plant gardens are conservation plots registered with the traditional healer associations. Vegetation in these plots has been restored by planting and managing the natural regeneration. During the two phases of UPP the project has worked with 12 communities and a total area of 15.5 hectares have been planted with 55 medicinal species which are rare or have disappeared locally. Now, leaves from some plants are being used by the traditional healers to cure patients.

Conservation of medicinal plants with local communities in Mali

Continued from page 3

Restoring the sacred forests in the village territories

The sacred forests are local natural plots which have been demarcated for public or individual ritual ceremonies in villages. These sacred forests are of conservation value and are threatened as a result of the negative impacts of climate change and the extension of people's habitations. With the communities' participation, five sacred forests of 75 hectares have been restored with enrichment planting of 15 useful species.

Determination of chemical groups of medicinal plants

In collaboration with the Department of Research on Traditional Medicine (University of Bamako), the chemical compositions of ten medicinal plants, frequently used by the traditional healers, have been studied. The phytochemical analysis of these plants provides evidence of the presence of chemical groups such as flavonoids, coumarins and saponosides, which effectively treat the most frequent illnesses in local community environments in Mali.

Training and informing local communities on the sustainable management of medicinal plants

All the local communities and organisations included in the project have been trained in plant propagation techniques, planting and the uses of the parts of medicinal plants. Groups have been employed to monitor the forest and to fight against bush fires.

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Medicinal plant seeds and oils being presented to the Minister of the Environment of Mali PHOTO: UPP TEAM MALI

Training in planting techniques and the management of plots PHOTO: UPP TEAM MALI

Planting of medicinal plants in the Bla territory PHOTO: UPP TEAM MALI

Planting community plots PHOTO: UPP TEAM MALI

Identification of a medicinal plant with a traditional healer, Mali PHOTO: UPP TEAM MALI

The Useful Plant Project in South Africa

By Avhatakali Mamatsharaga (UPP Co-ordinator, South Africa National Biodiversity Institute), **Alex Hudson** (Useful Plants Project Officer, MSBP) **and Tiziana Ulian** (International UPP Coordinator, MSBP)

Although South Africa, with the latest population estimate of 52.98 million, is regarded as the most developed country on the continent, it is still largely rural. A large proportion of people, both urban and rural-based, still rely on traditional medicine for treatment and improving their well-being. Muti (traditional medicine) markets in the urban areas are increasing whilst in many towns like Nelspruit, in the Mpumalanga province (northeast of South Africa), there is also an increasing number of muti sellers and shops which specialise in traditional medicine and Asian medicinal plants. In an interview with the traditional healers association, it was acknowledged that many previously common plant species are now harder to find, and propagated medicinal plants are gradually being accepted for treatment. Many associations are willing to start, or have started, their own plant nurseries and medicinal gardens.

Project MGU-the Useful Plants Project (UPP) was introduced by the team at the Lowveld National Botanical Garden (LNBG) to 15 rural communities, that lie just outside the southern part of the Kruger National Park and include the Shangaans, Sothos and Swazis tribes. The aim is to promote the *ex situ* conservation of indigenous medicinal plants and grow them in the communities.

The project began by inviting traditional healers to participate in the project through their associations. With their knowledge of the plants important to their communities, they greatly assisted in the identification of the medicinal plants and provided their vernacular names. The traditional healers were invited to work with local schools to allow them to transfer their knowledge about traditional medicines to children and to incorporate conservation activities into the school curriculum. Each school now has its own medicinal garden which means children do not have to travel many kilometres to visit the LNBG to learn about the plants.

Several workshops have been conducted since the start of the project with both the environmental teams in the schools and the traditional healers in the area. The workshops cover topics like plant uses, plant propagation, garden design and maintenance. Plants propagated at the LNBG have been delivered to the schools and the children have been involved in planting events, including "Arbor week", which catalysed neighboring schools into sending requests for plants.

On 22 May 2013 the LNBG celebrated the International Day of Biological Diversity by inviting the project participants to visit the recently developed medicinal plants garden. For nearly all the participants, it was their very first visit to a botanic garden and information started flowing as traditional healers from the three tribes met. Schools were encouraged to evolve their medicinal gardens to emulate the garden at LNBG.

The UPP team (South African and UK) with the children of Alexandria Primary School in front of the storyboard and medicinal garden PHOTO: E. MATTANA

The maintenance of the medicinal plant gardens is continuing in the schools in the communities. One school, Mphiti Primary School, developed a special programme where each student involved in the project adopted a tree growing at the school. The student takes full responsibility for the tree until they finish primary school when they recruit a new student to continue the legacy of looking after the tree. The kids so love and guard their trees, one could be pardoned for thinking the trees are like human beings to them!

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Planting medicinal plants in the schools PHOTO: L. SHAI, LNBG

Children at Mphiti Primary School next to the plants they 'own' PHOTO: A. HUDSON

MSBP Useful plant collections in research

With the MSBP's focus on seed conservation of endemic, endangered and economic plants we have conserved many useful species, for example 15% of our collections (2800 taxa) have a reported medicinal use (based on information from SEPASAL (RBGK, 2011) or from ethnobotanical notes received with the collections). The MSBP's seed list contains around 21,000 collections of 9,000 species available directly from the MSB or from our partners' seed banks. The MSBP's seed samples are sent across the world for a wide range of research, restoration and re-introduction programmes. Sixteen per cent of requested seeds are from medicinal plants and are used for many projects – from studying threatened species to investigating essential oils. The articles below illustrate projects using MSBP seed collections to improve our understanding of useful plants.

The MSBP seed list is available at http://apps.kew.org/seedlist

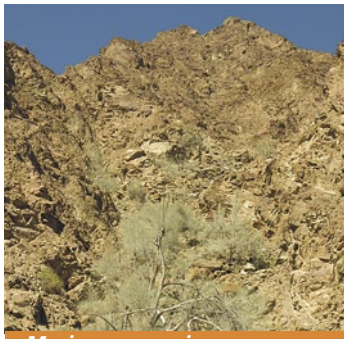
RBGK (2011) Survey of economic plants for arid and semi-arid lands. (SEPASAL) database. Royal Botanic Gardens, Kew. Available from http:// apps.kew.org/sepesalweb/sepaweb (Accessed March 2011).

Searching for useful Jordanian native species

By Khaled Abulaila (National Centre for Agricultural Research and Extension, Jordan)

Grazing animals are having a devastating impact on natural vegetation in Jordan. Finding wild plant species that can survive grazing and could be propagated on a large scale could relieve pressure on natural ecosystems. Amongst the seed collections stored in the National Centre for Agricultural Research and Extension (NCARE) seed bank in Jordan; particularly those collected in collaboration with the MSBP, there are some species with promising potential. Over the last year NCARE carried out propagation trials on three wild species which have a good palatability to grazing animals and are also native to dry habitats in Jordan. Two perennial grasses (*Lasiurus scindicus* and *Pennisetum divisum*) and one tree species (*Moringa peregrina*) were trialled with plans to include *Panicum turgidum* in future trials. The results showed *Pennisetum divisum* grew well, even when planted in saline conditions, while *Lasiurus scindicus* had initial germination problems but has since performed well. *Moringa peregrina* could be used (with frequent pruning) as a permanent source of green fodder for livestock.

Lasiurus scindicus
Photo R. Borosova



Moringa peregrina
Photo T. Heller

NCARE is also researching native crop wild relatives of cucurbits that could be used as root stocks for cultivated cucurbits. *Momordica balsamina* had good results as a root stock as it is resistant to nematodes but further research is needed to ensure that no undesirable traits are passed on to the cultivated cucurbit.

These trials are showing how native species and crop wild relatives can help improve cultivation, especially in locations with difficult growing conditions such as soils with high salt content, saline water or pest infestations.

Research into improving photosynthetic efficiency

By Elizabete Carmo-Silva (Research Scientist, Rothamsted Research, UK)

Rothamsted Research, established in 1843, is the longest running agricultural research station in the world. Our mission is to deliver knowledge and new practices to increase crop productivity and quality and to develop environmentally sustainable solutions for food and energy production. Research by the photosynthesis team led by Professor Martin Parry aims to optimise crop productivity by increasing the efficiency of carbon dioxide assimilation.

Crop biomass production depends on the assimilation of carbon dioxide during photosynthesis. The main player in carbon dioxide assimilation is the enzyme Rubisco, which is present in all plants. Despite this pivotal role, Rubisco is inefficient in today's atmosphere. The complex reaction mechanism of Rubisco evolved in a primitive atmosphere, with very little oxygen and more carbon dioxide than today's concentrations. Further adaptation of the enzyme to different environments has been slow.

The properties of Rubisco have been characterised for less than 2% of the world's plant species. Even within this limited dataset, there is diversity in the efficiency of Rubisco enzymes present in different plants. This suggests that more efficient forms of Rubisco are available in species yet uncharacterised. Hence, we are building a comprehensive dataset on the natural variation of Rubisco properties, for a diverse range of plant species.

Seeds of a number of species, including the medicinal plants *Artemisia judaica*, *Artemisia absinthium*, *Panicum maximum*, *Citrullus colocynthis*, *Citrullus lanatus*, *Chrysanthellum indicum*, *Chenopodium murale* and *Chenopodium album*, have been kindly supplied to us by the MSBP. Besides their medicinal properties, some of these species grow well in arid and hot environments and are predicted to contain a more efficient form of Rubisco in their leaves.

Rothamsted Research scientists Doug Orr (left) and Andre Alcantara (right) holding plants of *Chenopodium album* and *Artemisia judaica* before collecting leaves for Rubisco analyses
PHOTO: E.CARMO-SILVA

Our results will be used to identify the best Rubisco enzymes for directing improvement of photosynthetic efficiency in crop plants. This work is funded through a sub-contract by the University of Illinois as part of the Bill and Melinda Gates Foundation award RIPE: Realising Increased Photosynthetic Efficiency for Sustainable Increases in Crop Yield.

Neglected and underutilised species as potential oilseed crops

By Jayanthi Nadarajan, Ellie Merrett Wade and Charlotte Seal, (MSBP)

Seeds are attractive sources of nutrition and raw materials because of the high quantity of oils, carbohydrates or proteins which accumulate as energy reserves essential for germination and early seedling development. The oil content of seeds can vary from as little as 1% in peas to over 60% in brazil nuts (SID 2014), with seeds considered oily when their oil content is above 18% of their dry weight. Major commodities include sunflower (30% oil), coconut and palm kernel oils with values of around $1.3K, $1.7K and $1K per metric ton respectively (www.indexmundi.com, 2011). Demand for other non-edible species include the poisonous *Ricinus communis* (52% oil; SID 2014) and the biodiesel crop *Jatropha curcas* (28 – 42%; Heller 1996, Kaushik et al. 2007) of which some genotypes are toxic.

At the MSB we focus our research on neglected and underutilised species (NUS), which are often grown on a small scale in a sustainable way which has benefit to the local community and avoids the destruction of wild vegetation and natural habitats associated with large-scale production. Many wild oilseed species are also highly adapted to the environment they grow in and possess high genetic diversity, offering a source of desirable traits for breeding programmes. NUS therefore offer one solution to the increasing global demand for energy and food. We screen the seeds of species which are considered to have potential as oilseed crops; these may be seeds of plants with socio-economic importance (e.g. Cactaceae), species adapted to survive in extreme environments (e.g. halophytes;) and species selected for research are based on current usage (e.g. Asteraceae, Brassicaceae, Euphorbiaceae including *Jatropha*, Clusiaceae and Malvaceae). To increase the rate of screening and enable the oil content of rare and small seed collections to be quantified, we have recently started to use a non-destructive method, time-domain nuclear magnetic resonance (TD-NMR).

However, identifying which species have oily seeds is just the first step. Storage of oily seeds either for conservation or commercial purpose can be challenging as many of the tropical oily seeds store poorly under dry cold conditions including at -20 °C. A resolution to this challenge is important for seedbanks which are unable to store germplasm from tropical oilseed species and for oilseed producers in temperate areas who use cultivars with high amounts of fatty acids. Thus there is a high demand to identify which oilseeds will lose viability faster than desirable and to explore alternative storage conditions that may increase their longevity.

The longevity of seeds is related to the physical state of the seed components which can be determined by biophysical means using a Differential Scanning Calorimetry (DSC). DSC can be used to create 'thermal fingerprints' to observe differences in susceptibility to damage when exposed to different storage temperatures. Our screening study using DSC has focussed on the Asteraceae family which has the highest representation in the MSB (> 3000 species) and out of a sample of 103 Asteraceae species for which we have information, 86 % can be classified as oily. For 18 Asteraceae species, we have shown that lipid thermal fingerprints vary between oily seeds, with some having high melting temperature and others lower ones. It estimated that 5 out of the 18 species have a putative storage problem at -20 °C. If this value is translated to the whole family (28% of 23,000 species), more than 6000 species would be estimated to have storage problems at -20 °C.

It is likely that not all oily seeds will show reduced viability in storage at cold temperature. However, the combination of biochemical and biophysical approaches is an essential component to preserve the future availability of wild oilseed germplasm.

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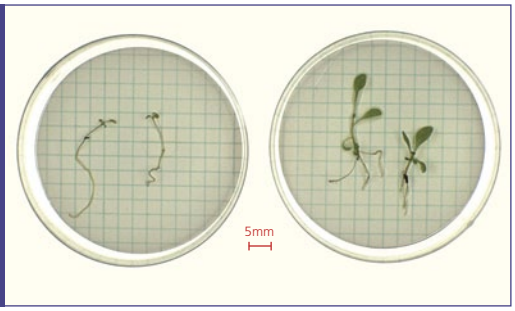
Seed Information Database (SID). Version 7.1. Available from: http://data.kew.org/sid/ (April 2014)

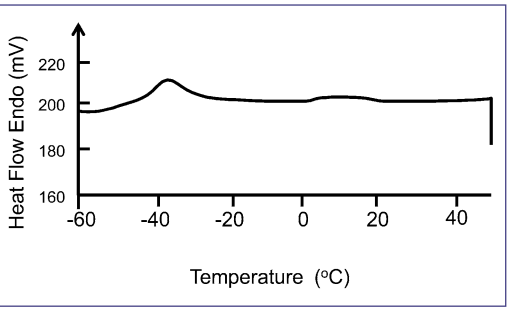
Seeds of *Jatropha pseudocurcas* a potential oilseed crop PHOTO: C. CHRISTENSEN

Plants such as the halophyte *Suaeda martima* have oily seeds and could be used to cultivate marginal lands PHOTO: C. SEAL

Seedlings of *Ratibida columnifera*, which has oily seeds, showing poorer recovery after one year storage at -20 °C (left image) than at -196 °C (right image) PHOTO: J. NADARAJAN



DSC thermal fingerprint of *Ratibida columnifera* showing lipid melting traces PHOTO: J. NADARAJAN



The medicinal plants of Georgia

By Tsira Mikatadze-Pantsulaia (National Botanic Garden Georgia), **David Kikodze** (Institute of Botany, Ilia State University, Georgia), **Marina Eristavi** (Institute of Botany, Ilia State University ,Georgia)

***Gymnospermium smirnowii* (Trautv.) Takht. (=*Leontice smiwrnowii* Trautv.) – a very rare species known from only few localities in East Georgia; the tubers of this plant contain biologically active substances and are used in Georgian traditional medicine to treat gastritis and tuberculosis; it is likely that this plant is intensively harvested in the wild which leads to substantial reduction in its abundance. Photo taken in spring in Lagodekhi Nature Reserve, Kakheti Region** PHOTO: D. KIKODZE

***Galanthus platyphyllus* Traub & Moldenke – a rare species endemic to the Caucasus region which contains galantamine and is used in pharmacology to treat radicular pain or radiculitis. Not known to be used in Georgian traditional medicine. Photo taken in May, near Cross Pass in the Greater Caucasus Mountains, Mtskheta-Mtianeti Region**
PHOTO: D. KIKODZE

Georgia forms a large part of the Caucasus Regional Hotspot – identified as one of the planet's most diverse and endangered regions by Conservation International. Georgia`s flora is estimated at 4130 vascular plant species, one fifth of which are endemics. It is known to contain a remarkably high number of species of medicinal value, with over 700 species utilised in Georgian traditional medicine and 200 taxa registered in the official pharmacopoeia.

Hundreds of Georgian plant species are threatened with extinction or exposed to the risk of genetic erosion. The vast majority of medicinal plants in Georgia are harvested in the wild and in some cases are overexploited. It is therefore of urgent necessity to take conservation measures for these species using both *ex situ* and *in situ* protection methods. For this purpose it is of critical importance to collect data on the distribution of these species and the vitality and fertility of their populations.

In 2001-2002 our organisation (then known as the Ketskhoveli Institute of Botany of the Georgian Academy of Sciences) collaborated with the Missouri Botanical Garden on the project "Informatics for the Sustainable Use of Plant Genetic Resources in the Republic of Georgia". Also at this time, we established the Caucasus Regional Seed Bank (CRSB) as part of the project "Sustainable Use and Conservation of Medicinal Plant Resources in the Republic of Georgia" between Georgian botanists and colleagues from Missouri Botanical Garden (the project was supported by the U.S. Civilian and Research Foundation). As an output of the above projects, seeds of 150 endemic and rare medicinal plants were collected and deposited in the CRSB. All the collections were incorporated into the TROPICOS database maintained by Missouri Botanical Garden. Following reorganisation, the CRSB is now a structural unit of the Department of Plant Conservation of the National Botanical Garden of Georgia.

The next step in the development of the CRSB was collaboration with the MSBP, which commenced in 2005. This partnership has proved to be extremely successful – not least through the conservation of around a quarter of the flora of Georgia to date. These collections are stored in the Seed Bank of the Caucasus in Tbilisi, and are duplicated in the Millennium Seed Bank in the UK. Since 2010 co-operation has flourished under the "Saving the Flora of the Caucasus" Programme which now includes neighbouring Armenia and Azerbaijan. Georgian botanists are keen to gather information on the full 700 medicinal species occurring in Georgia, collect the seeds and deposit them in both the CRSB and MSB.

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Building seed collections for pharmacological research in Kyrgyzstan

By Anara Umralina (Institute of Biotechnology, Kyrgyzstan)

At the present time about 4,100 higher plant species of 875 genera and 140 families are known in Kyrgyzstan's flora. The country is distinguished by a high concentration of plant species and a high degree of endemism (over 400 species). Realisation that there was an insufficient level of knowledge of the flora, especially endemic and rare species, and an absence of *ex situ* conservation and programmes to study the pharmaceutical potential of these plants was the basis for the establishment of a seed bank in the Institute of Biotechnology of the National Academy of Sciences of the Kyrgyz Republic.

The principal objective of our research is to find pharmacologically valuable species of the Kyrgyzstan flora, especially rare and endemic species. Currently there are 891 plant species in the seed bank of the Biotechnology Institute, 19 of them are not yet identified. These include 96 endemics and 41 species which are included in the Red Book of the Kyrgyz Republic. Collecting is carried out by botanists from the Biology-Soil Institute, Botanic Garden and Institute of Biotechnology.
The principle seed collector is Dr G Lazkov who leads the national herbarium. Since 2005 the MSBP has provided significant assistance in establishing our seed bank, through technical support, training, specialists exchange and visits. Working to MSBP standards means that we have high quality collections of seeds of the most interesting medicinal genera for study in culture.

At present we are studying two large genera – *Scutellaria* and *Hedysarum*, which are known for their medicinal properties.

Kyrgyzstan is home to 32 *Scutellaria* species and about 40 *Hedysarum* species (14% of the total *Hedysarum* species in the world); almost half of these are endemic and rare plants.

Particular success has been achieved with work on *Scutellaria andrachnoides*. The history of this endemic species is interesting. It was collected by Dr. Lazkov in 2006, although it had been believed to be lost for the previous 30 years. Our studies used *in vitro* cultures of *S. andrachnoides* and produced a callus culture and genetically transformed hairy root culture. It was revealed that these cultures synthesise wogonin which has the ability to suppress oncogenic cell growth. These two cultures were submitted to the Eurasian Patent Agency and a positive decision was obtained. We received a patent (EA #019010) for the callus culture. This work was implemented in cooperation with the Institute of Plant Physiology of the Russian Academy of Sciences.

Our collaboration with Kew has flourished in recent years as contact has developed with the Jodrell Laboratory in addition to the MSBP. In March 2014 Dr. B. Asanakunov visited the Jodrell laboratory for four weeks and he participated in joint study of *Scutellaria andrachnoides* plant material.

This work shows the importance of the study of wild flora. Our seed bank provides the opportunity not only for the conservation of Kyrgyzstan's plant diversity, but also for the study of the potential of medicinal plants with *in vitro* and biotechnological methods.

For further information contact Clare Trivedi (c.trivedi@kew.org)

Root culture PHOTO: I. KUZOVKINA

Scutellaria andrachnoides PHOTO: G. LAZKOV

Studying the effects of *ex situ* cultivation on the medicinal properties of Mexican oregano

By Louise Colville, (Biochemist, MSBP)

Wild Mexican oregano during the wet season
PHOTO: A. MORENO-RODRÍGUEZ, UNAM

A Mexican oregano plant grown in the greenhouse
PHOTO: A. MORENO-RODRÍGUEZ, UNAM

Mexican oregano (*Lippia graveolens*) is a shrub in the Verbenaceae family, which is found throughout the arid and semi-arid regions of Mexico. The leaves of Mexican oregano are widely used as an aromatic herb in cooking and in traditional remedies for a variety of ailments including diarrhoea, stomach ache and colic. The medicinal properties are due to its essential oil, which is rich in terpenes, particularly carvacrol and thymol. In addition, Mexican oregano contains a number of antioxidant flavonoids (Martínez-Rocha et al., 2007). The chemical composition, and hence the medicinal properties of Mexican oregano varies between populations and is highly dependent upon soil and climatic factors (Martínez-Natarén et al., 2014).

Mexican oregano leaves are generally harvested from wild plants to supply markets in Mexico and the United States. Mexican oregano is deciduous, and shrubs are bare during the long dry season, so harvesting occurs during the wet season from August to October, which coincides with the flowering period. Therefore, harvesting has serious implications for the reproduction and persistence of wild populations. In addition, harvesting leads to a reduction in plant growth and flowering, from which Mexican oregano plants are slow to recover (Osorno-Sánchez et al., 2012).

Mexican oregano is one of the most important useful species in the Coxcatlán Puebla region of Mexico, and the MSBP's Project MGU – the Useful Plants Project is working closely with the community in the village of San Rafael Coxcatlán and scientists from Universidad Nacional Autónoma de México (UNAM) to conserve useful plant species and investigate their sustainable use. PhD student Amanda Moreno-Rodríguez has been studying the effects of *ex situ* cultivation on the flavonoid content of Mexican oregano leaves in order to develop cultivation conditions which preserve the useful properties of the plants, and thereby provide a sustainable alternative to the over-exploitation of wild plants. Amanda compared the flavonoid content of plants grown under two different light intensities (full light and 30% shade) and two different soil moisture conditions (80% and 40% of field capacity) in a greenhouse (Moreno-Rodríguez et al., 2014).

The flavonoids were analysed in leaf extracts using high performance liquid chromatography (HPLC), and the identity of eight flavonoids was confirmed by liquid chromatography-mass spectrometry (LC-MS) analysis at Kew's Jodrell Laboratory. The effects of cultivation conditions were studied on three biologically active flavonoids: naringenin, naringin and pentahydroxyflavanone-hexoside. Pentahydroxyflavanone-hexoside was the most abundant of the three flavonoids in wild and greenhouse–propagated plants, whilst naringin was the least abundant. Neither was affected by light intensity or soil moisture. In contrast, naringenin levels were induced by high light intensity and low soil moisture, and naringenin was far more abundant in wild plants than in greenhouse-propagated plants. This suggests that naringenin is crucial for protection against high light conditions and drought, and may form a constitutive response to the extreme natural conditions encountered in semi-arid and arid regions, where light intensity can be very high, and rainfall is variable. Whilst *ex situ* propagation under high light and water deficit increased naringenin concentrations, it was not increased to the levels found in wild plants. Nevertheless, naringenin levels were a lot less variable in greenhouse-propagated plants, which is advantageous for producing plants with predictable medicinal properties. A further advantage is that greenhouse-propagated plants do not shed their leaves, so leaves are available for harvest all year round, and can better satisfy the continual demand for Mexican oregano. This research demonstrates the importance of optimising cultivation protocols to yield productive plants with active medicinal properties. *Ex situ* cultivation of Mexican oregano could alleviate the pressure on wild populations, and provide a sustainable resource for local communities.

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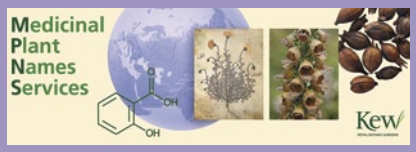
NEWS

Medicinal Plant Names Services

By Elizabeth Dauncey (Business Development Officer, MPNS)



Professionals working in the health, research and regulatory sectors, herbal or pharmaceutical industries, all need to access information about plants and communicate accurately and effectively about them. However, medicinal plants are used globally and are known by different names in different communities, health traditions, generations and languages.

To help overcome this problem, Kew's Medicinal Plant Names Services (MPNS), supported by a grant from the Wellcome Trust, is building a global resource for medicinal plant names. MPNS is using this resource to offer a range of services that aim to improve the safety and efficacy with which plant-based medicines are used and studied globally.

One service is an online portal that can be searched using a scientific, pharmaceutical, common or trade name. Search results display all the plants that the name may refer to, their current taxonomy and other names by which that plant is known in the medicinal plant literature.

The portal can be found at www.kew.org/mpns

For further information contact mpns@kew.org

Public-private partnerships in Kenya

As part of its mandate to produce and distribute high quality seeds of trees and shrubs to various planting programmes in Kenya and within the region, the Kenya Forestry Research Institute (KEFRI), is adopting a new policy of public-private partnerships for seed production. 'Private', in this case, means any persons or groups outside the mainstream Kenya government: botanically knowledgeable organisations, such as botanic gardens, are particularly suitable, but capable entrepreneurs are also welcome to apply for official collector status. The selected individuals or groups are trained and registered to collect and supply seeds to KEFRI, based on agreed contracts and set conditions.

The training includes subjects such as how to collect seed at the correct time, ground vs. crown collection, determining seed maturity, how to harvest, the issue of secondary dormancy, the process of orthodox and recalcitrant seed extraction and the final drying process. Applicants are also shown how to complete collection data sheets and reports.

Trainees receiving their certificates PHOTO: KEFRI

The seeds are then tested and only those which meet KEFRI's standards are paid for and distributed.

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The UK National Tree Seed Project builds on its pilot year

Kew staff with ash (*Fraxinus excelsior*) seed collection at Dovedale, Peak District National Park PHOTO: S.KALLOW

After an initial pilot year in 2013 the UK National Tree Seed Project has put the building blocks in place to establish the ambitious collection, but there is still a lot more to do. The project aims to make multi-provenance seed collections of all UK woody species, both trees and shrubs, across their native distribution. Fifty collections were made in all including 25 of juniper (*Juniperus communis*) and 20 of ash (*Fraxinus excelsior*). Collections were made in England, Scotland and Wales.

The pilot year's seed collecting has helped develop a sampling strategy which is practical and also maximises the use for scientific research. As a departure from the usual MSB protocol, the seeds from each individual plant will be kept separately. Trees will also be physically tagged and co-ordinates taken for each sample. This will enable researchers to return to the tree from which seeds were taken.

The sampling strategy makes use of the UK Forestry Commission 'native seed zones', a climatic and geological division of the UK into 24 zones, as a framework to capture genetic adaptation and maximum genetic diversity. Because of the challenges of making seed collections from large trees in difficult terrain, we have experimented with seed collecting techniques and explored what a realistic sample is. It was also important to develop a strict bio-security procedure, to minimise the risk of spreading pathogens during seed collecting.

An analysis of distribution through the native seed zone framework and also using elevation data has been carried out. This has been fed into a target list, which is now being used to develop work plans with a number of partner organisations. This pool of organisations will make the most of local knowledge and manpower, and includes botanic gardens, arborists, foresters and conservation organisations. To support workers who may be new to seed collecting, the project has published a tree seed collecting manual and will run a number of training events across the country in 2014.

New science collaboration between Kew and the Indian Council of Agricultural Research and Education

Richard Deverell (centre), Director of Kew, with Prof Ayyappan, Director General of ICAR, to his right after the signing of the inter-institutional MoU (13 Feb. 2014). They are joined by Hugh Pritchard (second from left), a team from the National Bureau of Plant Genetic Resources and Government of India officials PHOTO:ICAR

On 13 February 2014, the Royal Botanic Gardens, Kew launched ambitious plans to support the development and delivery of seed science for agricultural development and plant conservation in India, under a new 6-year Memorandum of Understanding with the Indian Council of Agricultural Research and Education (ICAR), Ministry of Agriculture. ICAR co-ordinates, guides and manages research and education in agriculture across the country.

The collaboration is founded on a commitment to enhance research skills and knowledge, achieved through the appointment of new staff on research projects. In addition, numerous MSc and PhD students will graduate, post-doctoral staff will receive specialist training in the UK and many young scientists (mainly from Asia and Africa) will benefit from participating in short-courses in plant conservation biotechnology.

Much of the focus of the collaborative research work will be on neglected and underutilised plants which contain valuable traits for the understanding of stress biology, in response to climate change, and the development of high value agriculture and nutrition. Areas of interest include: innovations in low temperature science to enable the preservation of fruit tree species for nutritional security; the development of biochemical markers for seed storage stability for food security; the evaluation of oilseeds of potential value as sustainable sources of energy; the use of genome sequence data to identify genes for stress tolerance and dormancy; the characterisation of seed persistence and germination in relation to invasiveness and threats to agrobiodiversity; and the development of robust models for *ex situ* seed conservation of the India flora. Collaborative research findings will be published regularly in international peer-reviewed journals and two scientific congresses will be organised.

Finally, seed conservation efforts will focus on species of value in traditional medicine, many of which are at risk from overharvesting and the impact of climate change, and species of horticultural importance, particularly orchids. Half the orchid species in India are found in Sikkim and Kew will work closely with ICAR's National Research Centre for Orchids, in support of the 'Global Strategy for Plant Conservation 2011–2020' of the Convention on Biological Diversity, which emphasises the importance of conserving threatened, socio-economic and culturally-valuable species.

For further details contact Hugh Pritchard (h.pritchard@kew.org)

Key science publications
(October – April 2014)

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5. Kolberg, H., & **van Slageren, M.** (2014) A synopsis of the genus *Pteronia* (Compositae: Astereae) in Namibia including the resurrection of *Pteronia quadrifaria*. *Kew Bulletin* 69: 9488.

Millennium Seed Bank Collection Figures May 2014

Total collections	70,747
Number of species	34,483
Number of genera	5,535
Number of families	333

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