Asian Biotechnology and Development Review

Vol. 13 No. 3 November 2011 ISSN: 0972-7566

Special Issue on Small Island Developing States (SIDS) of the Indian Ocean

Guest Editor: Ameenah Gurib-Fakim

RIS
Research and Information System for Developing Countries

Asian Biotechnology and Development Review

Research and Information System for Developing Countries (RIS), a New Delhi based autonomous think-tank under the Ministry of External Affairs, Government of India, is an organisation that specialises in policy research on international economic issues and development cooperation. RIS is envisioned as a forum for fostering effective policy dialogue and capacity-building among developing countries on international economic issues.

The focus of the work programme of RIS is to promote South-South Cooperation and assist developing countries in multilateral negotiations in various forums. RIS is engaged in the Track II process of several regional initiatives. RIS is providing analytical support to the Government of India in the negotiations for concluding comprehensive economic cooperation agreements with partner countries. Through its intensive network of policy think tanks, RIS seeks to strengthen policy coherence on international economic issues. For more information about RIS and its work programme, please visit its website: www.ris.org.in

The editorial correspondence should be addressed to the Managing Editor, *Asian Biotechnology and Development Review*, Research and Information System for Developing Countries (RIS). Zone IV-B, Fourth Floor, India Habitat Centre, Lodi Road, New Delhi-110003, India. Telephones: 24682177-80. Fax: 91-11-24682173-74. E.mail: ravisrinivas@ris.org.in Website: http://www.ris.org.in

RNI Registration No. DELENG/2002/8824

Printed by: D.K. Fine Art Press (P) Ltd.

This journal is abstracted in ***Cab International and Science of Science***, of Council for Scientific and Industrial Research (CSIR), New Delhi.

Asian Biotechnology and Development Review

Asian
Biotechnology
and
Development Review

Vol. 13 No. 3 November 2011 ISSN: 0972-7566

Special Issue on Small Island Developing States (SIDS) of the Indian Ocean

Guest Editor: Ameenah Gurib-Fakim

Contents

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 1-5

Small Island Developing States of the Indian Ocean: Towards An Action Plan for Medicinal Plants

Editorial Introduction

Ameenah Gurib-Fakim*

Medicinal plants are used extensively by pharmaceutical industries, and in production of cosmetics and fragrances. The global market for herbal drugs is growing and is estimated to be $ 60 billion annually. The annual growth is about 7 per cent. More than 40 per cent of the licensed drugs are originally of plant origin. Meeting the increasing demand for medicinal plants and products derived from them has become a major challenge on account of their unsustainable use. Poverty exacerbates this as medicinal plants provide opportunities to make quick profit from harvesting and selling them. Large scale deforestation and absence of regulation in cultivation and use and enforcement of those relevant laws are some of the factors that contribute towards the unsustainable use of medicinal plants. In the context of small island developing states of the Indian Ocean sustainable use of medicinal plants can be a blessing for many island states that lack other resources like minerals or oil, as they can provide employment and bring in earnings from exports. Processing of medicinal plants can be a profitable opportunity for Small and Medium Enterprises (SME) as this does not require huge investments in terms of capital or machinery and can be environmentally friendly too. Hence SME sector can be a potential sector for this industry to grow.

About 25 per cent of the global biodiversity in plants is found in Indian Ocean Islands and Sub-Saharan Africa. They constitute an important element in the traditional medicinal systems in this region. Often traditional medicinal systems are the ones that are accessible to majority of the population living in rural areas. Local and traditional medicinal systems depend heavily on medicinal plants and their usage in them is a culturally appropriate medical practice.

---

* Centre for Phytotherapy and Research Limited, Mauritius.
Email: afakim@cephyr-recherche.com

Unsustainable practices in cultivation and harvesting of medicinal plants affect their long-term availability for their use in herbal medicine. Many plant species are endangered. The irrecoverable loss on account of extinction of such species also results in loss of the associated traditional knowledge which is an inseparable component of bio-cultural diversity. This loss affects the prospects for bioprospecting also. But the situation is not so bleak to give up any hope on scope for sustainable cultivation or on conservation of medicinal plants or related traditional knowledge.

During the last two decades many initiatives have been taken to address these issues. The Convention on Biological Diversity (CBD) is an important international agreement that recognises the significance of bio-cultural diversity. Many governments have taken steps to implement its provisions, including those relating to Access and Benefit Sharing (ABS). UNESCO has done significant work in conservation issues and in promoting the understanding of the bio-cultural diversity.

As a part of its larger mandate, UNESCO organised an international workshop in Mauritius in collaboration with Centre for Phytotherapy Research, Ebene, Mauritius in April 2011 to address the above mentioned issues, focusing on the opportunities and challenges faced by Small Island States of the Indian Ocean in sustaining and using the rich bio-cultural diversity. Seventy participants from many countries in the region, and, from Asia, Africa and Europe took part in the workshop. The participants deliberated upon the issues through presentations and discussions. This workshop enabled the participants to understand the issues better and to learn from experiences of other countries. Besides this the interaction among participants resulted in development of opportunities for collaboration and exchange of knowledge and expertise.

The participants identified three key topics that needed further attention and suggested that stakeholders and policy makers should engage in a dialogue to arrive at solutions that are appropriate. They underscored the need to understand the emerging challenges and also the opportunities available for initiating measures to protect bio-cultural diversity and promote sustainable use of knowledge and natural resources. The dynamic linkages between national, regional and global agencies should be strengthened further. In this context, regional level initiatives can play a major role in identifying synergies among national strategies and assist in mutual learning and cooperation. The recommendations, that emerged from the workshop indicated earlier, underlined that steps have to be taken at national, regional and global levels. Hence they have been categorised on that basis taking into account cross-cutting issues and their linkages.

Global Issues

- Countries should develop policies to promote sustainable use and should discourage practices that result in unsustainablility with illegal harvesting and indiscriminate export of medicinal plants. Regional cooperation in this can go a long way in preventing unsustainable practices by taking effective measures against illegal trade and by learning from each other.
- Global platforms are needed where countries can learn from other countries, within the region and elsewhere, on developing and implementing policies on promotion of cultivation of medicinal plants and their sustainable use. These forums may also think in terms of developing regimes to monitor such cultivation and to promote cultivating them on a large scale by integrating cultivation, processing and production facilities.
- Successful working models in regulation of traditional medicine in the countries in the region can be studied and those experiences can be used by other countries to develop nationally appropriate regulatory regimes

Regional Issues

- Capacity building in Access and Benefit Sharing (ABS) should be enhanced and countries in the region and communities need assistance in developing regimes for realising the potential of ABS and in use of IPR for protecting traditional knowledge.
- Documentation of traditional knowledge including traditional medicinal knowledge and information on medicinal plants and their uses should be given importance. Initiatives in such documentation projects should take advantage of using digital technologies in classifying and cataloguing and should develop digital databases and use them for preserving and protecting knowledge associated with bio-cultural diversity.
- Capacity building initiatives should focus on learning from other countries, within and outside the region in implementing ABS and digitisation of traditional knowledge.
- Countries need assistance in implementing the Nagoya Protocol and in strengthening the ABS regimes. With reference to the Protocol,

countries need assistance in developing best practices in implementing Prior Informed Consent (PIC) and in realising the principle of equity in ABS regimes.

- Developing standards for herbal medicine is important. In this, countries can cooperate and learn from countries which have developed such standards. Standard setting and enforcement policies should become part of the framework to promote and regulate traditional medicine.
- Creating a network of stakeholders in traditional medicine is important as at this point many stakeholders work in isolation. Such networking can result in better understanding of and responding to the opportunities available to and challenges faced by them. Among the stakeholders, the role of practioners of traditional medicine is important and hence developing a network of such practioners should be given the priority it deserves.
- Successful working models in regulation of traditional medicine in the countries in the region can be studied and those experiences can be used by other countries to develop nationally appropriate regulatory regimes
- The current educational systems in traditional medicine should be assessed and remedial steps should be taken to revitalise them.
- Traditional Knowledge should be incorporated in school curriculum so that future generations are able to understand and appreciate it. Such transmission through the educational system will play an important role in preserving traditional knowledge.
- Schools, colleges and universities should play an important role in documenting traditional knowledge besides developing botanical gardens and herbariums housing traditional medicinal plants.
- Codes of good practice, professional ethics can be developed and adopted by traditional medicine practioners and this can include adherence to standards.
- Validation of traditional medicine is important. In this modern science can play a key role and hence importance should be given to scientific validation of herbal medicinal products and their safety and efficacy should be evaluated. Such exercises will enhance the legitimacy and credibility of traditional medicine. They will also give opportunities to improve the quality of traditional medicine, implement globally

accepted and standard practices in processing of materials and manufacturing in traditional medicines. Since many countries lack expertise in these issues, capacity building should be given priority.

National Issues

- The current inventory of medicinal plants should be updated and earlier initiatives can be revitalised or strengthened
- While revenue from export of traditional medicinal products is significant, most of it is derived from export of raw materials with little value addition. Countries should develop their capacities to process them and develop products based on such raw materials instead of remaining merely as suppliers. This means that they should give more importance to value addition than to encourage export of raw materials per se. The local industry should move up in production and supply chain and should be able to realise better returns from processing and manufacture.
- The current educational systems in traditional medicine should be assessed and remedial steps should be taken to revitalise them.
- Traditional Knowledge should be incorporated in school curriculum so that future generations are able to understand and appreciate it. Such transmission through the educational system will play an important role in preserving traditional knowledge.
- Schools, colleges and universities should play an important role in documenting traditional knowledge besides developing botanical gardens and herbariums housing traditional medicinal plants.

The articles in this special issue are based on the presentations made in the workshop. The authors represent different stakeholders and their views and suggestions represent the diversity in the opinions of different stakeholders. Irrespective of such diversity, the shared objective and issue of concern is protecting and promoting sustainable use of bio-cultural diversity in the region.

UNESCO has been kind enough to support this Special Issue of ABDR. UNESCO played a major role in the Workshop mentioned earlier. I am sure researchers, scholars and policy-makers would find this Special Issue of ABDR useful and interesting.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 7-25

Drugs and Phytomedicines in Indian Ocean and Madagascar: Issues in Research, Policy and Public Health

Philippe Rasoanaivo*

Abstract: Despite the richness and the endemicity of the Indian Ocean Islands and African plant biodiversity, the region has only contributed 83 of the world's 1100 leading commercial medicinal plants. There are two main ways to exploit the biodiversity for drug/phytomedicine discovery and development. The first approach is the today-dominating "single target - single compound" paradigm of drug discovery in pharmaceutical companies. This is mainly achieved by the bioprospecting activities. Existing bioprospecting programmes in Madagascar are outlined, and the regulatory frameworks are examined. The second approach is the complex, multi-component, multi-functional therapies of phytomedicines whose constituents may act in synergy. This is illustrated by the case of *Syzygium cumini* and *Centella asiatica*. Based on a recent example of an anti-malarial plant, a new holistic thinking on how to investigate anti-malarial plants is proposed. After that, the commercialisation of biodiversity is examined. Relevant on-line ethnomedical databases and scientific networks are given, clearly indicating the huge data available in the region. Suggestions are given on how to bridge the gap between basic research and commercialisation.

Keywords: Single drug, bioprospecting, African networks, IPRs, Madagascar, Indian Ocean.

Introduction

Small Indian Ocean Islands (Comoros, Mauritius, Réunion, Rodrigues, Seychelles) and Madagascar pack a great deal of biodiversity hotspot into a relatively small area of 594,221 square kilometres. In terms of the original extent of their native habitats, Madagascar and the Small Indian Ocean Island represent the 10th largest of the 25 biodiversity hotspots that have been identified by Conservation International. They rank 8th among the hotspots in terms of remaining intact habitat according to the most recent estimates of tropical forest cover. They harbour 11 endemic plant families, at least 310 endemic genera, and 8,900-10,500 endemic species.

* Ecole Supérieure Polytechnique, University of Antananarivo, Campus Ambohitsaina, Antananarivo, Madagascar and Institut Malgache de Recherches Appliquées, Madagascar. Email: rafita@moov.mg

Before the arrival of modern conventional medicine, people worldwide developed unique indigenous healing traditions adapted and defined by their culture, beliefs and environment, which satisfied the health needs of communities over centuries. The World Health Organisation defines traditional medicine as the sum total of the knowledge, skills, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness.[1] The development of traditional medicinal systems incorporating plants as means of therapy can be traced back to the Middle Palaeolithic age some 60,000 years ago as found from fossil studies.[2]

With the progress of science in the 19th century, the investigation of medicinal plants as medicines has involved the isolation of active compounds, beginning with the isolation of morphine from opium, and subsequently led to the isolation of early drugs such as cocaine, digitoxin, strychnine, tubocurarine, quinine, etc.

There are two opposite views in old Greek philosophy dealing with the two distinct approaches, namely single-constituent drugs *versus* multi-component phytomedicines. The underlying philosophy related to single drug is that "*every healing has its quintessence*", and the second one related to multi-component is that "*nature does nothing without purpose or uselessly*". The former approach forms the basis of today's dominating "single target-single compound" paradigm of drug discovery in pharmaceutical companies. In the latter approach, it is assumed that complex, multi-factorial diseases may require multi-component, multi-functional therapies, and complex molecular interactions produce effects that may not be achieved by single component. In industrialised countries, adaptations of traditional medicine are termed as "Complementary" or "Alternative" Medicine (CAM).

In the present article, we will examine first the two research paradigms with implications to policy and public health. Then we will discuss the commercialisation of biodiversity.

Paradigm of Bioactive Single Constituent of Plants

Historical Background

At the end of the 18th century, with the development of chemistry, a key step was taken in the field of medicine due to the isolation of active ingredients. At this point, morphine was the first isolation of a natural plant alkaloid.

It was discovered in 1805 by Freidrich Wilhelm Sertürner, an obscure, uneducated, 21-year-old pharmacist's assistant with little equipment but full of curiosity.[3] Sertürner wondered about the medicinal properties of opium, which was widely used by physicians. In a series of experiments, performed in his spare time, he managed to isolate an organic alkaloid compound from the resinous gum secreted by the opium poppy. Sertürner found that opium with the alkaloid removed had no effect on animals, but the alkaloid itself had ten times the power of processed opium. He named that substance morphine, after Morpheus, the Greek god of dreams, for its tendency to cause sleep. He spent several years experimenting with morphine, often on himself, learning its therapeutic effects as well as its considerable dangers. Although his work was initially ignored, he recognised its significance, and as he predicted, chemists and physicians soon grew interested in his discoveries. His pioneering work sparked the study of alkaloid chemistry. Pelletier and Caventou, who isolated quinine in 1820 from barks of the *Cinchona* tree, made also the second most significant progress. Sertürner's work also hastened the emergence of the modern pharmaceutical industry. At this point, in 1827, Heinrich Emanuel Merck from Germany pioneered commercial manufacturing of morphine for an expanding global market and continued along these lines when he began producing various alkaloids industrially, such as quinine at his own company in Darmstadt.

The morphine and quinine stories have established a model for the study of natural products that has been repeated many times hitherto, which is the search for the single active principle in plants, based on the assumption that a plant has one or a few ingredients which determine its therapeutic effects. The choice of pure compounds in the pharmaceutical industry has been dictated by several compelling reasons: amenable to synthesis of semi-synthesis for lead optimisation, or second/third generation of drugs; easily patentable; no reliance on crude raw materials; convenience for the investigation of mechanism(s) of action; and convenience for drug delivery including nanotechniques.

Biodiversity is a source, a reservoir, of chemical diversity which is a key factor for a successful drug discovery. The search for new medicinal, agrochemicals and other substances from living organisms is termed bioprospecting. For drug-targeted bioprospecting, an industrial partner is needed, which will be instrumental in converting the discovery into a commercial product.

What is Bioprospecting?

Bioprospecting, also known as biodiversity prospecting, is the exploration of biological material for commercially valuable genetic and biochemical properties. In simple terms, this means the investigation of living materials (plants, animals, marine organisms, micro-organisms) to see how they can be commercially exploited for the benefit of humans. Small samples of natural resources are collected for their potential value to industry, mainly in the pharmaceutical and cosmetic industry, biotechnology, and agri-business fields. Local communities close to where the material originates may have specialised knowledge on how the resources are used, and this is known as traditional or indigenous knowledge.

The practice of bioprospecting is as old as human civilisation. One of the earliest recorded plant collection expedition took place in 1495 BC when Queen Hatshepsut of Egypt sent a team to Ethiopia to collect *Boswellia* species, a plant whose fragrant resins produce frankincense. Similar expeditions occurred elsewhere in the world, and they were based on an explicit understanding of the economic value of the plants. In the Indian Ocean Islands, Pierre Poivre, a passionate botanist in Mauritius, undertook in 1767 the beneficial initiative of planting all available tropical aromatic and medicinal plans in a botanical park of Mauritius. He named it *Jardin des Pamplemousses*. He sent his nephew Sonnerat in 1768 to Madagascar with the aim of collecting Malagasy palms to supply the *Jardin des Pamplemousses*. Other botanists working in Madagascar, namely Commerson, Le Chapelier and Michaux shipped several plants to Mauritius. Conversely, Poivre disseminated several aromatic and spice plants in the Indian Ocean Islands, namely La Réunion, Comoros, Seychelles, Zanzibar, and Pemba. There was, therefore, a high traffic of plant exchange in the Indian Ocean in the 18th century. It is likely that most aromatic plants of economic value introduced to Madagascar entered the Island *via* Mauritius.

Bioprospecting Programmes in Madagascar

The International Cooperative Biodiversity Group (ICBG) programme was initiated in 1992, as a result of a series of meetings between scientists and US government officials concerned with maintaining a robust natural products drug discovery programme while contributing to biodiversity conservation. An ICBG agreement with Madagascar was signed in November, 1990, and this involved the Virginia Polytechnic Institute and State University and the Missouri Botanical Garden as US partners, and the *Centre National d'Application de Recherches Pharmaceutiques* (CNARP) and the *Centre National* *de Recherche sur l'Environnement* (CNRE) as Malagasy counterparts. The initial five-year contract has been renewed four times, extending the activities through 2010. Collecting in Madagascar began in 1991 and has taken place in a variety of habitats throughout the country. There were 6,496 samples collected between 1991-2001 from Madagascar for the US National Cancer Institute (NCI) programme[4] and it is estimated that nearly 10,000 samples have been collected hitherto. Results from ICBG working in Madagascar, Panama, and Suriname were reported.[5]

In 1994, a bioprospecting project was signed between *Institut Malgache de Recherches Appliquées* (IMRA) and the pharmaceutical company Sanofi Aventis, but it was discontinued in 2009. To the best of our knowledge, no published data is available on this programme.

The *Institut de Chimie des Substances Naturelles*, CNRS France in 2005 signed a bioprospecting agreement with the University of Antananarivo and IMRA. Nearly 1,000 plants have been sampled up to now. To comply with the national regulations, the project has received a formal collecting permit issued by the *Direction de la Valorisation de la Biodiversité*, Ministry of the Environment; and this permit has been renewed every six months. The project ended on November 2011, but ongoing phytochemical and or biological work is continuing.

The CRVOI (*Centre de Recherche et de Veille sur les maladies émergentes dans l'Océan Indien*) has funded a three-year project in 2008 on the search of new compounds against chikungunya virus. Three teams, located at the University of La Réunion, the University of Mauritius and the *Institut Malgache de Recherches Appliquées* (Madagascar), together with the *Institut de Chimie des Substances Naturelles* (CNRS France), have build a unique sample library consisting out of more than 1,500 crude plant extracts that have been evaluated for selective antiviral activity against CHIKV in Leuven (Belgium) and Marseille (France). Currently, a bio-assay-guided purification of pure substances is in progress, yielding the first results. Concomitantly, enzymatic assays are being developed in Marseille to evaluate and possibly characterise in detail the selective inhibitory effect of these compounds. The project officially ended in 13 November 2011, but phytochemical work is continuing.

Regulatory Framework Regarding Access and Benefit Sharing

Research, involving the use of biological resources of a country, is today based on agreements and permits which in turn are based on international and bilateral treaties. The most important of these is the 'Convention of Rio' or the 'Convention on Biological Diversity'.

The history of the Convention on Biological Diversity (CBD) has been reported in several websites.[6] Brief y, the fact that the Earth's biodiversity is fast disappearing became accepted wisdom during the 1980s, and species extinction caused by human activities continues at an alarming rate. Various approaches to identifying regions at greatest risk for biodiversity loss have been proposed, with the greatest attention focused on so-called "biodiversity hotspots". Species extinction caused by human activities continues at an alarming rate. In response to these threats, the United Nations Environment Programme (UNEP) convened an Ad Hoc Working Group of Experts on Biological Diversity in November 1988 to explore the need for an international convention on biological diversity. Soon after, in May 1989, it established the Ad Hoc Working Group of Technical and Legal Experts to prepare an international legal instrument for conservation and sustainable use of biological diversity. The experts were to take into account "the need to share costs and benefits between developed and developing countries" as well as "ways and means to support innovation by local people". By February 1991, the Ad Hoc Working Group had become known as the Intergovernmental Negotiating Committee. Its work culminated on 22 May 1992 with the Nairobi Conference for the Adoption of the Agreed Text of the Convention on Biological Diversity (CBD). The Convention was opened for signature on 5 June 1992 at the United Nations Conference on Environment and Development (the Rio "Earth Summit"). As is well known, the Convention establishes five main goals: the conservation of biological diversity, the access to genetic resources, the sustainable use of its components, the indigenous and local rights, and the fair and equitable sharing of the benefits from the use of genetic resources.

To comply with the CBD, one important key point in any bioprospecting is the drafting and signing of an agreement or Memorandum of Understanding that should cover issues on access to the genetic resources (biodiversity), on intellectual property related to discovery, on the sharing of benefits as part of the process (short-term), and in the event of discovery and commercialisation of a product (long-term), as well as on the conservation of the biological resources for the future generations. When ethnobotany-based approach is used, additional specific requirements, namely, prior informed consent, recognition of indigenous intellectual property rights are to be met. There are many documents dealing with these subjects which can be downloaded from the internet.[7]

Complexity, evolving feature and diversity, dominate the field of bioprospecting. Understanding these points and acquiring knowledge in the market as well as scientific, technical and legal realities of bioprospecting is vital for effective regulations. The endless 'bioprospecting versus biopiracy' conf ict comes from biodiversity-rich country providers and the technology-rich developed country users. Regulatory frameworks do not ref ect the reality of bioprospecting in both sides, and measures have been poorly formulated and implemented as seen in the title of documents. As a result, proposed regulatory documents have been often followed by criticisms to cite 'another false hope in biopiracy' regarding the Bonn Guidelines[8], or endless hotly debates on 'the road to an anti-biopiracy agreement.'[9]

It is important to bear in mind that benefits from bioprospecting may include monetary compensation (up-front payment, milestones payment, royalties, trust funds). But many researchers and policy makers now consider source country capacity building efforts (training, infrastructure development, equipment) and the building of collaborative links that will endure beyond the scope or duration of a specific project to be more important than the chances for financial benefits to alleviate rural poverty or improve biodiversity conservation after successful R&D activities on a specific compounds, which enters the market. Model ABS Agreements and Contractual Clauses can be found in the CBD website.[10] A useful document on benefit sharing in practice has been published recently.[11] In appendices, it gives a list of useful books and websites related to ABS.

Paradigm of Multi-component Phytomedicines

Nature has patiently shown her complex systems, harmoniously interacting with each other as a unit and herbalists have had much opportunity to observe this reality. What are called single herbs are in fact complex chemical compositions, but traditional systems of medicines generally assume that a synergy of all ingredients of the plants will bring about the maximum of therapeutic efficacy. In this approach, it is thought that complex, pleiotropic diseases may require multi-component, multi-functional therapies, and complex molecular interactions produce effects that may not be achieved by single component. Furthermore, a compound may act as pro-drug. *Tetrahydrocannabinol* (THC) which is an example of a pro-drug, as THC is only present in the plant as a minor degradation product of THC-acid, a constituent with little bioactivity. By heating the THC-acid through smoking, however, the active compound THC is formed. Another interesting example is willow *Salix* bark, well-known in Europe as an analgesic and the basis for the development for acetylsalicylate (aspirin), developed more than 100 years ago to treat, among others, headache. Aspirin is probably one of the most successful drugs ever made with new applications of this drug continually being discovered, but for which many questions about the mode of action still exist as no single clear target through which activity is exerted is known. Neither acetylsalicylate nor salicylate is present in willow bark; instead, the bark contains salicin, a glucoside from salicylic alcohol. In the body the sugar is split off and the alcohol is oxidised to salicylate, making this a clear example of a pro-drug. With the present-day paradigm of drug development salicylate may never have been found. We give below two relevant examples of Madagascar phytomedicines in which synergistic effects among constituents are necessary for their efficacy.

Syzygium cumini (*Eugenia jambolana*) is an edible plant used for long time as a remedy for the treatment of diabetes in India and Indian Ocean Island folk medicine. Several papers reported the antidiabetic properties of this species[12] but attempt to isolate the active ingredient(s) has failed hitherto. IMRA made a standardised polyphenol- and sterol-free 1-3, 1-6 glucan phytomedicine called Madeglucyl produced from the seeds of *Syzygium cumini* (also known as *Eugenia jambolana*) and commercialised by SOAMADINA, the commercial branch of IMRA. Toxicological and pharmacological data show that Madeglucyl is devoid of any side effect and can provide a support in maintaining normal sugar levels in several experimental conditions. Madeglucyl had its efficacy proven by clinical data obtained from studies in Madagascar, Germany and the USA, where it demonstrated a good tolerability and a significant effect already 15 days after starting the treatment. Moving with time to the e-marketing, Madeglucyl is the main ingredient of a new formulation sold under the trade name Glucanol Forte.[13] As a result of intensive literature search and compilation of data, immune stimulating properties have also been ascribed to Madeglucyl. The phytomedicne is sold under the trade name Glucanol with strong emphasis on the immune system support of the drug in the labelling.[14]

Centella asiatica (also known as Gotu kola and *Hydrocotyle asiatica*) is a perennial, herbaceous creeper with kidney shaped leaves, found in India, Sri Lanka, Madagascar, Cameroon, Tanzania, Kenya, South Africa, Australia, China, and Japan. The species prefers to grow in shady, moist, or marshy areas at an altitutude of 600 to 1200 m above see level. It is a tropical medicinal plant with a long history of therapeutic uses. *Centella asiatica* contains several active constituents, of which the most important are the pentacyclic triterpenes, which are in the form of genuine (asiatic acid, madecassic acid), and of glycosides (asiaticoside, madecassoside). Historically, this tends to be forgotten, but asiaticoside was first isolated in crystalline form in Madagascar[15] as a follow-up of the clinical trial of the plant in the treatment of leprosy.[16] The name madecassoside given to another constituent and the trade-name Madecassol given to the commercial drug were probably chosen to remind the country because Madecasse originating from the Malayan language is an obsolete word used in the past to describe something related to Madagascar. *Centella asiatica* has gained worldwide reputation for its triterpene constituents used in the treatment of several illnesses, including small wounds, chaps, skin disorders (such as psoriasis and eczema), skin ulcers, burn and scar, and chronic venous insufficiency and varicosities.[17] The mixture of the four triterpenes acting probably in synergy is much more potent than a single constituent. Scientific findings also exhibited that the aqueous extract of *C. asiatica* has cognitive enhancing effect and an antioxidant mechanism is involved. Additionally, *C. asiatica* leaf extract was not only showed to improve spatial learning performance and enhance memory retention in neonatal rats during growth spurt period, but was also found efficient in enhancing hippocampal neuronal dendritic arborisation in rats, thus providing evidence to show the effect of this plant extract on the brain regions involved in learning and memory. But none of the single constituents showed therapeutic applications in learning performance in humans.[18]

Evaluating Efficacy of Traditional Recipes: Getting Outside the Box

The example of *Centella asiatica* clearly shows that a crude extract may have multiple and unrelated biological activities. We are entering a century marked by specialisations in almost every field and profession. This trend of mechanistic thinking, which focuses on the parts rather than the whole, doesn't hold its own in the field of healing, where the subject is the living human body with its subtle dimensions, complexities and interactions of all the different parts. There are several examples of herbal medicines with reputedly excellent therapeutic effects, which subsequently produce disappointing results when evaluated in the laboratory with the standard biological screenings. Conversely, there are several bioactive compounds isolated from plants with excellent biological activity in the laboratory, which are ineffective or too toxic to use in human patients. To develop evidence-based traditional medicines, we need to return to the principles of historical holistic methods of drug discovery: back to *in vivo* experiments and examination of mixtures, pro-drugs and synergism, which could quite possibly result in finding new modes of actions, new targets and new lead compounds.

One recent example in our laboratory is a plant reputedly used to treat malaria. The standard *in vitro* isotopic microtest and *in vivo* 4-day suppressive test gave negative results with 2 per cent parasite inhibition at 10µg/ml and 18 per cent parasite inhibition at 100mg/kg respectively. But unexpectedly at Day-8, there was a drastic drop of the parasitemia down to 0.8 per cent and a proliferation of lymphocytes. It was a starting point of new thinking in malaria chemotherapy research. Looking back to previous malaria chemotherapy research, investigation on antimalarial plants has been mainly focused on killing the parasites but rarely consider other mechanisms. We need to think on "both sides of the coin", taking into account both the parasite and the host. Many anti-malarial herbal remedies may exert their anti-infective effects not only by directly affecting the parasite, but also by stimulating natural and adaptive defence mechanisms of the host. The immune system is the first line host defence, and it is always associated with a complex inf ammatory process and subsequent oxidative stress which are partly responsible for the disease symptoms (immunopathology). Treating malaria may involve a holistic approach consisting of killing the parasites, boosting the immune system and managing the inf ammatory process, and this cannot be achieved by a single constituent. The naturally-occurring drug curcumin may be a good candidate, thank to its various biological activities such as immuno-stimulating, anti-inf ammatory, antioxidant.[19] But its short half-life and subsequent poor bioavailability are limiting factors for clinical usefulness. During evolution and natural selection, humans have developed eff uxing mechanisms for detoxification to prevent pure naturally-occurring compounds to be absorbed.

Tolerance is defined as all of the mechanisms that regulate the self-harm that can be caused by the immune response, and also other mechanisms that are not directly related to immune resistance. The phenomenon of natural antimalarial immunity is known as premunition, in which infected individuals can withstand the presence of parasites in their blood at levels that would elicit sickness in unprotected individuals. This might be another example of tolerance in that the body is somehow tolerating the *Plasmodium* species rather than inducing a large immune response that would cause pathology. While most emphasis has been directed to eliminate the invading malaria parasites or blocking its invasion, but very little has been done on the tolerance mechanisms. They may the ones that will probably be most useful in terms of medical intervention because they are less likely to affect resistance to the malaria parasites. Our ongoing work on the above mentioned antimalarial plant, using adequate drug/extract combination, has given promising results in malaria treatment, tolerance and protection as well as passive transfer immunity in mouse models.

To the best of our knowledge, there has been practically no work on the role of traditional knowledge about tolerance in the response to the infectious disease. To exploit fully the potential of traditional medicine, we need to consider its holistic approach and the necessity of having a multi-disciplinary team. To this end, we have considered the following steps in our malaria research:

i. First killing the parasites, or at least reducing the percentage parasitemia in the blood. At this point, it has been observed that nearly all plant extracts do not produce complete parasite clearance. Furthermore, it is known that central player in the generation of immune responses is the dendritic cell. Hemozoin has profound suppressing effects on dendritic cell function, and large excess of this compound may enhance immunopathology or facilitate the parasite's survival by depressing beneficial immune system.[20]

ii. Going beyond the paradigm of current drug combination which is "curative + curative", and shifting to "curative + protective", taking into account extracts that have immuno-stimulating and anti-inf ammatory effects. The basic idea is boost the immune system while switching the initial pro-inf ammatory immune response to a predominantly anti-inf ammatory response generated by cytokines, like thermostat regulation, which mediates parasite clearance while simultaneously avoiding severe pathology.

iii. Going beyond the boundaries of standard *in vivo* tests and putting great attention on the post-fourth day events, which have been neglected: evolution of parasitemia until mice death, appearance or proliferation of lymphocytes, mice survival.

Commercialisation of Biodiversity

Overall, despite the richness and the endemicity of the Indian Ocean islands and African plant biodiversity, the region has only contributed 83 of the world's 1100 leading commercial medicinal plants. There are many reasons for this: externally-driven research activities; overdependence on the North; inability to do fund-generated activities; skill gap and a funding gap in the Indian Ocean Islands and Africa to translate research finding in academia into marketable products; lack of culture of innovation; and ignorance of the patenting mechanism.

H.A.M. Dzinotyiweyi, Minister of Science and Technology Development, Zimbawe said at a plenary lecture of TWAS in 2010: "*It is now time to break the walls between science and commerce and to start building bridges instead*".

Basic and applied research is the process of generating new knowledge, and this may lead to publications and other scientific productions. Development is the process of translating new or existing knowledge into invention, and this may result in patents and related matters. Innovation is the process of turning an invention into a marketable product. Innovation is, therefore, more than invention; it also involves the commercialisation of ideas, implementation and modification of existing products, systems and resources.

Huge data exists in the Indian Ocean Islands and Africa on ethnomedical knowledge as well as scientific productions published through scientific networks.

African Ethnomedical Databases Available on the Web

Africa is a big continent with poor infrastructures for the dissemination of local research results. It is difficult to have an exhaustive overview of all published ethnobotanical data. We give below useful information on the most accessible and free databases, thank to the use of the information and communication technologies.

AFLORA: African Flora is a database of ethnobotanical information collected in tropical Africa. It was promoted since late 1980s by the Centre for African Studies, Kyoto University, and involving both Japanese field researchers working in Africa and other researchers who are interested in ethnobotany of tropical Africa. The purpose of the projects is to accumulate information on plant use and nomenclature, and to facilitate effective information retrieval through web system.[21] More than 10,000 records of useful plants in Africa are stored in terms of usage, vernacular name, ritual or spiritual meanings. It is probably the only database site, which really provides ethnobotanical information, and as such deserves particular attention for future similar work in Africa.

IRD: Institut de Recherche pour le Développement, formerly known under the acronym ORSTOM (Office de Recherche Scientifique et Technique d'Outre-Mer), is at crossroad of natural and social sciences in francophone African countries. Over sixty years of efforts, IRD has now more than 110,000 references available and 37,000 downloadable documents in PDF format.[22] Particularly, data from biodiversity, inventory of medicinal plants, ethnology, etc., can be easily retrieved at free access from the website endowed with key word search.

PHARMEL: Pharmacopée et Medecine TraditionneLle is a francophone traditional medicine and pharmacopoeia database created in 1986 with the help of the French Organisation *Agence de Coopération Culturelle et Technique* and whose aim is to gather the data concerning the uses of medicinal plants in folk medicine in 21 African countries. This database based on series of ethnomedical inventories, was published between 1980 and 1990 by the same French Institution. This database itself contains nearly 20,000 recipes based on more than 4,000 plant species.[23] Beyond the compilation of medicinal uses as such which is usually too concise to ref ect the richness of practices of numerous ethnic groups in each country, the main value of the database lies in the proposed standardised mode of coding the collected data. The key to these codes has been published;[24] it allows for a considerable improvement of the gathered information with special consideration given to the specification of the dosage, and the standardised data entry facilitates comparisons.[25]

PRELUDE: Programme de Recherche et de Liaisons Universitaires pour le Développement is a bilingual database concerning the use of thousands of plants in different traditional veterinarian and human medicines in Sub-Saharan Africa. The aim of this database is to have documentation that provides access to condensed information from a variety of sources regarding the use of traditional medicinal plants in different regions of Africa. A PRELUDE sub-network titled "Health, Animal Products, Environment" offers a database with 7,500 entries in traditional veterinary medicine for Sub-Saharan Africa. The information stored in the database is gleaned from scientific articles, books, papers given to congresses or directly to the Sub-Network meetings.[26]

PROTA: Plant Resources of Tropical Africa, as initiative of Wageningen University in the Netherlands, is an international, non-profit foundation. It intends to synthesise the dispersed information on the approximately 7,000 useful plants of tropical Africa with estimated 200,000 references, an estimated 30,000 photographs and drawings and 6,000 geographic distribution maps, and to provide wide access to the information through web databases, books, CD-Roms and special products. PROTA initiators found that in tropical Africa there are over 7000 plant species that are used for food, medicine, forage, fuel, clothing, and construction among other uses. However, exploitation of Africa's plant resources for poverty alleviation, empowerment of women, health improvement and environmental sustainability is highly underdeveloped. A major factor contributing to under-exploitation is a lack of readily available and consolidated information for policy and decision makers in government, private sector, research, education and rural development, and also the millions of people who directly depend on plant resources for their livelihoods. A comprehensive overview of the state of knowledge on Africa's useful plants allows for timely identification, conservation and sustainable use of promising species for food security, income generation, medicine development, bio-fuel production, environmental protection and adaptation to climate change. In the course of its development, PROTA has evolved from a static encyclopaedia to an interactive information platform called PROTA4U on the useful plants of tropical Africa.[27]

There is also a commendable initiative of the World Health Organisation (WHO) through the Health InterNetwork Access to Research Initiative (HINARI). The HINARI Programme, set up by WHO together with major publishers, enables developing countries to gain access to one of the world's largest collections of biomedical and health literature. More than 7,500 information resources are now available to health institutions in 105 countries, areas and territories benefiting many thousands of health workers and researchers, and in turn, contributing to improved world health. HINARI Access to Research in Health Programme provides free or very low cost online access to the major journals in biomedical and related social sciences to local, not-for-profit institutions in developing countries. Local, not-for-profit institutions in two groups of countries may register for access to the journals through HINARI. The country lists are based on GNI per capita. Institutions in countries with GNI per capita below $1600 are eligible for free access. Eligible categories of institutions are: national universities, research institutes, professional schools (medicine, nursing, pharmacy, public health, and dentistry), teaching hospitals, government offices and national medical libraries. All staff members and students are entitled to access to the journals.

African Networks on Medicinal Plants and Drug Discovery

The African Ethnobotany Network (AEN) was founded at the 15th AETFAT Congress held in 1997 in Harare and comprises 27 African countries. The network published a review of ethnobotanical literature from Eastern and Southern Africa,[28] and a review of ethnobotanical literature from Central and West Africa.[29]

Two regional networks on natural products, namely, NAPRECA (Natural Products Research Network for Eastern and Central Africa);[30] and WANNPRESS (West African Network of Natural Products Research Scientists);[31] hold impressive data on the botany, chemistry and pharmacology of African biodiversity.

AAMPS (African Association of Medicinal Plants Standard);[32] is a non profit association registered in Mauritius, and dedicated to the development of quality control and quality assurance standards for African medicinal plants and herbal products. The outstanding achievement of AAMPS is the publication of the 'African Herbal Pharmacopoeia' with most up-to-date and extensive data on the uses, quality, safety and efficacy of 52 most important African medicinal plants.

Regarding network on drug discovery, ANDI (African Network for Drug and Diagnostic Innovation)[33], was conceived by the WHO through the Special Programme for Research and Training in Tropical Diseases (TDR), and launched as a concept at Abuja in 2008 by several African institutions, policy makers, Africans in the Diaspora, the African Development Bank and other stakeholders. In this regard, the African biomedical research landscape including the level of intra-African expertise and collaboration was assessed to support the development of the Network. Its mission is "to promote and sustain African-led health product innovation to address African public health needs through the assembly of research networks, and building of capacity to support human and economic development". The long-term vision is "to create a sustainable platform for R&D innovation in Africa to address Africa's health needs". ANDI has reported a critical analysis of the drug discovery for neglected diseases in Africa and has now a clear strategic and business plan available in the website. ANDI is largely recognised as the best network in Africa for drug innovation.

How to Bridge the Gap Between Basic Research and Commercialisation?

Commercialisation is a complex exercise requiring multi-discipline approach and financial investment to take an idea/technology to the market place. It is now the right time for the region to go beyond just publishing and deliver products.

First of all, it is timely to coordinate, develop, and harmonise the various isolated and fragmented efforts in generating knowledge in the region. Secondly, many African institutions have insufficient capacity to manage innovations and to translate findings from the bench to the bedside. Consequently, they are unable to support the development of products from the R&D efforts of its research institutions. Undoubtedly, what we need most in the Indian Ocean Islands and Sub-Saharan Africa is to instil to scientists in the region the culture of innovation, fundraising and business, and to engage in product development of affordable standardised phytomedicines. We need also to gain knowledge of how the patent and other intellectual property systems work and, how to use these to locally develop and deliver novel products and services derived from the region's rich biodiversity and traditional knowledge; otherwise, we may lose ownership of such innovations.[34] Finally, we need to learn the mechanisms of financing in business, that is, grants, bootstrapping, angel investment, venture capital, dept financing, etc.

Successful R&D commercialisation and technology transfer is a result of close collaboration between three entities: (i) researcher/technology provider, (ii) entrepreneur, and (iii) funding agency/venture capital willing to take the risk of investing and promoting discoveries. Working with researchers in the universities provides an opportunity for the private sector to tap into many technologies and inventions. As university R&D often lacks industrial focus, it also provides a challenge to the private sector to move the academic technology and inventions into the market place.

Intellectual Property and Patent Systems in Africa

Intellectual property includes: patents, trademarks, copyrights, industrial design, confidential information, trade secret, layout design, geographical indications. The role of patent system is to: (i) encourage technological innovation, (ii) promote competition and investment, (iii) encourage dissemination of information, and (iv) promote technology transfer.

An excellent document regarding patent systems in Africa has been published.[35] Brief y, African countries may have their national patent system, like in Madagascar whose name is *Office Malgache de la Propriété Industrielle* (OMAPI). There are two regional patent systems in Africa: *Organisation Africaine de la propritété Intellectuelle* (OAPI) for francophone countries, and African Regional Intellectual Property Organisation (ARIPO) for Anglophone countries. Furthermore, African countries may belong to international patent treaties, namely, the Paris Industrial Property Convention (PIPC), the Patent Cooperation Treaty (PCT) and the WTO-TRIPS agreements. Readers are kindly requested to read these documents if they want to obtain useful information.

Conclusion

Biodiversity is the result of three billion years of evolution, a unique heritage and vital resource for humankind. There are two main ways to exploit this heritage: biodiversity as a source of chemical diversity which can be explored for single constituent drug discovery; and biodiversity as source of multi-component material acting in synergy which can be used for phytomedicines.

The two approaches may lead to commercialisation, and this raises the problems of access to genetic resources, the intellectual property rights and the benefit sharing. In this regard, due to complexity of the subject, realistic attitude would be the best way to proceed.

Endnotes

1 WHO (2001), (2002).

2 Lietava (1992).

3 Huxtable and Schwarz (2001).

4 Miller *et al.* (2005a); Miller and Callmander (2005b).

5 Kingston (2011).

6 http://www.cbd.int/history/.

7 The relevant documents written by experts in regional/international institutions are, namely: OAU's Model Law for the protection of the rights of local communities, farmers and breeders, and for the regulation of access to biological resources (2000): an explanatory booklet; Bonn Guidelines on access to genetic resources and fair and equitable sharing of the benefits arising out of their utilisation (2002), Secretariat of the Convention on Biological Diversity; Swakopmund Protocol on the Protection of Traditional Knowledge and Expressions of Folklore (2010) within the Framework of the African Regional Intellectual Property Organisation (ARIPO); Updated WIPO documents on Traditional Knowledge, Genetic Resources and Traditional Cultural Expressions/Folklore (2011); and Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation to the Convention on Biological Diversity (2011).

8 http://www.itpgrfa.net/International/content/bonn-guidelines-access-genetic-resources-another-false-hope-against-biopiracy

9 http://www.twnside.org.sg/title2/books/pdf/The.Road.to.an.Anti-Biopiracy.Agreement.pdf.

10 http://www.cbd.int/abs/resources/contracts.shtml.

11 Phillips (ed), (2009).

12 Anonymous (2009).

[13] Relevant information can be found at http://www.truebotanica.com/paged192.html.
[14] Relevant information can be found at http://www.neinstitute.com/comfiles/pages/21.shtml.
[15] Bontems and Todryk (1942).
[16] Grimes and Biotean (1947)
[17] Brinkhaus (2000).
[18] Loiseau, personal communication
[19] Mimche (2011).
[20] Urban (2006).
[21] http://130.54.103.36/aflora.nsf.
[22] Information can be found at http://www.documentation.ird.fr.
[23] Lejoly (1997).
[24] Adjanohoun (1992).
[25] The software for ethnobotanical data capture can be downloaded freely from the web: http://www.ulb.ac.be/sciences/bota/pharmel.htm.
[26] A freely accessible web search can be found at http://www.metafro.be/prelude.
[27] PROTA4U is a bilingual platform, and information can be found at http://www.prota4u.org/.
[28] Cunningham (1997).
[29] http://www.napreca.net
[30] www.wannpres.org
[31] www.aamps.org
[32] www.andi-africa.org
[33] Dounias (2000).
[34] Kartal (2007).
[35] Mengistie (2010).

References

Adjanohoun, E., G.Cusset, J.Eyme, M.Lebras, J.Lejoly, T.Richel and P. Waechter. 1992. Banque de données de médecine traditionnelle et pharmacopée (PHARMEL). Notice d'emploi du logiciel de saisie des données, Agence de Coopération Culturelle et Technique, Paris.

Anonymous. 2009. "*Syzygium cumini*", in Ministère de la Santé de Madagascar (ed) : Vers une pharmacopée Malagasy : monographies d'usage. pp 199-215. Antananarivo : Direction de la Pharmacie, du Laboratoire et de la Médecine Traditionnelle.

Bontems J. E. 1942. "Sur un hétéroside nouveau: l'asiaticoside". Gazette Médicale de Madagascar, 5 : 29-33.

Brinkhaus, B, M. Lindner, D. Schuppan and E. G. Hahn. 2000. "Chemical, Pharmacological and Clinical Profile of the East Asian Medical Plant *Centella asiatica***".** *Phytomedicine*, 7(5): 427-448.

Cunningham, A. B. 1997. "Review of Ethnobotanical Literature from Eastern and Southern Africa.**"** AETFAT- People and Plants Initiative UNESCO-WWF-Royal Botanical Garden Kew. Bulletin of the African Ethnobotany Network, 1: 23-87.

Dounias, E., W. Rodrigues and Petit C. 2000. "Review of Ethnobotanical Literature from Central and West Africa.**"** AETFAT- People and Plants Initiative UNESCO-WWF-Royal Botanical Garden Kew. *Bulletin of the African Ethnobotany Network*, 2: 1-133.

Grimes, C. and Boiteau P. 1947. “Rapport sur la thérapeutique de la lèpre”. Société des Amis du Parc Botanique et Zoologique de Tsimbazaza, 8ème et 9ème Rapports Annuels, Années 1944 et 1945, 51-55.

Huxtable, R. J. and Schwarz S. K. W. 2001. “The Isolation of Morphine.” *Reflections*, 1(4): 189-191.

Kartal, M. 2007. “Intellectual Property Protection in the Natural Product Drug Discovery, Traditional Herbal Medicine and Herbal Medicinal Products”. *Phytotherapy. Research*, 21: 113-119.

Kingston D. G. I. 2011. “Modern Natural Products Drug Discovery and Its Relevance to Biodiversity Conservation”. *Journal of Natural Products*, 74(3): 496-511.

Lejoly, J. 1997. “La banque de données ethnobotanique PHARMEL sur les plantes médicinales africaines**”**, in D. Barreteau, R. Dognin and C. von Graffenried Eds : L’homme et le Milieu Végétal dans le Bassin du Lac Tchad, Séminaire du Réseau Méga-Tchad à Sèvres (France) 18-20 septembre 1991, pp 383-392. Paris : ORSTOM.

Lietava, J. 1992. “Medicinal Plants in a Middle Paleolithic Grave Shanidar IV”. *Journal of Ethnopharmacology*, 35(3): 263-266.

Mengistie, G. 2010. *The Patent Systems in Africa: Its Contribution and Potential in Stimulating Innovation, Technology Transfer and Fostering Science and Technology.* Addis Ababa: UNECA.

Miller, J. S., Bradley A., Randrianasolo A., Randrianaivo R. and Rakotonandrasana S. 2005a. “Sampling A Diverse Flora For Novel Biochemicals: An Analysis of NCI Collections from Madagascar”. *Economic Botany* 59(3): 221-230.

Miller J. S., Birkinshaw C. and Martin Callmander. 2005b. “The Madagascar International Cooperative Biodiversity Group (ICBG): Using Natural Products Research to Build Science Capacity”. *Ethnobotany Research & Applications*, 3: 283-285.

Mimche, P. N., D. Taramelli and L. Vivas. 2011. “The Plant-based Immunomodulator Curcumin as a Potential Candidate for the Development of an Adjunctive Therapy for Cerebral Malaria”. *Malaria Journal*, 10(Suppl 1): S10. doi: 10.1186/1475-2875-10-S1-S10.

Phillips, D. (ed). 2009. *Plants, People and Nature: Benefit Sharing in Practice.*Mauritius: AAMPS Publishing.

Urban, B.C. and Todryk S. 2006. “Malaria Pigment Paralyzes Dendritic Cells**”**. *Journal of Biology*, 5: article 4. doi: 10.1186/jbiol37.

WHO. 2001. “Promoting the Role of Traditional Medicine in Health Systems: A Strategy for the African Region”. WHO Regional Office for Africa, Temporary location, Harare, Zimbabwe. (Document AFR/RC50/9 and Resolution AFR/RC50/R3).

WHO. 2002. “WHO Traditional Medicine Strategy 2002-2005”. World Health Organisation, Geneva, WHO/EDM/TRM/2002.1.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 27-36

Biotechnology in Medicine in the 21st Century: Natural Medicine and Intellectual Property Rights

Tomasz Twardowski*

Abstract: Despite extensive debate, there is no consensus on whether natural medicine is the property of local community or all society. Similarly, it is being argued whether the genetic data should be available for open research or access should be limited to owner and potential beneficiary. The emergence of whole-genome sequencing methods is increasingly generating unequalled amounts of genetic data, making the need for a clear feedback policy even more urgent. In this debate, two positions can be broadly discerned: a restrictive disclosure policy ('no feedback except life-saving data') and an intermediate policy of qualified disclosure ('feedback if the results meet certain conditions'). Both positions present the principle underlying the arguments. The debate should no longer address whether research results should be returned, but instead how best to make an appropriate selection and how to strike a balance between the possible benefits of disclosure and the harms of unduly hindering biomedical research.

Keywords: Natural medicine, patents, IPRs.

Introduction

The modern medicine is characterised by key words like gene therapy, xenotransplantation, stem cells (pluripotent and totipotent), molecular diagnostics, personalised medicine as the future of tailored medicine or biopharmaceuticals. However, all the roots of modern medicine are in nature and in natural medicines. Human made drugs like aspirine (chemically synthesised, today) or antibiotics like peniciline (obtained through biosynthesis in bioreactors) or even modifications and so-called tailored drugs and drug design performed *in silico* based on nature.

The mostly used sources of natural medicines are plants and trees, fungi and bacteria. The common knowledge collected by local communities concerning the medical properties for example, of flowering plants is very difficult to be translated into the language of modern, reproducible and

* Institute of Bioorganic Chemistry, Polish Academy of Sciences, Poland.
Email: twardows@ibch.poznan.pl

patentable science and technology. The very local authorities (for example, shaman), patent attorney and biotechnologist from multinational company usually used different language, technology and create different values. Association of animals and plants with gods and goddesses and time of plant collection (for example, 6 am or 6 pm) as well as parts of plants used (like f owers or leaves) are critically important for medical effect but often impossible to be included in patent application formula.

The most significant source of new medicines is the nature. This is the background of many questions and controversies related to modern technologies used in pharmaceutical industry: whole-genome sequencing, structure analysis of proteins and nucleic acids, access to the data and who owns the data and who can use them, followed by the many ethical problems. Why it is so difficult to solve these problems is relatively easy to answer. The pharmaceutical business is connected with huge money related to three questions: Who pays for research? Who is the owner of the results? And who takes the profit? In significant extent the answer is in patents: Patents protect the results of innovation in the technical sciences and secure investments in research and development.

The Patent

The 'human' inventions are as old as civilisation. From the very beginning the inventions were protected first by privileges (granted by monarch), next by national law, later on we observed internationalisation of patent law and recently we discussed globalisation of intellectual property rights. The first known patent privilege in Europe was granted in1234 and concerned the pump used to dewater mines. The other example is the patent privilege given in 1421 in Florence to the architect Filipp Bruneleschi who invented a boat used for transport of heavy stone blocks. All early patent privileges had three common characteristics, similar also to recent patent system: a certain territory, stimulation of local investments or encouraging to invest in production, to make profits.[1]

The general description of a patent helps to understand more clearly: *"A patent is a right granted for any device, substance, method or process which is new, inventive and useful. A patent is legally enforceable and gives the owner the exclusive right to commercially exploit the invention for the life of the patent".*[2]

This definition provides a general picture of what a patent is. A patent ensures the monopolistic status of the inventor and benefits resulting from the innovatory solutions. In addition, patents can prompt companies and manufacturers to fair competition which leads to constant technical improvement making the quality of people's lives better. However, there are also some negative aspects of patents. They introduce monopoly rights. Serious matter are the patented life-saving pharmaceuticals which are held at high prices because of lack of competition. Citizens in many countries cannot afford them. It leads to consideration of patents on the basis of the most important criterion that is saving life of human being. Different ideas are provided to solve this serious problem, for example, to completely eliminate patents in pharmaceutical industry and to give monetary awards to the companies that develop new drugs. It would allow other companies to sell generics at lower prices. These proposals seems unrealistic and impossible to be effective in the free-market economy. If an inventor does not want to patent his invention, there is a possibility of using a family secret or defensive publication that will prohibit from patenting it by someone else in the future.

A patent prohibits from selling, making and using the invention by the third parties throughout the whole term of validity of the patent which in the most countries is 20 years from the application date. Thus, a patent protects the result of innovation in the technical sciences and secures investments in research and development. However, the application for a patent is synonymous to agreement of sharing the details of the invention with the public; patent is not a secret.

Very high costs involved in the development and commercialisation of new drugs require a strong legal defense against illegal copying and unfair competition. That is why patents are so important in modern pharmaceutical industry. The innovative companies find it necessary to protect their work from infringement and expect legal exclusiveness for production as a guarantee of profit generation.

International Organisations

Legislation differs in different countries. Patents are governed by both international treaties and national laws; however their reach is territorial. The given country formulates its patent law and creates the national patent office which is responsible for granting of patents. The international patent related organisations, viz. World Intellectual Property Organisation (WIPO), European patent Office (EPO), Trade Related Aspects of Intellectual Property Rights (TRIPs) of WTO and Paris Convention play important role in the global arena. The Paris Convention for the Protection of Industrial Property was signed in 1883 by 14 countries (173 member countries at present).

Paris Convention as well as Patent Cooperation Treaty (PCT) determine the principal rules related to patent systems, the most important of which is the right to claim priority. It means that the applicant when filing a patent application in any of the member countries has the one year lasting right to apply for the same patent in any other member state. Such notation protects inventors against infringement internationally. The international unification of the patent law is possible due to actions undertaken by the WTO. The TRIPS makes it possible for nations to have a forum on common patent law. Acceptance of this agreement is necessary for joining WTO. Moreover, there are international treaty procedures such as the PCT being governed by WIPO, (a part of United Nations) and involving the European Patent Convention (EPC) which is not related to European Union. EPO is an inter-governmental organisation that was set up on 7 October 1977 on the basis of the European Patent Convention (EPC) signed in Munich in 1973. It has two bodies, the EPO and the Administrative Council, which supervises the Office's activities. The EPO currently has 38 member states. The important platforms for international relationships offer European Union Directive on Biotechnological Inventions (44/1998/EC); Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure (established 1977) and European Patent Convention (1973).

There are similar adjustments implemented in the most of African countries by the two organisations: African Regional Intellectual Property Organisation and African Intellectual Property Organisation. In Eurasia the nine members of the Commonwealth of Independent States have created the Eurasian Patent Organisation.

At the international level there are many organisations dealing with patents. Global patenting is very complicated from legal point of view. National law and local language have to be respected and the cost is enormously high. Furthermore, the considerable costs stemming from current translation requirements and the need for multiple litigation procedures entail significant disadvantages for European innovators compared to their US and Asian counterparts. These costs are, to a large extent, unproductive and superf uous. For example: A European patent validated in 13 countries costs might be up to € 20,000, of which nearly € 14,000 might arise from translations alone.

Biotechnology and New Drugs

Biodiversity is natural source of drugs and based on common knowledge as well as on richness of local f ora and fauna. Biological diversity associated with traditional knowledge is the key to tomorrow's medicines. Access to biological resources simultaneously with application of modern biotechnology techniques will solve many problems of medicine. Natural medicines combined with innovative technology could be a very powerful tool.

Biotechnology is the integration of natural and engineering sciences in order to achieve the application of organisms, cells or their derivatives in production of substances or creation of their molecular analogues for specific use. Commonly we recognised the different colors of biotechnology: "white" biotechnology referring to use of biosystems in industrial production and environmental protection, "red" biotechnology which is connected with pharmacology and healthcare, use of genetically modified animals and plants in agriculture which is called "green" and studies of legal and social aspects of bioscience known as "violet" biotechnology.[3]

In case of pharmacy biotechnology is a very risky business. The total cost of introduction of an entirely new drug to a market is estimated up to be one billion of USD and up to 15 years may be required to commercialise an innovative medicine. Such high cost of market implementation arises from the high standard of tests, mostly the clinical trials and also marketing. That is why only big, multinational companies develop new innovative drugs; it is hard for small biotech companies to stay on the market. They usually cannot afford such enormous costs.

The high value is placed on previous milestone discoveries. Some of them were patented and are very valuable even today, for instance isolation of penicillin by Alexander Fleming in 1929; discovery of DNA double-stranded helical structure by Watson and Crick in 1953 followed by deciphering of gene code by Khorana and Nirenberg in 1967; recombination of DNA carried out by Paul Berg in 1972; elaboration of hybrydome technique done by Koehler and Millstein in 1975; DNA sequencing technique developed by Maxam and Gillbert in 1977; discovering and invention of the polymerase chain reaction by Kary Mullis in 1985 (later on patented!); and human genome sequencing by two teams of researchers independently, headed by Craig Venter and Francis Collins (data presented in 2001).

These discoveries and inventions contributed enormously to the transfer of bioscience from academic research laboratories to the industrial application. This fast development and wide application of biotechniques evoked the problem of patents in biotechnology to arise. The patent can be assigned to any inventions which are novel, possess industrial application and are not derived from obvious technological state. Biotechnological invention (bioinvention) comprises biomaterial isolated from nature with human engineering activity or artificially created in the laboratory. A biological procedure is a protocol carried out on the biological material. The biotechnological inventions for which a patent may be granted are considered in three groups:

1. inventions with biological material isolated from its natural habitat or artificially synthesised in any technological process even when derived from naturally existing matter;
2. inventions being isolated from organism or artificially synthesised in any technological process, including a gene sequence or its part, even if the structure of these elements are identical with the framework of their equivalents occurring naturally; and
3. inventions related to animals and plants, however not limited to plant species or animal breed;

It has to be stressed that not all biotechnological discoveries can be patented; patents cannot be granted for inventions whose use is incompatible with law or could be regarded as contradictory to the principles of ethics, in particular within Europe:[4]

- methods of human cloning;
- use of human embryos for industrial or commercial purposes;
- genetic modification procedures to be carried out on genotypes of human germ line;
- genetic modification procedures carried out on animal genotypes, which may cause their suffering with no significant medical benefits for human or animals or animals being results of adoption of these procedures;
- species of plants and breeds of animals as well as all strictly biological methods of their raising;
- human and animal treatment means or any diagnostic methods; and
- human body and tissues in every stage of its formation and upgrowth or any part of it, including complete or partial gene sequence.

Most classical inventions in biotechnology include:

- micro-organisms - bacteria, yeast, moulds, viruses, animal or plant cells - either isolated from nature or created in the laboratory, for example, by means of binary fusion, mutagenesis, DNA transformation or hybrydome production;
- DNA molecules – genes, primers sequences in diagnostic marking, viral vectors in genotheraphy;
- proteins;
- monoclonal antibodies;
- transgenic plants and animals;
- pharmaceutical composition, vaccines, diagnostic reagents;
- use of all substances mentioned above in industrial, agricultural, medical or diagnostic applications; and
- apparatus and equipment used in production of biomolecules, cultivation of microorganisms or being a part of industrial, agricultural, medical or diagnostic process.

The most common bio-inventions concern organisms isolated or created in the laboratory using genetic engineering techniques or micro-organisms which produce a novel substance, for example an antibiotic or biomolecule (protein), or when an innovative procedure is applied. If the general criteria of patenting are fulfilled, these bio-inventions are patentable (new, inventive and of commercial value product or process). The different situation takes place with other types of bio-inventions like genes and genetic sequences. The owner of the invention applying for exclusive rights is obliged to determine the human engineering intervention, reproducibility of the invention and industrial, medical or diagnostic application of genes. The same requirement has to be fulfilled if the gene sequence or partial gene sequence is used in production of any protein, peptide or its part – it is necessary to determine the function of obtained product. In the submitted completed application form one should present gene sequence, product of its expression and function of the product including commercial application of the invention. Even commonly known bioproduct (like a protein existing in nature) can be patented under the conditions it was not described before. It was isolated in laboratory with novel properties and has specific use in medicine, industry, etc., and in general the bioproduct can be considered as innovative.

Animals and plants related inventions are permitted to be patented under the condition that they are not technically restrictive only to species. Production procedure can be stipulated only if they consist of at least one stage which is not strictly biological.

On the basis of EPC, patents are never granted for procedures of human and animal diagnostic or treatment. However, this prohibition does not include substances of medical significance and diagnostic methods consisting of steps carried out *in vitro*, outside the human body. Medical and diagnostic innovations are the ones which require the most detailed characteristic, because even slight modification of one stage can change the entire examination results. Characteristics that can be patented in that discipline are for example, diagnostic procedure for another disease stage. Medical substances can stipulate, for example, when new treatment applications are found (known drug acting against new disease), new dosing or patients group.

One should also recognise the significance of teaching and popularisation of new methods and techniques; the very good examples of the excellent job are two videos produced for the project in Mali and Botswana.[5]

Conclusion

Benefit sharing principles today are connected with access to genetic resources and shall be the subject to prior informed consent and granted on mutually agreed terms. As patents are increasingly globally marketed, there exists a logical trend towards the international and global harmonisation of intellectual property laws. WIPO, TRIPS and regional and bilateral trading arrangements have already been successful in providing a forum for nations to enforce patent laws. International organisations (for example, UNIDO, WIPO and EPO) organise meetings regularly and bring together stakeholders from governments, rights-holders' groups and civil society in order to facilitate constructive debate on current challenges.[6] Disclosure of the inventions and subsequent publications are fundamental to the European patent system. The European Publication Server is where the public can obtain official copies of European patent documents. The European Patent Register provides details of the procedural status of patent applications at the EPO. The EPO's collection of over 60 million patent documents from all over the world is available to the public via the free Espacenet service on the internet. The EPO also provides a wide range of other products for searching patent databases.

The enabling technologies face challenges in emerging and global markets, for instance, North–South conf ict, differences between original medicines and generics, as well as value of patens versus "family" secret. Patents (intellectual property rights) protect the results of innovation in the technical sciences and secure investments in research and development. Intellectual property rights in red biotechnology has many means: connections of science, technology and industry; globalisation; innovations, property and profit; highly skilled workers in industry and academia; productivity, growth and structural changes; and information and communication policy. The critical factor determining the acceptance is the knowledge of scientific, (reproducible) data.

All in all, due to complexity of bioinnovantions and quick development of biotechnology the problem of patents granting is extremely complicated and multistage. There are many limitations in each branch of biotechnological researches and patent granting is very often a source of controversy. Every bioinvention has to fulfill general patents rules and those designed specifically for biotechnology. In summary, we believe the owners of the patents will lead and dictate the economy of tomorrow. The harmonised law is the best guarantee for fair and equal rights for all players. Harmonisation on global scale is possible and needed.

Endnotes

1 http://www.wipo.int; http://www.epo.org; http://uprp.gov.pl

2 Patent Amendment (Human Genes and Biological Materials) Bill 2010 [No. 2] Bills Digest No. 107, 2010 and #8211;11, 11 May 2011 Roger Beckmann Science, Technology, Environment and Resources Section Sharon Scully, Law and Bills Digest Section.

3 Biotech Applied (1990); Clark (1999); Vogel (2000); UNIDO (2011).

4 Burhoi (2006).

5 http://www.kew.org/science-conservation/save-seed-prosper/millennium-seed-bank/using-our-seeds/helping-communities-worldwide/botswana/index.htm

6 *Ibid*.

References

Biotech Applied. 1990. *Gene Therapy- An Overview.* Biotechnology Industry Organisation.

Burhoi, Astrid. 2006. *Moral Exclusions in European Biotechnology Patent Law.* Kandidatuppsats Bolag and marknad; Lunds Universitet. Retrieved on December 19, 2011 from http://biblioteket.ehl.lu.se/olle/papers/0002294.pdf

Clark, William R. 1999. *The New Healers: The Promise and Problems of Molecular Medicine in the Twenty-first Century.* New York: Oxford University Press.

UNIDO. 2011. "The Mauritius Session" during the International Workshop on Bioprocessing, Policy and Practice: Conservation and Use of Medicinal Plants of the Small Island Developing States (SIDS) of the Indian Ocean and Madagascar, April 20-22, 2011; The Link Ebène City Hotel.

Vogel, G. 2000. “Gene Therapy: FDA Moves against Penn Scientist.” *Science 290's* H.C.M. van den Akker, *Environmental Risk Assessment of Replication Competent Viral Vectors in Gene Therapy Trials*, Report 601850001/2008.

Van den Akker, H.C.M 2008 Environmental *Risk Assessment of Replication Competent Viral Vectors in Gene Therapy Trials.* Report 60185001/2008 Bilthoven, the Netherlands.

Websites

http://www.kew.org/science-conservation/save-seed-prosper/millennium-seed-bank/using-our-seeds/helping-communities-worldwide/mali/index.htm

http://www.wipo.int

http://www.epo.org

http://uprp.gov.pl

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 37-52

Genetic Diversity in Mauritius and Antimicrobial Evaluation: Case Study of *Lomatophyllum* Species in the Mascarene Islands

J. Govinden-Soulange*, S. Khoyratty**,
M. Ranghoo-Sanmukhiya* and H. Kodja**

Abstract: *Lomatophyllum tormentorii and Lomatophyllum purpureum* originate from Mauritius. *Lomatophyllum macrum* originates from Réunion Island. The three *Lomatophyllum* species are endemic medicinal plants. These endemic Aloes are used in the Mauritian and Réunion Island pharmacopoeia to treat bacterial infections and as antispasmodic. It has been proved that *Lomatophyllum* species and Aloe vera share some genetic similarities. Consequently we report the genetic diversity of the *Lomatophyllum* species by measuring the genetic distance, which they have with *Aloe vera*. Phytochemical screening of the crude extracts showed that alkaloids, anthraquinones, coumarins, phenols, saponins and tannins were present in all samples. The antimicrobial properties of *L. tormentorii* and *L. purpureum* were attributed to the presence of alkaloids, coumarins and saponins which are known to possess antimicrobial attributes. Moreover, some biologically active compounds within the *Lomatophyllum* were identified and their possible similarities with Aloe vera were unveiled.

Keywords: *Lomatophyllum* species, *Aloe* species, antimicrobial activity, genetic closeness, genetic diversity, Mauritius, Mascarene Islands.

Introduction

The Aloe family contains 400 different species and originates from the African continent. The plant has thick leaves that contain the water supply for the plant to survive long periods of drought. An orange-yellow sap runs inside the leaf. When the green skin of a leaf is removed a clear mucilaginous substance appears and contains fibres and water. This part of the leaf is called the gel and is consumed.[1] Only two species of Aloe are grown commercially, viz. *Aloe barbadensis* Miller and *Aloe aborescens*. The original use of the Aloe plant was in the production of Aloin, a yellow sap

[*] University of Mauritius, Mauritius. Email: joyces@uom.ac.mu (Corresponding Author).
[**] Université de la Réunion, Ile de la Réunion, France. Email: shahnookhoyratty@gmail.com
[*]University of Mauritius, [**] Université de la Réunion, France.

used for many years as a laxative ingredient by the pharmaceutical industry. Another main ingredient Aloe gel, a clear colourless semi-solid gel that was also stabilised and marketed.[2]

The genus Lomatophyllum is closely related to the genus Aloe and the only known diagnostic character is that the fruits are f eshy at maturity in Lomatophyllum while they are capsular in Aloe.[3]

There is confusion in the use of common names of *Lomatophyllum* species. The same name Mazambron or Mazambron Marron can refer to different plants. *Lomatophyllum* species is often confused among themselves or with members of the *Aloe* genus.[4] As such, *Lomatophyllum macrum* is also known as *Aloe macra* in Réunion Island and yet, it is not a member of the *Aloe* species.[5] There is also confusion in the traditional pharmacopoeia. It is assumed that such confusion is due to the close morphological resemblance of different plants which is not readily distinguishable by non-experts.

Medicinal Uses

Lomatophyllum is a genus of succulent plants with a dozen of species. Eight species are found in Madagascar and four species are found in the Mascarenes Islands.[6] *Lomatophyllum tormentorii* and *Lomatophyllum purpureum* are endangered species that are endemic to the island of Mauritius. *Lomatophyllum lomatophylloides* is endemic to the island of Rodrigues.[7] *Lomatophyllum macrum* is endemic to Réunion Island.

A typical member of the *Lomatophyllum* species such as *Lomatophyllum lomatophylloides* has the following botanical characteristics that provide for morphological classification. It is a succulent herb up to 40 cm tall; stem short, decumbent, unbranched. The leaves in a lax rosette, erect to arranged spreading; stipules absent; petiole absent; blade lanceolate, up to 75 cm × 8 cm, apex attenuate, margin with short deltoid teeth, 5–15 mm apart. Inf orescence consisting of few cylindrical racemes, 15–20 cm long, lax, with acuminate apex; peduncle up to 12 cm long, with 2–3 branches; bracts lanceolate, up to 4 mm long. Flowers bisexual, regular, 3-merous; pedicel c. 2 cm long; perianth tubular, 1.5–2 cm long, lobes 6, free to base, pale reddish orange; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit a berry 15–20 mm long, many-seeded.

Aloe vera Linne or *Aloe barbadensis* Miller is a succulent from the Aloe family. *Aloe vera* is probably native to the North African region. It is an almost sessile perennial herb leaves 30 to 50 cm long and 10 cm broad at the base colour pea-green (when young spotted with white) bright yellow tubular f owers 25 to 35 cm in length arranged in a slender loose spike stamens frequently project beyond the perianth tube.[8] The leaves of *Aloe vera*, *Lomatophyllum macrum*, *Lomatophyllum purpureum* and *Lomatophyllum tormentorii* plants resemble closely. The f owers of *Lomatophyllum macrum* and *Lomatophyllum purpureum* resemble while the f owers of *Lomatophyllum tormentorii* and *Aloe vera* resemble while f owers are an important organ used in botanical classifications of plants. Similarly, although different in size, *Lomatophyllum purpureum* and *Lomatophyllum macrum* fruits resemble.[9] Furthermore, research in chemo-taxonomy has placed Lomatophyllum into the same genus as Aloe.[10]

Furthermore, *Aloe vera* is referred in several possible names such as *Aloe barbadensis* Mill., *Aloe chinensis* Bak., *A. elongata* Murray, *A. indica* Royle, *A. afficinalis* Forsk., *A. perfoliata* L., *A. rubescens* DC, *A. vera* L. var. littoralis König ex Bak., *A. vera* L. var chinensis Berger, *A. vulgaris* Lam. All the nomenclatures describe the same plant. However, according to the International Rules of Botanical Nomenclature, *Aloe vera* (L.) Burm. f. is the legitimate name for this species.[11]

Medicinal uses are reported in the pharmacopoeia for *Aloe barbadensis*, *Lomatophyllum* species in general and *Lomatophyllum macrum*. Such reports highlight the importance of the plants.

It is well documented that anthraquinones, such as chrysophanol, have antimicrobial activity. In this way, methanolic extracts of the root of *Colubrina greggii* S. Watson has antimicrobial activity against *Staphylococcus aureus*, a bacteria used in the evaluation studies in this work. And the antimicrobial activity has been related to an anthraquinone.[12]

In the case of *Aloe* species., it has been shown that there is a correlation between the dose of anthraquinone present in the aloin and the antimicrobial activity observed. More specifically, the Aloe showed antibacterial activities against *E.coli*.[13]

Anthraquinones from leaves of *Tectona grandis* have been shown to have antimicrobial activities against *Klebsiella pneumoniae*.[14] In fact, nine different anthraquinones and preanthraquinones known to be characteristic of Aloe, has been found in seven species of Lomatophyllum. On this basis, it has even been suggested that Lomatophyllum should be included in Aloe.[15]

Table 1: *Aloe Barbadensis* and *Lomatophyllum* Species in Relation to their Medicinal Uses according to the Pharmacopoeia

Plant	Use	Reference
Aloe barbadensis	-Cold -Soothe inf ammatory pains -Muscle cramps and pains -Soothing and Moisturising -Laxatives -Burns and incisions -Cancer -Wound healing -Peptic ulcers -Disturbance to gastrointestinal tract -Herpes -Skin disorders -Against fungus *Aspergillus niger*	Gurib-Fakim (2002) Gurib-Fakim (2003) Dagne *et al.* (1994) Reynolds and Dwek (1999) Vogler and Ernst (1999) Ali *et al.* (1999)
Lomatophyllum species	-Muscular pain -Increase f ow in weak periods	Gurib-Fakim (2002)
Lomatophyllum macrum	-Not used in traditional medicine -Antiviral activity v/s Herpes simplex type 1 (HSV-1) virus	Fortin *et al.* (2002)

Source : Authors' compilation.

This study aimed at: (1) Comparing the phytochemical composition of *Lomatophyllum purpureum*, *Lomatophyllum tormentorii*, *Lomatophyllum macrum* and *Aloe vera*. (2) Comparing the antimicrobial activities of *Lomatophyllum purpureum*, *Lomatophyllum tormentorii*, *Lomatophyllum macrum* and *Aloe vera* against each other. (3) Correlating the differences in phytochemical composition observed for the different plants in (1) to the antimicrobial activities observed in (2). (4) Finding the genetic relatedness using Random Amplified Polymorphic DNA (RAPD) markers between *Lomatophyllum purpureum*, *Lomatophyllum tormentorii*, *Lomatophyllum macrum* and *Aloe vera*. (5) Validating placing *Lomatophyllum* species and *Aloe* species in different genus through the genetic data of relatedness given the confusion that exists and (6) Correlating the morphological similarity, phytochemical composition and antimicrobial activity with the genetic relatedness obtained.

Methodology

The first part of the work consisted of molecular studies through RAPD marker analysis. The procedure consists of performing DNA extraction followed by RAPD. Amplicon profiles are then generated for each sample. The amplicon profiles for primers that yield the most polymorphic bands are then scored and the scores are added on a scoring matrix to generate a dendrogram through cluster analysis. The dendrogram will give a quantitative relationship, in terms of distance, between the different samples at the level of the DNA.

DNA extraction: Genomic DNA was isolated from the leaves using a modification of the Doyle and Doyle (1987) DNA extraction method. One gram of fresh leaves of *Aloe vera* and *Lomatophyllum* species were removed from the polysaccharides rich gel, found inside the leaf, with a scalpel. The leaf material was then placed into a mortar and pestle and ground with liquid Nitrogen. The powdered leaf material was then added to 5 ml of CTAB isolation buffer (2 per cent hexadecyltrimethylammonium bromide (CTAB), 1.4 M NaCl, 0.2 per cent 2-mercaptoethanol, 20mM EDTA, 100mM Tris-HCl, pH 8.0) buffer pre-heated to 60 degrees in a water bath. The sample was incubated for 60 minutes with occasional gentle swirling. An equal volume of chloroform:isoamyl alcohol (24:1) was then added and mixed gently but thoroughly. The sample was then centrifuged at 5000 rpm for 15 minutes at 4 degrees centigrade.

The aqueous upper phase was then removed into a 15 ml corning tube. A second chlorofom:isoamyl alcohol extraction was performed followed by centrifugation as before. To the supernatant, ice cold isopropanol stored at -20 degrees centigrade was added at 2/3 volumes. The corning tube was then mixed gently and kept overnight at -20 degrees centigrade. The next day, the tube was centrifuged at 8,000 rpm for 20 mins at 4 degrees centigrade. 5 ml of 70percent alcohol was then added and the sample left on ice for 1 hour. The sample was then centrifuged at 8,000 rpm for 15 minutes. The supernatant was then discarded and the pellet was dried into a desiccator pump for 1 hour. The dried pellet was then dissolved in 500 microlitre of TE-buffer (10mM Tris-HCl, 1mM EDTA at pH 7.5). RNAase A was then added to the sample at 1:100 volume by volume and the sample was incubated for 30 minutes at 37 degrees centigrade. The sample was re-precipitated using ammonium acetate (7.5 M stock, pH 7.7) to a final concentration of 2.5 M, mixed and 2.5 volumes of cold ethanol was then added. The sample was gently mixed to precipitate the DNA. The DNA was spin at 10,000 rpm for 10 minutes. The pellet was retained and dried and re-suspended in 100 microlitre of TE buffer. Before performing RAPD marker analysis, it is essential to both quantify the concentration of DNA in solution as well as find the quality of the DNA.

DNA amount and purity :. The yield of DNA per gram of leaf tissue extracted was measured using a UV Spectrophotometer at 260 nm. The purity of DNA was determined by calculating the ratio of absorbance at 260 nm to that of 280 nm. DNA concentration and purity was also determined by running the samples on 0.8 per cent agarose gel based on the intensities of band when compared with the Lambda DNA marker.

RAPD analysis: A standard RAPD protocol was chosen and modified from Padmalatha and Prasad (2006). The reaction was prepared as follows: Each 15 µl reaction volume contained 50 ng of template DNA, 1X PCR Buffer (10 mM Tris HCl pH 8.3; 50 mM KCl), 3 mM MgCl2, 0.2 mM dNTP Mix, 0.5 µM of primer, 0.2 U of Taq DNA polymerase. The thermocycler was programmed for an initial denaturation step of 5 min at 94°C, followed by 40 cycles of 1 min at 94°C, 1 min at 36°C, extension was carried out at 72°C for 2 min and final extension at 72°C for 10 mins. PCR products were electrophoresed on 1.5 per cent (w/v) agarose gels, in 1X TBE Buffer and then stained with ethidiumbromide. Gels with amplification fragments were visualised and photographed under UV light. RAPD primers were tested as follows: OPA-18, OPC-14, OPS-11, OP-001, OPO-18, OPP-16, OPO-19, OPD-06, OPA-17 and OPD-0.1 The RAPD primers which were retained for scoring were those that gave the highest polymorphism and are: OPA-17, OPO-19, OPD-06, OPO-18 and OPD-06.

Dendrogram and Matrix: Using the amplicon profiles for the selected RAPD primers, a scoring matrix was made for polymorphic amplicons. A dendrogram and similarity matrix was then built by input of the scoring matrix data in Numerical Taxonomy System Personal Computer (NTSYS-PC Version 2.2 by Exeter Software).

The second part of the work consisted of assessing the biological activity of the *Lomatophyllum* species and to compare such activity to that of *Aloe vera*.

Plant Material: The plant materials were obtained from the Native Plant Propagation Centre of the National Parks and Conservation Service, Curepipe, Mauritius. The plant materials obtained were *Lomatophyllum purpureum*, *Lomatophyllum tormentorii* and *Lomatophyllum macrum* and *Aloe vera*.

Crude extract: The plant material was crushed into a mortar and pestle with liquid nitrogen. The macerated tissue was then placed into a jar sealed with parafilm. The parafilm was pitted with holes and placed in a lyophiliser overnight. 1g of dried plant material was then extracted in 10mL solvent methanol/dichlroromethane (1: 1, v/v) by sonication for 1 h.

The crude extract was then filtered using a filter paper attached to a pump and the resulting filtrate was then concentrated to dryness using a rotary evaporator. The residues left in the round bottom f ask of the rotary evaporator were then resuspended in 90 per cent methanol for antimicrobial screening.

Fractionation: Soxhlet extraction was carried out with solvents of increasing polarity such as hexane, chloroform, chloroform: methanol (4:1, v/v), chloroform: methanol (1:1, v/v) and methanol.

Phytochemical screening: Phytochemical screening was performed for major constituents using qualitative methods described by Harborne *et al.,* (1975) and Trease and Evans (1989). The percentage of anthraquinones was calculated based on the method recommended in European Pharmacopoeia (2006).

Microdilution and antibacterial assay: The serial dilution technique described by Eloff (1998) was used to determine the minimum inhibitory concentration (MIC) for antibacterial activity of crude and fractionated extracts. Two millilitre cultures of three bacterial strains [*Staphylococcus aureus* (ATCC no. 12600), *Escherichia coli* (ATCC no. 11775) and *Klebsiella pneumoniae* (ATCC no. 13883)] were prepared and incubated overnight at 37°C. The overnight cultures were diluted with sterile MH (Mueller-Hinton) broth (1 ml bacteria/100 ml MH) to an absorbance of 0.4–0.6 at 600 nm. For each bacterium used, 100 ml of the compound solution tested was two-fold serially diluted with 100 ml sterile distilled water in a sterile 96-well microplate. A similar two-fold serial dilution of streptomycin (Sigma) (0.01 mg/ml) was used as positive control against each bacterium. Methanol was used as negative control and 100 ml of bacterial culture was added to each well. The plates were covered, sealed and incubated overnight at 37°C. Bacterial growth was tested with the addition of 50 ml of 0.2 mg/ml p-iodonitrotetrazolium violet (INT) to each well after incubation at 37°C for 30min. Bacterial growth in the wells was indicated by a red colour, and colourless wells indicated inhibition by the tested extracts.

Results

The molecular studies and dendrogram generated a dissimilarity matrix that quantifies the level of difference that exists among the different plants tested at the molecular level with RAPD markers.

Based on the amplicon profiles of the RAPD primers OPA-17, OPO-19, OPD-06, OPO-18 and OPD-06, the dissimilarity matrix shows that

Lomatophyllum tormentorii is in the same clade as *Lomatophyllum purpureum*. However, *Lomatophyllum macrum* is closely related to both *Lomatophyllum tormentorii* and *Lomatophyllum purpureum*.

Table 2: Dissimilarity Matrix Showing the Relative Distances between the Different *Lomatophyllum* Species.

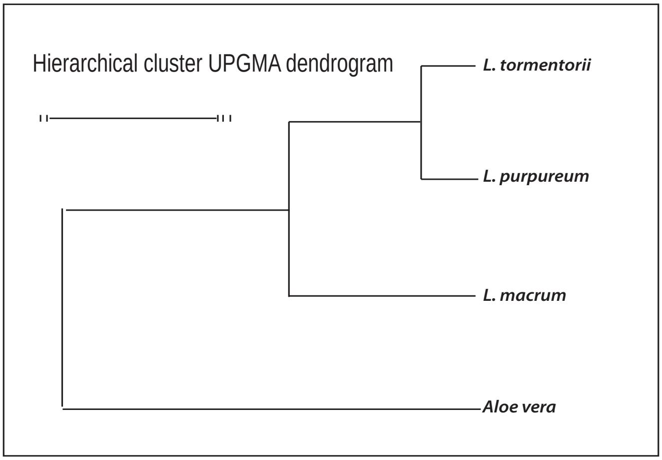
	Aloe vera	*Lomatophyllum macrum*	*Lomatophyllum tormentorii*
Lomatophyllum macrum	0.58823530	-	-
Lomatophyllum tormentorii	0.65000000	0.18750000	-
Lomatophyllum purpureum	0.63157894	0.25000000	0.06250000
Dissimilarity matrix			

Source : Authors' compilation.

Dendrogram for *Lomatophyllum tormentorii*, *Lomatophyllum purpureum*, *Lomatophyllum macrum* and *Aloe vera* constructed from RAPD marker data for primers OPA-17, OPO-19, OPD-06, OPO-18 and OPD-06 which were the most polymorphic. The distance matrix for the dendrogram is shown in Table 2. The dendrogram is a graphical representation of the dissimilarity matrix.

From the dendrogram, it can be observed that *Aloe vera* is an outgroup, that is, it lies far from the *Lomatophyllum* species *L.macrum, L.purpureum* and *L.tormentorii* and based on RAPD marker data.

Figure 1: Dendrogram for *Lomatophyllum tormentorii, Lomatophyllum purpureum, Lomatophyllum macrum* and *Aloe vera*



Source : Authors' compilation.

For the part of the work concerned with the biological activity, the cold extraction produced crude extract with varying yields from 1g freeze dried leaf that was dissolved in 10ml of solvent. Thus, 4mg of residue was obtained for *L. tormentorii*, 10mg of residue was obtained for *L. purpureum*, 7mg of residue was obtained for *Aloe vera* and 4mg of residue was obtained for *L. macrum*.

The phytochemical screening was performed on all the plants in this work for alkaloids, anthraquinones, terpenes, phenols, saponins, tannins, coumarins, f avones and leucoanthocyanins with varying results.

Table 3: Phytochemical Constituents of Crude Extracts of Lomatophyllum Species from the Mascarene Islands

Extract	*Lomatophyllum purpureum*	*Lomatophyllum tormentorii*	*Lomatophyllum macrum*	*Aloe-vera*
Alkaloids	+	+	+	+
Anthraquinones	Absent	Absent	Absent	Absent
Terpenes	+	+	+	+
Phenols	++	++	+	+
Saponins	+	++	+	+++
Tannins	+	++	+	Absent
Coumarins	+	+	+	+
Flavones	Absent	Absent	Absent	Absent
Leucoanthocyanins	Absent	Absent	+	Absent

Source : Authors' compilation.

Key: + Trace, ++ Metabolite present, Absent: Metabolite absent

Anthraquinones and f avones were absent from the crude extracts. Anthocyanins were detected in the crude extracts of *Lomatophyllum macrum* from Réunion Island but not in the other plants. Alkaloids, terpenes, phenols, saponins, coumarins were present in crude extracts from all plants. However, the relative amount varied across the plants tested.

Table 4: Phytochemical Differences between Fractionated Extracts of *Lomatophyllum* Species from the Mascarene Islands

Fraction	*Lomatophyllum purpureum*	*Lomatophyllum tormentorii*	*Lomatophyllum macrum*	*Aloe vera*
Hexane	-	-	-	Tannins
Chloroform	-	-	-	Alkaloids
Chloroform/ Methanol (4:1)	Anthra-quinones	Anthra-quinones	Antho-cyanins	Anthra-quinones

Table 4 continued...

Table 4 continued...

Chloroform/ Methanol (1:1)	-	-	Flavonoids, anthocyanins	-
Methanol	Tannins	-	Tannins, f avonoids, anthocyanins, coumarins	Tannins

Source : Authors' compilation.

Although anthraquinones were absent from the crude extract of all plant samples, anthraquinones were detected in chloroform/methanol (4:1) extract of *Lomatophyllum* and *Aloe vera* but not in *L. macrum* from Réunion Island. Other compounds detected in fractionated extracts of *Lomatophyllum* species are anthraquinones and f avonoids.

Table 5: Phytochemical Similarities between Fractionated Extracts of *Lomatophyllum from Mascarene Islands*

Fraction	***Lomatophyllum purpureum***	***Lomatophyllum tormentorii***	***Lomatophyllum macrum***	***Aloe vera***
Hexane	Alkaloids Terpenes	Alkaloids Terpenes	Alkaloids Terpenes	Alkaloids Terpenes
Chloroform	Coumarins	Coumarins	Coumarins	Coumarins
Chloroform/ Methanol (4:1)	Tannins, Coumarins, Alkaloids	Tannins, Coumarins, Alkaloids	Tannins, Coumarins, Alkaloids	Tannins, Coumarins, Alkaloids
Chloroform/ Methanol (1:1)	Tannins, Coumarins, Alkaloids	Tannins, Coumarins, Alkaloids	Tannins, Coumarins, Alkaloids	Tannins, Coumarins, Alkaloids
Methanol	Alkaloids	Alkaloids	Alkaloids	Alkaloids

Source : Authors' compilation.

L. purpureum, *L. tormentorii*, *L. macrum* and *A. vera* share similarities in the presence of alkaloids, terpenes, coumarins and tannins across all fractions tested. However, the concentrations and types may vary but had not been tested.

Table 6: Anthraquinone Composition of Lomatophyllum of Mascarene Islands & *Aloe vera*

Species	**% Anthraquinones in crude extract**
Lomatophyllum purpureum	1.13
Lomatophyllum tormentorii	0.95
Lomatophyllum macrum	0.39
Aloe vera	4.24

Source : Authors' compilation.

Although anthraquinones was not detected in fractions of all species, there is an indication that such compounds were present but at a relatively small concentration. *Lomatophyllum* species from Mauritius is richer in anthraquinone concentration than from Reunion Island.

The antimicrobial activities of crude extracts and fractions showed different results for the plants tested.

Table 7: Minimum Inhibitory Concentration for Antibacterial Activity of Crude Extracts of Lomatophyllum Species from Reunion and Mauritius v/s *Aloe vera*

	Staphyloccocus aureus (ATCC12600)	Klebsiella pneumoniae (ATCC13883)	Escherichia coli (ATCC11775)
Aloe vera (mg/ml)	28.0 +/- 0	12.75 +/- 0	28.9 +/- 0
Lomatophyllum tormentorii (mg/ml)	13.3 +/- 7.1	73.4 +/- 0	13.3 +/- 7.1
Lomatophyllum purpureum (mg/ml)	9.04 +/- 0	9.04 +/- 0	9.04 +/- 0
Lomatophyllum macrum (mg/ml)	4.22 +/- 0	4.69 +/- 0	8.44 +/- 0
Streptomycin 0.01 (mg/ml)	0.004 +/- 0	0.008 +/- 0	0.003 +/- 0

Source : Authors' compilation.

The crude extract of *Lomatophyllum macrum* from Réunion Island showed the lowest MIC against the three bacteria tested. However, there is a difference between the MICs against the specific bacteria with *Staphyloccocus aureus* being the lowest at 4.22 mg/ml and *Escherichia coli* being the highest at 8.44 mg/ml. The MIC for *Lomatophyllum purpureum* is constant against the three bacteria tested, at 9.04 mg/ml. Unexpectedly, the crude extract of *Aloe vera* showed the highest MIC values.

Table 8: Range of Minimum Inhibitory Concentrations of *Lomatophyllum* Species and *Aloe vera* Fractions Against the three Pathogens Tested

	E. coli	K. pneumoniae	S. aureus	Range
Aloe vera (mg/ml)	0.008	1.12	0.04	0.008 – 1.12 mg/ml
L. purpureum (mg/ml)	10.73	2.77	10.73	2.77 – 10.73 mg/ml
L. tormentorii (mg/ml)	10.31	10.31	4.01	4.01 – 10.31 mg/ml
L. macrum (mg/ml)	4.22	49.88	49.88	4.22 – 49.88 mg/ml

Source : Authors' compilation.

In the case of the fractions tested, *Aloe vera* had the lowest MICs against the three pathogens. With the exception of *L. macrum* against *E. coli*, *L. macrum* fractions showed the highest MICs values of all fractions from the plants tested. An *L. purpureum* fraction against *K. pneumoniae* shows the closest MIC to that of *Aloe vera* among all other plant fractions tested.

The most active fraction, the fraction with the lowest MIC, is 0.008mg/ml for *Aloe vera* Chloroform: Methanol (4:1) fraction against *E.coli*. This MIC was correlated to a high anthraquinone level in this fraction. In descending order of highest MIC were *L.purpureum*, *L.tormentorii* and *L.macrum* fractions.

Table 9: Fractions from different plants with the Highest Antimicrobial Activity

Aloe vera	Chloroform: Methanol (4:1) fraction
L. purpureum	Methanol fraction
L. tormentorii	Chloroform: Methanol (4:1) fraction
L. macrum	Chloroform: Methanol (4:1) fraction

Source : Authors' compilation.

Crude extracts of *Lomatophyllum macrum* had a more significant antimicrobial activity against all tested microorganisms. However, the trend is reversed for fractionated extracts, that is, the *Aloe vera* fraction from Chloroform: Methanol (4:1) has the lowest MIC at 0.008 +/- 0.03 against *E.coli*.

Analysis

The results from the molecular analysis show that, as was expected, *Lomatophyllum purpureum* and *Lomatophyllum tormentorii* (both originating from the same region, that is, Mauritius) are more related together than to *Lomatophyllum macrum* (which originates from another region, that is, Réunion Island). This has been confirmed by a dendrogram. The data also suggests that *Lomatophyllum macrum* evolved on a different line to *Lomatophyllum purpureum* and to *Lomatophyllum tormentorii* for some time. However, this result must later be confirmed by population genetics studies. The possible difference in evolution could be due to the spatial distribution of the three species. Hence, the different plants may have a common ancestor but evolved under specific environmental conditions. Over time, this also affected the production of secondary metabolites in such plants. From the dendrogram, *Aloe vera* is an outgroup which shows that *Lomatophyllum* species and *Aloe* species are well placed in different genus. Despite the fact that *Lomatophyllum tormentorii* morphologically resembles more *Aloe vera* among all of the plants tested, especially the succulent parts, *L. tormentorii* and *A. vera* are the least related plants, with a distance value of 0.65 on the dissimilarity matrix, in the group. This observation through genetic data, shows the limitation of morphological data in classification in the case of *Aloe vera* and the *Lomatophyllum* species. The main Phytochemicals detected in *Lomatophyllum* species and *Aloe vera* were alkaloids, coumarins, tannins, phenols, saponins and terpenes. Plants that are rich in terpenoids, alkaloids, coumarins, phenols and tannins are reputed to have antimicrobial attributes[16] in accordance to the MICs observed. *Aloe vera* anthraquinone has been previously shown to have antimicrobial activity.[17] Anthraquinone has also been shown to have antimicrobial properties in several plants, against the three bacteria tested in this work.[18]

Quantitative studies for anthraquinone show that *Lomatophyllum macrum* contained the lowest percentage of anthraquinones compared to *Lomatophyllum* species from Mauritius and *Aloe vera*. The differences were more pronounced in composition of fractionated extracts of *Lomatophyllum* species and *Aloe vera*. Anthraquinones was detected in chloroform/methanol (4:1) fractions of *Lomatophyllum purpureum*, *Lomatophyllum tormentorii* and *Aloe vera* from Mauritius. *Aloe vera* shows significant antimicrobial attributes compared to the *Lomatophyllum* species with respect to fractionated extracts. *Aloe vera* fractions had MICs in the range 0.008–1.125 mg/ml followed by the Mauritian species and finally by *L. macrum* from Réunion Island. The antimicrobial activity correlated to the level of anthraquinones, with the highest in *Aloe vera*, followed by *Lomatophyllum purpureum* and *Lomatophyllum tormentorii*.

The MIC values also show that for plants that are closely related on the dendrogram, the MIC against the same three pathogens are close. Thus, the antimicrobial activity seems to follow the genetic relatedness of the different plants tested. It is interesting to investigate further whether the genetic relatedness across many more *Lomatophyllum* and *Aloe* species can actually act as predictors for their antimicrobial activities as well as phytochemical composition. Future research should thus focus in this direction.

Conclusion

Although general similarities were found in the phytochemical composition of the different fractions, the exact phytochemical composition and antimicrobial activities of the fractionated extracts differed. RAPD markers with more than 28 polymorphic bands were obtained and used to make the dendogram. Three species of *Lomatophyllum* species clustered together and separated clearly from *Aloe vera* validating their placement into a separate genus. Fifteen bands were common to all three *Lomatophyllum* species but the two Mauritian species *Lomatophyllum tormentorii* and *Lomatophyllum purpureum* are more genetically close to each other than to the Réunion Island species *Lomatophyllum macrum*. *Lomatophyllum tormentorii* is the least related to *Aloe vera* while *Lomatophyllum tormentorii* and *Lomatophyllum purpureum* are the closest in all the plants tested according to the dissimilarity matrix. The level of antraquinone may be correlated to the antimicrobial activity.

The dendrogram suggests that *Lomatophyllum* species from Mauritius and Réunion Island evolved separately for some time. This is a potential hypothesis to be confirmed by population genetics studies. Most morphological differences between *Lomatophyllum* species from the Mascarene Islands and *Aloe vera* are ref ected at the molecular, phytochemical and antimicrobial levels. It has been observed that *Lomatophyllum purpureum*, *Lomatophyllum tormentorii*, *Lomatophyllum macrum* and *Aloe vera* share similarities in the presence of alkaloids, terpenes, coumarins and tannins across all fractions tested. However, the exact types of such phytochemicals may vary but had not been tested. Such a test can be carried out by using Liquid chromatography / Mass Spectroscopy (LC-MS) and proton nuclear magnetic resonance (1H NMR) to elucidate the structure of the different phytochemicals involved. Such a test is important given that previous results by thin layer chromatography (TLC) and high performance liquid chromatography (HPLC), placed *Lomatophyllum* species and Aloe vera in the same category based on chemotaxonomy.[19]

However, this study shows that *Aloe vera* and the *Lomatophyllum* species are in different clades and are thus separated, based on RAPD marker data. One possible method to refine such classifications in the future is to consider several techniques of classification into one combined system, that is, chemotaxonomic data, morphological data and genetic data. This research shows that the use of *Lomatophyllum* species in the traditional pharmacopeia is founded as compared to the well characterised plant *Aloe vera* as a model. However, further research should be carried out in this direction but the preliminary tests show the potential of *Lomatophyllum* species for pharmaceutical exploitation.

Endntoes

[1] Agarry *et al.* (2005).
[2] Nature for Science (2011).
[3] Ben-Erik *et al.* (1995).
[4] Guého (1988).
[5] Riviere *et al.* (2007).
[6] Antoine *et al.* (1978).
[7] Gurib-Fakim (2003).
[8] Nature for science (2011).
[9] Riviere *et al.* (2007).
[10] Ben-Erik *et al.* (1995).
[11] Nature for Science (2011).
[12] García-Sosa *et al.* (2006).
[13] Tian *et al.* (2003).
[14] Krishna and Jayakumaran (2011).
[15] Ben-Erik *et al.* (1995).
[16] Bhalsing and Maheswari (1998); Cowan (1999).
[17] Cock (2008).
[18] García-Sosa *et al.* (2006); Tian *et al.* (2003); Krishna and Jayakumaran (2011).
[19] Ben-Erik *et al.* (1995).

References

Agarry, O.O, M.T., Olaleye and C.O., Bello-Michael. 2005. “Comparative Antimicrobial Activities of Aloe Vera Gel and Leaf.” *African Journal of Biotechnology* Vol. 4 (12), pp. 1413-1414

Ali, M.I., M.H.A., Elgamal and M.H., Mousa. 1999. “Antifungal Effects of Different Plant Extracts and Their Major Components of Selected Aloe Species.” *Phytother Res 13*: 401–407.

Antoine, R., J.P.M., Brenan and G. Mangenot. 1978. Flore Des Mascareignes, La Réunion, Maurice, Rodrigues. Familles 177–188. Mauritius: The Sugar Industry Research Institute

Ben-Erik, V.W., A., Yenesew and E., Dagne. 1995. “The Chemotaxonomic Significance of Root Anthraquinones and Pre-anthraquinones in the Genus Lomatophyllum (Asphodelaceae)” *Biochemical Systematics and Ecology*. Vol. 23. No. 7/8. Pp. 805-808

Bhalsing, S.R. and V.L., Maheswari. 1998. Plant Tissue Culture - A Potential Source of Medicinal Compounds. *J Sci Ind Res.* 57: 703-708

Bosch, C.H. 2011. Aloe lomatophylloides Balf.f. In: Schmelzer, G.H. and A., Gurib-Fakim. Protabase. URL:http://www.prota4u.info/downloads/Aloe+lomatophylloides/Aloe+lomatophylloides.pdf.

Cock, I. E. 2008. “Antimicrobial Activity of Aloe Barbadensis Miller Leaf Gel Components.” *Int J Microbiol* 2: 1–11.

Cowan, M.M. 1999. “Plant Products as Antimicrobial Agents.” *Clinical Microbiology Reviews*. Vol.12, No.4. Pp. 564-582

Dagne, E. and A. Yenesew. 1994. “Anthraquinones and Chemotaxonomy of the Asphodelaceae.” *Pure Appl Chem* 66: 2395–2398.

Doyle, J. J. and J. L. Doyle. 1987. “A Rapid DNA Isolation Procedure for Small Quantities of Fresh Leaf Tissue. *Phytochemistry Bulletin* 19: 11-15

Eloff, J.N. 1998. “A Sensitive and Quick Microplatemethod to Determine the Minimal Inhibitory Concentration of Plant Extracts for Bacteria.” *Planta Med 64*: 711–713.

European Pharmacopoeia. 2006. Direction Européenne de la Qualité des Médicaments. Pharmacopée Européenne, 6th edn. Conseil de l’Europe: Strasbourg.

Fortin, H., C., Vigor, F., Lohézic-Le Dévéhat, V., Robin, B., Le Bossé, J., Boustie and M. Amoros. 2002. *In vitro antiviral Activity of Thirty-six Plants from La Réunion Island. Fitoterapia 73*. Pp. 346-350

García-Sosa ,K., N., Villarreal-Alvarez, P., Lubben and L., Pena-Rodríguez. 2006. “Chrysophanol, an Antimicrobial Anthraquinone from the Root Extract of Colubrina greggii.” *J. Mex. Chem. Soc.* 50(2). Pp. 76-78

Guého, J. 1988. La végétation de l’Ile Maurice. Editions de l’Océan Indien: Rose-Hill, Mauritius.

Gurib-Fakim, A. 2002. *Mauritius Through its Medicinal Plants*. Mauritius: Editions le Printemps.

Gurib-Fakim, A. 2003. *An Illustrated Guide to the Flora of Mauritius and the Indian Ocean Islands*. Caractère Ltée: Baie du Tombeau, Mauritius.

Harborne, J.B, T.J., Mabry, H., Mabry. 1975. *The Flavonoids*. Chapman & Hall Ltd., London; 168–175.

Krishna, M.S. and N.A., Jayakumaran. 2011. “Anthraquinones from Leaves of Tectona Grandis: A Detailed Study on its Antibacterial Activity and other Biological Properties.” *International Journal of Phytomedicine*. Vol 3, No 1: Pp. 50-58

Nature for Science. 2011. Definition, Testing and Application of *Aloe vera* and *Aloe vera* gel.

Padmalatha, K., M.N.V., Prasad. 2006. “Optimisation of Dna Isolation and PCR Protocol for Rapd Analysis of Selected Medicinal and Aromatic Plants of Conservation Concern from Peninsular India.” *African Journal of Biotechnology*, Vol. 5 (3), pp. 230-234

Reynolds, T. and A.C., Dwek. 1999. Aloe vera leaf gel: a review update. *J Ethnopharmacol*. 68 (1-3): Pp. 3-37

Riviere, M., R., Lucas and R., Therodora. 2007. Choka, agave, aloes, mazambron: confusions a eviter.

Tian, B., Y.J., Hua, X.Q., Ma and G.L., Wang. 2003. “Relationship between Antibacterial Activity of Aloe and its Anthraquinone Compounds. Zhongguo Zhong Yao Za Zhi.” 28(11): Pp. 1034-7

Trease, G.E. and E.C., Evans. 1989. *Pharmacology*, 11th edn. Balliere Tindall: London; 60–75.

Vogler, B.K. and E., Ernst. 1999. “Aloe vera: A Systemic Review of its Clinical Effectiveness.” *Br J Gen Pract* 49: 823–828.

Websites

http://www.nature4science.com/AloeVera/1_DescriptionofAloeVera.pdf Accessed: June 2011

http://www.lansiv-kreol.net/environ_mazanbron01.htm Accessed: June 2011

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 53-60

Antimicrobial Activity of Some Endemic Species of *Albizia* (FABACEAE) from Madagascar

Danielle A. Doll Rakoto*, Clara Rajemiarimoelisoa*,
Ranjana Randrianarivo*, Delphin Ramamonjison*,
Christian Raheriniaina*, Noelinirina Raharisoa* and Victor Jeannoda*

Abstract: Plants belonging to the genus *Albizia* (Fabaceae) are traditionally subject of medicinal uses in many countries. Their various properties (larvicidal, antimicrobial, antiparasitic, cytotoxic, effects on nervous system, etc.) were thoroughly investigated. In Madagascar, *Albizia* is represented by 27 species of which 25 are endemic and two were introduced from other countries. Actually, neither chemical nor pharmacological study on the Malagasy species is reported in the literature. We assessed the antimicrobial activity of extracts from five endemic species of *Albizia*. Results showed that the extracts from A_3 and A_5 showed activity against all the tested germs at various degrees.

Keywords: *Albizia*, seeds, extracts, antimicrobial, minimum inhibitory concentration, minimum bactericidal concentration, Madagascar

Introduction

A large number of people in many developing countries have been relying on traditional medicines, in which plants constitute the principal element, for their health care needs for centuries. Plants belonging to the genus *Albizia* (Fabaceae) are trees found in countries in Africa, Asia and South-America where they are widely used in indigenous pharmacopoeia.[1] *Albizia* species have been the subject of several chemical and pharmacological studies. Thus, many structures (heterosids, alkaloids) were elucidated[2] and various activities such as anthelmintic[3], cytotoxic[4], larvicidal[5] or antimicrobial[6] were found.

In Madagascar, *Albizia* is represented by 27 species of which 25 are endemic and two were introduced from other counties. No previous report on both the chemical constituents and the pharmacological activities of

*Laboratoire de Biochimie appliquée aux Sciences médicales, Département de Biochimie fondamentale et appliquée, Faculté des Sciences, Université d'Antananarivo, Madagascar. Email : dad.rakoto@yahoo.fr (Corresponding Author).

The authors acknowledge the PER/AUF project for financial support and *Institut Pasteur de Madagascar* for providing micro-organisms.

these plants could be found in the literature. Since infectious diseases account for the significant proportion of health problems, antimicrobial principles from five Malagasy species of *Albizia* encoded A_1, A_2, A_3, A_4 and A_5, were studied in this work. They were purified and the major secondary metabolites were identified by phytochemical screening. Extracts or pure compounds were tested *in vitro* against two Gram positive bacteria: *Staphylococcus aureus*, *Bacillus subtilis*, three Gram negative bacteria: *Klebsiella pneumoniae, Escherichia coli, Salmonella typhi* and one yeast *Candida albicans*. Minimum inhibitory concentration (MIC) and Minimum bactericidal concentration (MBC) were determined on susceptible germs.

Preparation of Pure Compounds and Extracts

Seeds of plants A_1, A_2, A_3, A_4 and A_5 were used in this study. Fruits were collected in western and southern regions of Madagascar. Seeds were washed, sun-dried and ground into a fine powder, using a microgrinder Culatti. For all the species, the methods of extraction and purification of active principles are shown on figures 1-5. Pure compounds and extracts were subjected to preliminary phytochemical testing for the major chemical groups.[7] The major secondary metabolites identified in extracts are shown in Table 1.

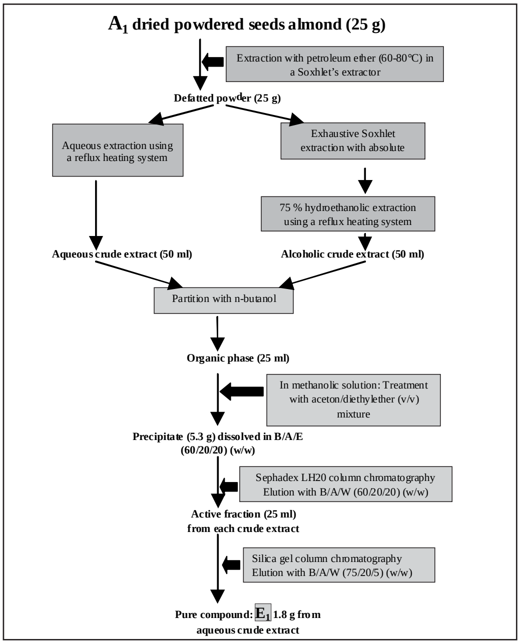
Except E_1 which didn't contain triterpenes, all extracts showed the presence of unsaturated sterols, triterpenes and deoxysugars, indicating glycosidic nature of active principles. The presence of saponins, in addition with positive foam test and hemolytic effect (not shown) mean that antimicrobial compounds may be saponins. Saponins and other glycosides were isolated and identified from other species of *Albizia*.[8]

Table 1: Phytochemical Screening of Extracts from 5 Malagasy Species of *Albizia* (A_1 to A_5)

Phytochemical compounds	Extracts					
	E_1	E_{21}	E_{22}	E_3	E_4	E_5
Alkaloids	–	–	–	–	–	–
Flavonoids	–	–	–	–	–	–
Anthocyanins	–	–	–	–	–	–
Phenols	–	–	–	–	–	–
Quinons	–	–	–	–	–	–
Unsaturated sterols	+	+	+	+	+	+
Triterpenes	–	+	+	+	+	+
Deoxysugars	+	+	+	+	+	+
Saponins	+	+	+	+	+	+

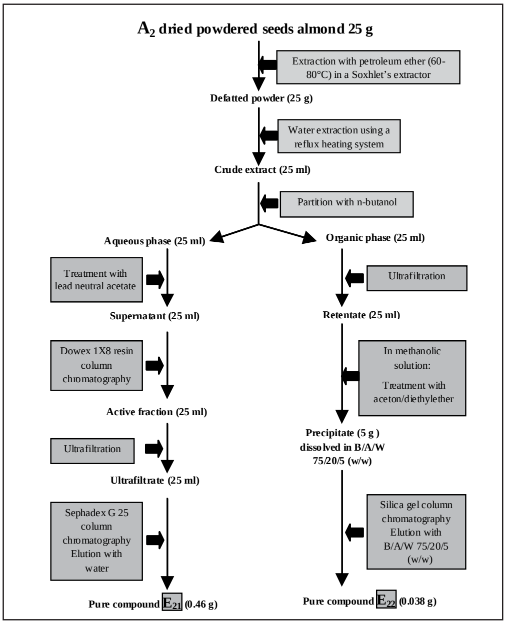
Source: Authors' compilation.
- : negative test + : positive test
E_1, E_3, E_4, E_5 : purified extracts from plants A_1, A_3, A_4 and A_5 respectively
E_1, E_{21}, E_{22} : pure compounds from plant A_1, A_2 respectively

Figure 1: Extraction and Purification of Active Principle from A_1 Seeds



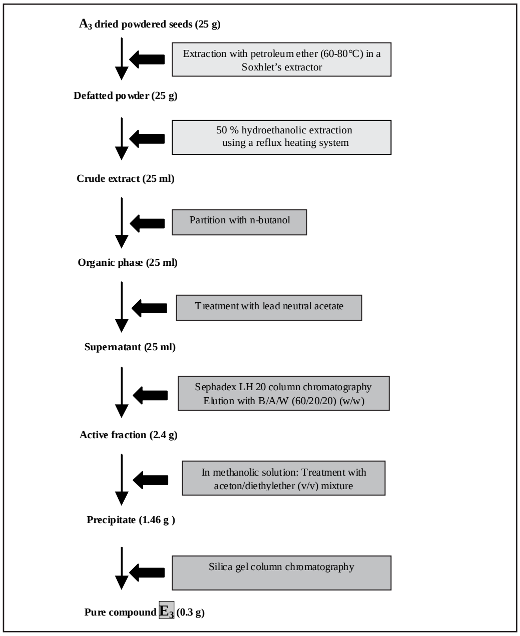
Source: Authors' compilation.

Figure 2: Extraction and Purification of Active Principle from A_2 Seeds



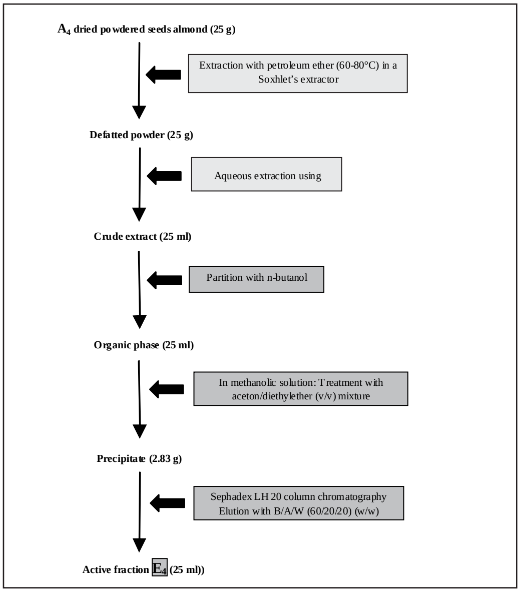
Source: Authors' compilation.

Figure 3: Extraction and Purification of Active Principle from A_3 Seeds



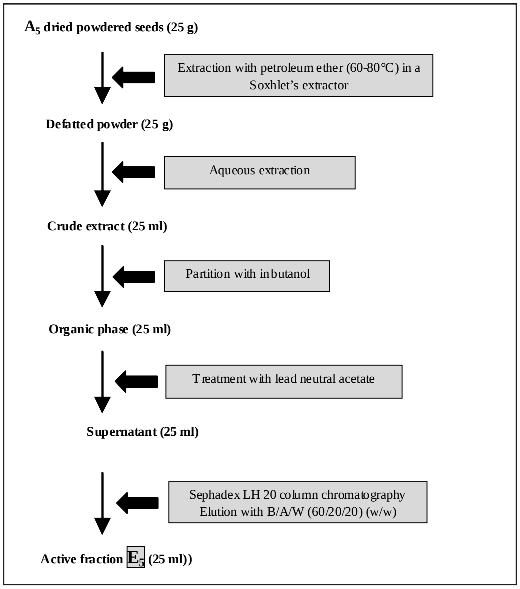
Source: Authors' compilation.

Figure 4: Extraction and Purification of Active Principle from A_4 Seeds



Source: Authors' compilation.

Figure 5: Extraction and Purification of Active Principle from A_5 Seeds



Source: Authors' compilation.

Assays on Micro-organisms

The pathogenic micro-organisms consisted of two Gram positive bacteria: *Staphylococcus aureus*, *Bacillus subtilis*, three Gram negative bacteria : *Klebsiella pneumoniae, Escherichia coli, Salmonella typhi* and one yeast *Candida albicans*. They were isolated and identified from heterogeneous cultures available in *Institut Pasteur de Madagascar*. The antimicrobial tests were carried out by disc diffusion method in Mueller Hinton agar.[9] The average inhibition zone (mm) is shown in Table 2.

Table 2: *In vitro* Antimicrobial Activity of Extracts from Five Malagasy Species of *Albizia*

Microorganisms	Extracts (µg/disc)						
	E_1 (25)	E_{21} (31,25)	E_{22} (31,25)	E_3 (400)	E_4 (400)	E_5 (500)	Reference antibiotics
Gram positive bacteria							
Staphylococcus aureus	8	12	10	11	9.5	11	Vancomycin (30 µg) 23 mm
Bacillus subtilis	–	ND	ND	13	11	16	Furan (25 µg) 33 mm

Table 2 continued....

Table 2 continued....

Gram negative bacteria							
Klebsiella pneumoniae	–	10	10	9	7	10	Furan (25 μg) 32 mm
Escherichia coli	9	–	–	11	9	13	Furan (25 μg) 34 mm
Salmonella typhi	–	8	–	9	7	11	Furan (25 μg) 30 mm
Yeast							
Candida albicans	14	20	12	10	8	13	Amphotericin B (100μg) 12 mm

Source: Authors' compilation. – : No activity ND : Not determined

According to these results, the extracts E_3 and E_5, respectively from A_3 and $A_{5,}$ showed activity against all the tested germs. *Bacillus subtilis* seemed to be the most susceptible bacterium (13 mm inhibition zone for E_3 and 16 mm for E_5) to these extracts. On the other hand, all of the extracts inhibited the growth of *Staphylococcus aureus* and *Candida albicans* at the tested concentrations. E_{21} (pure compound) exhibited the strongest activity against the fungus (20 mm). In a general manner, Gram positive germs, including *Candida albicans,* were more susceptible than Gram negative ones. Similar results were obtained with some other species of *Albizia*.[10]

MIC was determined for each extract on the most susceptible germ by broth dilution method.[11] Each medium showing no visible growth is subcultured on Mueller Hinton agar plates. After 24 hours at 37°C, MBC was the corresponding concentration required to kill 99.9 per cent of the cells.[12] MIC and MBC determined are given in Table 3.

Table 3: Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of Extracts from Five Malagasy Species of *Albizia*

Extracts	**Sensitive germs**	**MIC (μg/ml)**	**MBC (μg/ml)**
E_1	*Staphylococcus aureus*	320	2500
E_{22}	*Candida albicans*	6.25	100
E_{22}	*Klebsiella pneumoniae*	50	800
E_3	*Escherichia coli*	2500	10 000
E_4	*Staphylococcus aureus*	625	10 000
E_4	*Escherichia coli*	1250	20 000
E_5	*Escherichia coli*	12 500	12 500

Source: Authors' compilation.

Pure compound E_{22} from the plant A_2, showed the lowest MIC (6.25 μg/ml) and MBC (100 μg/ml) against *Candida albicans*. With MIC values corresponding to 100 µg/ml and 12.5 µg/ml respectively, *Albizia myriophylla* and *Albizia gummifera*[13] showed lower activity than A_2 against this germ.

Conclusion

Infectious diseases account for a significant proportion of health problems in Madagascar. Hence five species of *Albizia* plants native to Madagascar were tested for their antimicrobial properties. The tests confirmed the presence of triterpenes, unsaturated salts and deoxysugars in these plants. Out of the five species, two reported activity against all the five tested germs.

Endnotes

1. Githiori *et al.* (2003); Geyid *et al.* (2005); Zheng *et al.* (2006); Murugan *et al.* (2007); Rukayadi (2008).
2. Zou *et al.* (2006); Rukunga *et al.* (2007).
3. Githiori *et al.* (2003).
4. Zou *et al.* (2006).
5. Murugan *et al.* (2007).
6. Agyare *et al.* (2005); Geyid *et al.*, (2005); Sudharameshwari *et al.* (2007).
7. Farnsworth (1966); Marini-Bettolo et al. (1981).
8. Pal *et al.* (1995); Debella *et al.* (2000); Zou *et al.* (2006).
9. Rios *et al.* (1988).
10. Mbosso *et al.* (2010); Rukayadi (2008); Sudharameshwari *et al.* (2007).
11. Duval and Soussy (1990); Ferron (1994).
12. *ibid.*
13. Mbosso *et al.* (2010); Rukayadi (2008).

References

Agyare, C., Koffuor, G. A., Mensah, A. Y., and Agyemang, D. O. 2005. "Antimicrobial and Uterine Smooth Muscle Activities of *Albizia ferruginea* Extracts". *BLACPMA*, 5(2): 27-31.

Debella, A., Haslinger, E., Schmid, M. G., Bucar, F., Michl, G., Abebe, D., and Kunert, O. 2000. "Triterpenoid Saponins and Sapogenin Lactones from *Albizia gummifera*". *Phytochemistry*, 53: 885-892.

Duval, J., and Soussy, C. J. 1990. Antibiothérapie. *Masson éd.*

Ferron, A. 1994. Bactériologie médicale. Edition C. et R.

Farnsworth, N. R. 1966. "Biological and Phytochemical Screening of Plants". *J. Pharm. Sci.*, 55: 225-276.

Geyid, A., Abebe, D., Debella, A., Makonnen, Z., Aberra, F., Teka, F., Kebede, T., Urga, K., Yersaw, K., Biza, T., Mariam, B. H., and Guta, M. 2005. "Screening of Some Medicinal Plants of Ethiopia for Their Anti-microbial Properties and Chemical Profiles". *J. Ethnopharmacol.*, 97: 421-427.

Githiori, J. B., Höglund, J., Waller, P. J., and Baker, R.L. 2003. "The Anthelmintic Efficacy of the Plant, *Albizia anthelmintica*, against the Nematode Parasites *Haemonchus contortus* of Sheep and *Heligmosomoides polygyrus* of Mice". *Vet. Parasitol*, 116: 23-34.

Marini-Bettolo, G. B., Nicoletti, M., and Patamia, M. 1981. “Plant Screening by Chemical and Chromatographic Procedure under Field Conditions”. *J. Chromatogr.*, 218:113-217.

Mbosso, E. J. T., Ngouela, S., Nguedia, J. C. A., Beng, V. P., Rohmer, M., and Tsamo, E. 2010. “*In vitro* Antimicrobial Activity of Extracts and Compounds of Some Selected Medicinal Plants from Cameroon”. *J. Ethnopharmacol.*, 128: 476-481.

Murugan, K, Murugan, P., and Noortheen, A. 2007. “Larvicidal and Repellent Potential of *Albizia amara* Boivin and *Ocimum basilicum* Linn against Dengue Vector, *Aedes aegypti* (Insecta: Diptera: Culicidae)”. *Biores. Technol.,*98: 198-201.

Pal, B. C., Achari B., Yoshipppkawa, K., and Arihara, S. 1995. “Saponins from *Albizia lebbeck”*. *Phytochemistry,* 38(5): 1287-1291.

Rios, J. J., Recio, M. C., and Villar, A. 1988. “Screening Methods for Natural Products with Anti-microbial Activity: A Review of Literature”. *J. Ethnopharmacol.*,23: 127-149.

Rukayadi, Y., Shim, J. S., and Hwang, J.K. 2008. “Screening of Thai Medicinal Plants for Anticandidal Activity”. *Mycoses,* 51: 308-312.

Rukunga, G/ M., Muregi, F. W., Tolo, F. M., Omar, S. A., Mwitari, P., Muthaura, C. N., Omlin, F., Lwande, W., Hassanali, A., Githure, J., Iraqi, F. W., Mungai, G. M., Kraus, W., and Kofi-Tsekpo, W. M. 2007. “The Antiplasmodial Activity of Spermine Alkaloids Isolated from *Albizia gummifera”*. *Fitoterapia*, 78: 455-459.

Sudharameshwari, K., and Radhika, J. 2007. “Antibacterial Screening of *Aegle marmelos, Lawsonia inermis* and *Albizia lebbeck”*. *Afr. J. Trad.CAM*, 4(2): 199-204.

Zheng, L., Zheng, J., Zhao, Y., Wang, B., Wu, L., and Liang, H. 2006. “Three Anti-tumor Saponins from *Albizia julibrissin.*Bioorg”. *Med. Chem. Lett*., 16: 2765-2768.

Zou, K., Zhao, Y. Y., and Zhang, R. Y. 2006. “A Cytotoxic Saponin from *Albizia julibrissin*”. *Chem. Pharm. Bull*., 54(8): 1211-1212.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 61-75

Conservation and Management of Medicinal Plants: Experiences from Seychelles

D. Matatiken*, L. Hoareau**, M. Kante***, J. Mougal****, P. Rene#, M. Rosalie##, R. Spiro### and F. Vidot####

Abstract: The Seychelles is considered a biological hotspot because of its unique assemblage of plants and animals. Many of these species are valued for their medicinal properties. The Government recognises the uniqueness of the country's biodiversity that forms part of its natural heritage and is committed to its protection and management. More than 47 per cent of the total land area is presently under legal protection. Local dependence and the traditional use of biodiversity remains very strong in these islands. However, collection and use of these plants is not currently being regulated and thus the practice can become unsustainable. It is, therefore, important to engage with all stakeholders, local practitioners in particular, to ensure that sustainable exploitation practices are put in place to guarantee the future survival of species used and to prevent overharvesting of the genetic materials. Further, access to local biodiversity by foreign companies needs to be regulated so that the country and the multiple stakeholders and indigenous knowledge holders have a fair share of the benefits arising from the commercial use of our biodiversity. Traditional practices and knowledge need to be protected from unregulated bio-prospecting and acts of biopiracy. The Government is putting in place a regulatory framework in response to the Nagoya protocol to regulate access and the sustainable utilisation of the country's genetic resources. However, this law will not prevent local practitioners from using the local biodiversity which they have been using for generations to sustain the livelihoods of these users.

Keywords : Seychelles, conservation, medicinal plants, traditional practices, formulation, traditional knowledge.

Introduction

The Seychelles archipelago consists of 115 granitic and coralline islands, distributed between 3° to 5° South and 55° to 56° East, in the southwest Indian Ocean. The Seychelles are the only mid-oceanic islands of

* CEO, Seychelles National Parks Authority. Email: boga@seychelles (Corresponding author).
** Programme Specialist,International, Basic Science Programme Unit, UNESCO, Paris. Email: l.hoareau@unesco.org.
*** Principal Chemist, Seychelles Bureau of Standards, Mahe Seychelles. Email: mkante@seychelles.sc.
**** Research Officer, Seychelles, National Parks Authority, Mahe Seychelles. Email: James_mougal@yahoo.com.
# Chairperson, Complementary Health Care Services Board. Email: prene@gov.sc.
Department of Culture.
Chairperson, Association of Promoters of Complementary Health (APOCHIS), Seychelles.
Local practitioner in Seychelles.

continental origin and, as a result, they have generated immense geological and bio-geographical interest. Geographical evidence indicates that the granitic islands may be of the same age as Africa, having been part of the great supercontinent Gondwanaland. However, following complex geological processes such as continental break-up, these islands broke off from this land mass. The f ora and fauna evolved in isolation over millenia, giving rise to new species. For example, there are six palms which are endemic to the Seychelles, including *Lodoicea maldivica*, commonly known as the *coco de mer* (double coconut), with the biggest and heaviest seeds in the plant kingdom.[1] Certain species have retained their primitive f owering characteristics. *Medusagyne oppositifolia,* commonly known as the jelly fish plant for its unusual fruit and f owers which resemble the head of the Medusa from Greek legend, is a particular example. It is the sole representative of the endemic family Medusagynaceae.[2] The biodiversity of Seychelles has generated immense interest in biological circles and its conservation is of paramount importance.

The Seychelles have a rich diversity of terrestrial and marine f ora and fauna which have undergone evolutionary changes triggered by complex processes of land separation and geographical isolation. It is estimated that the terrestrial environment has over 1000 species of plants of which 250 are indigenous and 750 introduced plant species; 12 globally threatened endemic birds, five endemic bats, seven endemic caecilians, five endemic frog species, two freshwater fish, two sub species of terrapins with more species and subspecies of lizards which are endemics. The endemic insect life is even more numerous and diverse. Equally, the marine life includes over 1000 species of fish, 55 species of sea anemones, 300 scleractinian corals, 150 species of echinoderms and 350 species of sponges, but with lower endemism.[3]

The Seychelles is renowned internationally as a biodiversity hotspot[4] recognised as such by Conservation International, whilst the International Union for the Conservation of Nature (IUCN) and the World Wildlife Fund (WWF) have identified the islands as a centre of plant diversity. The Seychelles is party to several environment-related international conventions resulting in the commitment to fulfill certain obligations to ensure the conservation of biodiversity (See Table 1 below).

Table 1: Seychelles and Biodiversity related Multilateral Agreements

Biodiversity-Related Conventions	Signature /Accession	Ratification
African Convention on Conservation of Nature and Natural Resources, Algiers, 1968		14.10.97
Convention on the Wetlands of International Importance, Especially as Waterfowl Habitat, Ramsar, Iran, 1971	14.11.04 (S)	22.11.04
United Nations Convention on the Law of the Sea (UNCLOS), 1982	10.12.82 (S)	16.09.91
Agreement relating to the Implementation of part XI of the UNCLOS, 1982	29.07.94 (S)	15.12.94
Agreement for Implementation of Provisions of the UNCLOS, 1982, Relating to Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Species	04.12.96 (S)	
Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, Nairobi, 1985	21.06.85	29.05.90
Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region, Nairobi, 1985	21.06.85	29.05.90
Protocol Concerning Cooperation in Combating Marine Pollution in Cases of Emergency in the Eastern African Region, Nairobi, 1985	21.06.85	29.05.90
Convention on Biological Diversity, Rio de Janeiro, 1992	10.06.92 (S)	22.09.92
Cartegena Protocol on Bio safety to the Convention on Biological Diversity, 2000	23.01.01 (S)	13.05.04
Bonne Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilisation, 2002		
UN Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification Particularly in Africa, (UNCCD), Paris, 1994	14.10.94 (S)	26.06.97
Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)	1977	
Convention on Migratory Species (CMS)		
Climate Change/Protection of the Ozone Layer United Nations Framework Convention on Climate Change (UNFCCC), Rio de Janeiro, 1992	10.06.92	22.09.92
Kyoto Protocol to the UNFCCC, 1997	20.03.98 (S)	16.02.05
Vienna Convention for the Protection of the Ozone Layer, 1985	06.01.93 (A)	

Table 1 continued...

Table 1 continued...

Montreal Protocol on Substances the Deplete the Ozone Layer, 1987	06.04.93 (S)	
Vienna Amendment, 1990	06.01.93 (A)	
London Amendment, 1990	06.01.93 (A)	
Copenhagen Amendment, 1992	06.01.93 (A)	
Nagoya Protocol		

Source: Mwebaza *et al.* (2009).

In an effort to conserve biodiversity, the Government has placed almost half of the total land area under legal protection (See Table 2). These areas provide for the protection of habitats and ecosystems in which myriad species thrive. However, the local biodiversity is continuously under threat from a number of anthropogenic and biological factors. The former may include development whilst the latter includes the introduction and spread of alien invasive species (AIS). AIS are considered one of the most serious threats to biodiversity in island ecosystems. They compete with indigenous species for resources and space. Much of the natural forest and vegetation has been replaced or overgrown by introduced species like cinnamon (*Cinnamomum verum*), the cocoplum (*chrysobalanus icaco*) and albizia (*Paraserianthes falcataria*).[5] Other threats include forest fires as well as the impact of climate change. Climate change can result in the displacement and also destruction of habitats (for example, ocean acidification). The greatest challenge is to mitigate against those impacts.

Table 2: List of Marine and Terrestrial Protected Areas

Site Name	National Designation	Owner-ship	Marine or Terrestrial	Total Area (ha)	Total Terr. Area (ha)	Total Marine Area (ha)
African Banks	Protected Area	Govt.	Both	3,00	0	3,00
Aldabra	Special Reserve	Govt. (leased)	Both	35 000,00	20 800,00	14 200,00
Aride Island	Special Reserve	Govt. (leased)	Both	70,00	70,00	0.00
Baie Ternay	Marine National Park	Govt.	Marine	87,27	0,99	86,28
Cousin Island	Special Reserve	NGO	Both	1,50	0,3	1,20
Curieuse	Marine National Park	Govt.	Both	1 578,15	294,46	1 283,69

Table 2 continued...

Table 2 continued...

Ile Cocos, Ile La Fouche, Ilot Platte	Marine National Park	Govt.	Both	170,53	5,05	165,48
La Digue Veuve	Special Reserve	Govt.	Terrestrial	8,00	8,00	0
Morne Seychellois	National Park	Govt.	Terrestrial	3 045,00	3 045,00	0
Port Launay	Marine National Park	Govt.	Both	157,85	3,59	154,26
Praslin	National Park	Govt.	Terrestrial	675,00	675,00	0
Silhouette	Marine National Park	Govt.	Both	3 045,00	1 390,00	1 655,00
Ste Anne	Marine National Park	Govt.	Both	1 384,75	388,71	996,04
Vallee de Mai	Nature Reserve	Govt. (leased)	Terrestrial	81,00	81,00	0
Six sites: Beacon, Booby, Boudeuse, Etoile, Ile aux Vache, Les Mamelles	Nature Reserves	Govt.	Terrestrial	15,00	15,00	0
Total				45 322,05	26 777,10	19 368,95

Source: Mwebaza *et al.* (2009).

Policy and Regulatory Framework

The Seychelles has a population of less than 100,000 and an area of less than 500 square kilometres. The Ministry for Environment has regulatory function and is also responsible for policy matters in the protection of biodiversity. Body corporates on the other hand were created to implement specific actions such as the management of protected areas. This action is consolidated by the work of dynamic non-governmental organisations (NGOs) and groups in the private sector that attach great importance to the biodiversity and are increasingly investing in their protection. By effectively managing the biodiversity, the country's obligations under various multilateral agreements and conventions are met and fulfilled.

Despite its small size and its equally small population, the Seychelles has a comprehensive policy and regulatory framework to protect its marine and terrestrial biodiversity. But many of the laws were developed at the dawn of the last century and today are very outdated and require urgent revision to take on board current concerns and aspects of local development. Environmental concerns are articulated in Article 38 of the Constitution, which states that "*it is the right of a person to live in a clean environment and the responsibility of the state is to ensure that this right is respected and resources are used and managed sustainably*." There are several laws that regulate certain species of plants but they are not comprehensive enough to encapsulate all medicinal plants used (see Table 3 below).

Table 3: Law Pertaining to the Conservation of Plants

Legislation	Species	
Coco-de-Mer (Management) Decree, 1978 (as amended by Act 10 of 1994)	Coco-de-Mer	
Breadfruit and Other Trees (Protection) Act	BOTANICAL NAME	COMMON NAME
	1. *Adenanthera pavonina*	Lagati (Agathie)
	2. *Albizia falcataria*	Albizya (Albazia)
	3. *Terminalia catappa*	Bodanmyen (Badamier)
	4. *Hernandia sonora*	Bwa Blan (Bois Blanc)
	5. *Imbricaria sechellarum*	Bwa-d-Nat (Bois de Natte)
	6. *Heritiera littoralis*	Bwa-d-Tab (Bois de Table)
	7. *Alstonia macrophylia*	Bwa-Zonn (Bois Jaune)
	8. *Sideroxylon ferrugineum*	Bwa Mazambik (Bois Mozambique)
	9. *Albizia lebek*	Bwa Nwar (Bois Noire)
	10. *Dillennia ferruginea*	Bwa Rouz (Bois Rouge)
	11. *Tabebuia pallida*	Kalis Dipap (Calice du Pape)
	12. *Casuarina equisetifolia*	Sed (Cedre, Filao)
	13. *Eucallyptus sp.*	Kaliptis (Eucalyptus)
	14. *Artocarpus altilis*	Friapen (Arbre a Pain)
	15. *Intsia bijuga*	Gayak (Gayac)
	16. *Artocarpus intergrifolia*	Jak (Jaquiet)
	17. *Melia dubia*	Lilak (Lilac)
	18. *Swietenia macrophylla*	Maogani (Mohogany)
	19. *Eugenia malaccensis*	Ponm Gouvernment (Pomme Gouvernment)
	20. *Pterocarpus indica*	Sandragon (Sandragon)
	21. *Sandoricum indicum*	Santol (Santol)
	22. *Calophyllum inophylum*	Takamaka (Takamaka)
	23. *Tectonia grandis*	Tek (Teck)
	24. *Cocos nucifera*	Pye Koko (Coconut)
	25. *Deckenia nobilis*	Palmiste
	26. *Nephrosperma Vanhoutteanum*	Latanier Millepattes
	27. *Verscheffeltia ssplendida*	Latanier Latte
	28. *Roscheria melanocheates*	Latanier Hauban
	29. *Phoenicophorum borsigianum*	Latanier Feuille
	30. *Lodoicea maldivica*	Coco-de-mer

Source: Mwebaza *et al.* (2009).

In addition to the two regulations, the Coco de mer Decree and the Breadfruit and other trees Act, there are more policies that make reference to the use of plants. These policies do not target medicinal plants, but their use in the broad context of biodiversity exploitation is widely covered. For example, the new Seychelles Sustainable Development Strategy 2011-2020 makes reference to sustainable use and sustainable harvesting of plants. Similar mention is made under the National Strategy for Plant Conservation 2005 -2010.[6] This mention was made because of the immense interest amongst bio-prospectors for possible use of local plants in the pharmaceutical industry.[7] The policy also makes reference to the need to have the appropriate mechanism and the required law to ensure that the state benefits from a fair share of advantages arising from the commercial use of these plants. This is significant given that so many parties, including the Seychelles, have signed the Nagoya protocol, an international instrument for access and benefit sharing (ABS) issues.

The National Plant Conservation Strategy 2005-2010 (Plant Conservation Action Group and Botanical Garden Section 2005) has a slight bearing on the use of medicinal plants.[8] One of the reasons for this is because a number of the plants that are currently being used in the domain of traditional medicine, are indigenous; they grow in the Seychelles but they originate from other countries either in the region or in other tropical areas of the world. Most of the endemic plants used, such as *Bois Doux* (Bwa dou - *Craterispermum microdon)* and *Bois Jolicoeur* (Bwa zoliker - *Pittosporum senacia subsp. Wrightii.*) are believed to have been overharvested in the past. As a result, the species are now rare and restricted in range. A possible reason for this could be unsustainable harvesting practices such as ring barking (removal of the bark around the stem of the tree) which could result in the death of the tree. Such practices have to be discontinued and the collectors informed on appropriate harvesting techniques to ensure the survival of these endemic and endangered plants.

The successes of conservation in the Seychelles are the result of good collaboration that exists between various partners and stakeholders involved in the conservation of biodiversity. The Government is responsible for enforcing regulations and for developing new laws in line with commitments under international conventions. The country has put in place several policies and national strategies in conservation management. The major responsibility for biodiversity conservation and management in the Seychelles rests with the Government and, in particular, with the Environment Department. The Seychelles National Parks Authority was set up to manage all the marine and national parks whilst the Seychelles Fishing Authority was created for management and research in the area of fisheries. The Seychelles Islands Foundation is responsible for the management of two World Heritage sites, the *Vallée de Mai* and Aldabra atoll. A dynamic NGO community is also involved in the implementation of these conservation efforts. These include the Nature Protection Trust of Seychelles (NPTS), Nature Seychelles, the Plant Conservation Action Group (PCA), the Marine Conservation Society of Seychelles (MCSS), Island Conservation Society of Seychelles (ICS), amongst others. These NGOs are involved in biodiversity conservation, research and/or education and awareness building. The NGOs have strong collaborations or are affiliated with reputed organisations such as Birdlife International. Similarly, some of the private sector has become more implicated, together ensuring that biodiversity is managed effectively. The part all these actors play in developing national strategies can be evidenced by the process for drawing up the National Strategy for Plant conservation 2005-2010 which was drawn up through active consultations involving government, NGOs, parastatals and the private sector.[9]

Role of Traditional Practitioners in the Seychelles

Traditional practitioners are still making use of the unique f ora for medicinal purposes. These traditional healers, or herbalists as they are locally known, utilise local f ora to produce concoctions used as medicines to treat and cure various diseases and ailments. The practice has developed and thrived over the last two centuries and was used long before modern medicine was introduced to these islands. Whereas practitioners draw from native plant sources many of which are common to other island in the Indian Ocean and Africa, this natural phyto pharmacopoeia has been expanded over time with the addition of new plant species brought in from other sources through a process of knowledge and information exchanged among practitioners, for example, rosemary (*Rosmarinus officinalis*) or origano (*Origanum vulgare*) from la Reunion and others like the Aloe Vera, which was introduced to Seychelles as an ornamental plant but is now used for its medicinal properties and as such has been embraced by local practitioners. There is a fairly vibrant exchange among traditional practitioners in the areas of knowledge, experience and even plants. Most native plants are now cultivated; however, many are sometimes subject to difficulties in propagation and large-scale production. It is likely that the use and practice of traditional medicine was more common in the past, especially for the poorer inhabitants. Still, even today many people prefer and have recourse to local practitioners to resolve their health problems. Among the major ailments treated are hypertension, diabetes, gynaecological-related issues like menopause, skin problems like eczema, especially in children, and respiratory disorders including asthma. Increasingly, stress related problems and migraine are also frequently treated.[10]

Preparations and use of traditional medicine is often complex and based on a long apprenticeship. Preparations often comprise the combination of plants; for example the treatment of stress requires a complex preparation including bitter orange *(Citrus aurantium)*, thyme (genus *Thymus*), rosemary (*Rosmarinus officinalis*), origano (*Origanum vulgare*) and four other ingredients. A thorough knowledge of the local species, their location, use and anecdotal evidence of their efficacy is part of this training. Traditionally, transmission remains largely from the practitioner to his or her children. However, now some effort is being put into developing information products for the public and in particular working with school children. Practice of traditional medicine is made more complex by introduction of personalised touches to these practices by individual practitioners.[11]

It is important that the local traditional knowledge is protected and handed down to future generations. This important consideration in the preservation of this part of the cultural heritage is coupled with considerations for conservation of the plant species exploited by this user group. The practitioners need to be provided with appropriate training on methods for sustainably harvesting plants or plant parts; for example, how to harvest bark from trees so as not to kill the plant itself and thereby ensuring its future survival. In this context, governmental authorities have to ensure that local practitioners work closely with relevant non-governmental organisations to make certain that the practitioners are sensitised and effectively trained to ensure that plant materials are collected sustainably by using appropriate and practicable methods. Local practitioners also need to be sensitised to develop and adopt appropriate marketing strategies to add value to their products

Complementary Health Care Services Board in Seychelles

The Complementary Health Care Services Board (CHCSB) was set up in 2004 and is being regulated under the Seychelles Licensing Act. It comes under the Ministry of Health and has as its main function to assess the credibility of all applicants of complementary health care services in the country. The Board is appointed by the Minister for Health for a two year period and comprises a medical officer, a pharmacist, a physiotherapist, a representative of the Seychelles Licensing Authority, a public health officer, a representative of the consumers' association, a Complementary and Alternative Medicine (CAM) practitioner and a representative of the Association for the Promoters of Complimentary Health (APOCHIS).

Box: Fifteen Commonly Used Plants in Traditional Medicine in the Seychelles

Botanical name	Local name	Main use
1. *Catharanthus roseus*	Roz anmer; Saponer	diabetes, lack of appetite, treatment for intestinal parasites
2. *Cymbopogon citratus*	Sitronnel	Fever, teething problems
3. *Mentha arvensis*	Lanment	Fever, colic, indigestion
4. *Vernonia cinerera*	Gerivit	Intestinal gas, f atulence
5. *Citrus limon (acida)*	Limon	Fever,
6. *Coleus ambionicus*	Grobonm	Fever, cough and cold
7. *Carica papaya*	Papay	Constipation
8. *Phymatodes scolopendia*	Kapiler	Chicken pox
9. *Justica gendarussa*	Lapsouli	Teething problems, impetigo
10. *Acalypha indica*	Lerb sat	Tonic, f atulence
11. *Cassia alata*	Katrepeng	Skin diseases, fungus, eczema
12. *Euphorbia hirta*	Zanrober	Diarrhoea, respiratory disease
13. *Euphorbia tirucalli*	Bwa malgas	Diarrhoea, ingestion
14. *Lantana antidotalis*	Vyeyfiy	Cough, pneumonia
15. *Vernonia cinerera*	Gerivit	Intestinal gas, f atulence

Source: Authors' compilations.

The role of the CHCSB is to govern, administer and set policy relating to the CAM professions. It controls the registration of persons in respect of any CAM profession, receiving and appraising applications for license to practice channeled through the Seychelles Licensing Authority; this includes interview of applicants, liaising with necessary agencies with regards to authentication of certificates, carrying out visits to premises and providing advice to applicants on related matters. It sets standards including recommendation on good hygiene and a code of ethics including respect of the individual, confidentiality and privacy. In this regard, the CHCSB has the responsibility to inspect premises used in the above context and to monitor practices. It is authorised to conduct investigations with regard to professional conduct and ethical standards and to make recommendations to the competent authority for the issuing or revoking of licenses for such practice.

In addition, the Board encourages practitioners to keep clear, accurate and up to date records to facilitate optimum client care and to satisfy legal requirements. It monitors the health and safety issues including safe practices and the personal and professional standards of practitioners of alternative medicine. It also advises the Ministry of Health on any matter falling within the scope of CAM. The Board also provides advice to other interested partners on matters related to complementary health, and to the Seychelles Licensing Authority on applications of license to practice.

The Association of Promoters of Complementary Health in Seychelles (APOCHIS) was created in 2003 and deals more specifically with traditional and alternative medicine practices in Seychelles. These practices include all the form of therapies as well as traditional medicine which are not covered by conventional health services. Such therapies include but are not limited to ref exology, energy therapy, massage therapy, homeopathy, etc.

This NGO was established as a non-profit making organisation under the umbrella of the Liaison Unit of Non-Governmental Organisation of Seychelles (LUNGOS) and is registered with the national registrar of associations. It groups practitioners and promoters of various forms of complementary and alternative medicine in the country. As such it attempts to promote all forms of complementary health practices that are not regulated under the complementary health care regulations.

Traditional medicinal practices date back to the first settlers in Seychelles but were not formally recognised by the health authorities until the World Health Organisation (WHO) incorporated them in their formal documents. With the grouping of practitioners of complementary health within an association, the Ministry of Health gave some form of recognition to the practitioners of several therapies that are now licensable with a seat on the Board of the CHCSB. Traditional medicine as such is still not a licensable practice although it is being accessed by the population.

The association tries to promote the use of traditional medicine through sensitisation programmes that include annual fairs, talks, radio programmes and school activities. Further, the promotion of medicinal plants has taken on a new dimension with tourism establishments setting up their own medicinal and spice gardens with a view to providing their clients with a variation in organic and local herbal teas (infusions), one such establishment can be found at La Plaine St Andre.

Through the action of NGOs like APOCHIS and other organisations like Nature Seychelles information on medicinal plants and their uses are becoming more accessible to the general public and in particular to school children. Some practitioners are involved in propagating knowledge of medicinal plants though the Heritage Garden project in schools. A Heritage Garden has also been established in a joint Project between Nature Seychelles and the Wildlife Clubs, with the collaboration of the Department of Natural Resources and the Ministry of Education, to introduce young people to native plants, their use and related ecological information, thus enabling them to participate in the conservation efforts.[12]

Science Working with Practitioners

Invaluable information of the traditional knowledge in Seychelles was transmitted on two levels, at the level of the family on the one hand, and on the other hand at the level of the traditional healers. This information on the use of the plants for medicine was transmitted orally over the last centuries.

Traditional knowledge on the use of the medicinal plants can indeed be used as a basis for research. The botanical and especially chemical study of the medicinal and aromatic plants of Seychelles was inspired by the knowledge of local healers, still called herbalists. The sustainable use of the plant resources, for medical purposes or for research, presupposes the conservation and the protection of the biodiversity and the rational use of the medicinal and aromatic plants, thus allowing for continued research and the generation of potential new discoveries and molecules from these plant species.

In the Seychelles where nature still abounds in endemic species, it is evident that traditional practices have largely depended on this resource. However public opinion and acceptance of these practices have been somewhat slow and hesitant, in part because of the association of such traditional practices with superstition.

The botanical study of the plants of the Seychelles, including the medicinal and aromatic plants, was carried out simultaneously by many foreign and Seychellois researchers. Today nearly 500 plants have been studied with details of their botanical characteristics, habitat, etc. Chemical studies of the medicinal and aromatic plants of Seychelles has also been carried out at various levels:

a) Collaboration with international partners (in particular, since 1985, with the Institute of Cancerology in Virginia, United States). The preliminary results obtained showed that certain species of plants of Seychelles present very interesting properties in the treatment of diseases such as cancer.

b) The *Plantes Aromatiques et Medicinales de l'Ocean Indien* - PLARM/COI/FED Project (1990-1995) which allowed for the inventorisation and study of more than 400 medicinal and aromatic plants of Seychelles, including the identification of the principle chemical components (ex: alkaloids, phenols, tannins, coumarins, etc.), and also the extraction of essential oils and the identification of the chemical composition of these oils.

c) Doctoral theses of both foreign and Seychellois students which are increasing in number.

d) Training of students of the Institute of the Health of Seychelles, in the techniques, from preliminary chemical screening of the medicinal plants to the extraction and analysis of the essential oils.

e) Annual school projects, in preparation for the national "Science and Technology Fair".

The chemical analysis of the medicinal and aromatic plants of Seychelles was carried out by the laboratory of Applied Sciences, at the Office of the Seychelles Bureau of Standards (SBS). These produced interesting results which warrant further investigation. However, the Small Island States in general and in this case Seychelles, face a number of constraints in this. Little or no funding is made available purely for scientific research; the limited number of people are qualified in the field of research on the medicinal and aromatic plants; and research infrastructure is poorly developed. All this constitute real challenges and creates a high dependence on external, more developed research centres. With the creation of the University of Seychelles, however, and along with new faculties therein, there is hope that the study of the medicinal and aromatic plants of Seychelles will be strengthened. On the other hand, this work can, without a doubt, be carried out and continue to be developed within the framework of regional and/or international scientific cooperation.

Traditional knowledge on the common use of plants of Seychelles for medicinal purposes served as a basis for the analytical studies carried out in Seychelles. The ethnobotanical data on the medicinal and aromatic plants of this study were provided by the Research Section of the National Heritage unit of the Ministry of Culture in Seychelles and by local traditional healers.

The chemical analysis of the medicinal plants of Seychelles has enabled the better elucidation of the basis of certain traditional recipes. It is interesting to know, for example, that the clove and lemongrass contain a component called euegnol, a phenol which confers the disinfectant property to these plants, or that a decoction of guava leaves recommended by our traditional healers in cases of diarrhoea, contains certain tannins, and that it is the presence of these tannins which confers this anti-diarrhoeal property to these plants. However, the detection and isolation of these chemical compounds can only allow for hypotheses that a compound identified is the, or one of the bioactive substances from the plant. Pharmacological studies are needed to confirm or refute claimed therapeutic properties attributed to these plants. The infrastructure to pursue these studies is lacking and collaboration within and outside the region is imperative to fully evaluate the benefits and efficacy of native plants.

There should not be a dichotomy between traditional knowledge and scientific research, rather it would be more productive to identify similarities between these two systems of knowledge, to integrate the information from both or allow for complementarity. Together, these two systems of knowledge could form a solid and dynamic combination contributing to the wellbeing of our populations and their environment.

Nevertheless some crucial concerns regarding safety are apparent in certain circumstances in the use of the medicinal plants and highlights the need for quality assurance and quality control measures of traditional remedies. Other questions raised stem from the interface between intellectual property rights and traditional practices, rights on biological and other resources, and most appropriate methods to further develop such knowledge systems and to exploit these resources in a sustainable and equitable manner.

Conclusion

Traditional practitioners (or local healers, herbalists, etc.) are highly knowledgeable in various spheres of life in society. It is, therefore, important to establish mechanisms to identify those who have relevant knowledge and to collaborate with them. Traditional knowledge is an essential part of our history and culture and can contribute to the development of our countries. For this purpose, it must be inventoried and documented in a coherent and systematic way. This collection and storage should be complemented by appropriate dissemination, and comparison with available data and exchange between interested parties.

Working together we can be optimistic about the future conservation of our traditional knowledge and the protection of our endangered biological resources. Innovation within traditional knowledge systems could be beneficial and inform scientific research if scientists are allowed to invest adequate resources in this endeavour with the support of society, government, NGOs, funding agencies, researchers, etc.

Endnotes

1. Matatiken and Dogley (2005).
2. Fay *et al*. (1997).
3. Beaver (2000).
4. Myers *et al*. (2000).
5. Seychelles (2005) and Beaver (2000).
6. Seychelles (2005).
7. Lewis-Lettington and Dogley (2005).
8. Seychelles (2005)
9. Seychelles (2005).
10. Personal Communiation with F. Vidot.
11. *ibid*.
12. Shah (2011).

References

Beaver, K. 2000. Native Plants of Seychelles: A Basic Checklist and Field Guide

Fay, M., F. Swensen, S. M. and Chase, M. J. 1997. "Taxonomic Affinities of *Medusagyne oppositofilia* (Medusagynaceae)". *Kew Bulletin*, 52(1): 111-120.

Lewis-Lettington, R. and Dogley, D. 2005. *Commentary on the Development of the Republic of Seychelles Access to Genetic Resources and Benefit Sharing Bill*.

Matatiken, D. & Dogley, D. 2005. *Guide to Endemic* Palms *and Screw Pines of the. Seychelles Granitic Islands*. Plant Conservation Action Group.

Mwebaza, R., Njuguna, P., Corullus, I. and Matatiken, D. 2009. *A Situation Report: the Nature and Extent of Environmental Crimes in Seychelles*. Institute for Security Studies.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca G.A.B., and Kent, J. 2000."Biodiversity Hotspots for Conservation Priorities". *Nature* 403(6772):853-8.

Shah, N. 2011. Save our Green Medicine, Nature Seychelles: http://greenhealthseychelles.wordpress.com/2011/01/31/save-our-green-medicine/

Seychelles. 2005. *National Strategy for Plant Conservation 2005-2010*. Plant Conservation Action Group.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 77-83

Traditional Roles and Future Prospects for Medicinal Plants in Health Care

Ameenah Gurib-Fakim*

Abstract: There is enormous potential for finding more compounds out of the tropical species, since very few species have been studied so far for their pharmaceutical potential. Medicinal plants typically contain mixtures of different chemical compounds that may act individually, additively or in synergy to improve health. A multidisciplinary approach combining natural product diversity with total, combinatorial synthetic and biosynthesis may provide an apt solution to new innovative approaches. There is also growing evidence to show that old molecules are finding new applications through a better understanding of traditional knowledge and clinical observations. Reverse pharmacology and transdisciplinary exploratory studies are increasingly being studied these days. Rationally designed polyherbal formulation is being developed as option for multi-target therapeutic and prophylactic applications. This has led to the development of standardised, synergistic, safe and effective traditional herbal formulations with robust scientific evidence that can also offer faster and more economical alternatives.

Keywords: Traditional medicines, medicinal plants, ethnobotanical inquiry, phytomedicines.

Introduction

It is a fact that plants and people share a symbiotic relationship. Throughout the ages, humans have relied on nature for their basic needs for the production of food-stuffs, shelters, clothing, means of transportation, fertilisers, f avours and fragrances, and, not the least, medicines. Plants have formed the basis of sophisticated traditional medicine systems that have been in existence for thousands of years and continue to provide mankind with new remedies. Although some of the therapeutic properties attributed to plants have proven to be erroneous, medicinal plant therapy is based on the empirical findings of hundreds and thousands of years. Yet the interest in nature as a source of potential chemotherapeutic agents continues. The importance of ethnobotanical inquiry as a cost-effective means of locating new and useful tropical plant compounds cannot be over emphasised.

---

* Centre for Phytotherapy and Research Limited, Mauritius.
Email: afakim@cephyr-recherche.com

The domestication and breeding of local varieties of crops and livestock have also shaped biodiversity. Existing species on earth today trace their lineage back to an explosion of life in the Cambrian period some 500 million years ago. The wealth of life on earth and its rich biological diversity is the product of billions of years of evolutionary history. Over the course of time, human cultures have emerged and adapted to the local environment, discovering, using and altering biotic resources. The tropics are known to harbour a major proportion of the planet's biological diversity. It has been estimated that approximately half (125,000) of the world's f owering plant species live in the tropical forests. Brazil, which has some 55,000 species of plants, has reports on only 0.4 per cent of the f ora.

Tropical rain forests continue to support a vast reservoir of potential drug species especially as plants are known to be primary sources of all medicines in the world and continue to provide mankind with new remedies. More than 80 per cent of the world's population in the world still depends on traditional medicine for their primary health care.[1] They continue to provide scientists with invaluable compounds of starting points for the development of new drugs. The potential for finding more compounds is enormous as at date only about 1 per cent of tropical species have been studied for their pharmaceutical potential. This poor understanding of plants is particularly acute in the tropics. The existence of undiscovered pharmaceuticals for modern medicine has often been cited as one of the most important reasons for protecting tropical forests, so the high annual extinction rate is a matter for concern, to say the least. To date about 50 drugs have come from tropical plants.[2]

Many of the plant-derived pharmaceuticals and phytomedicines currently in use today were used by native people around the world. Some of this knowledge has been documented and codified or studied schematically. Medicinal plants typically contain mixtures of different chemical compounds that may act individually, additively or in synergy to improve health. A single plant may, for example, contain bitter substances that stimulate digestion, anti-inf ammatory compounds that reduce swellings and pain, phenolic compounds that can act as an antioxidant and venotonics, anti-bacterial and anti-fungal tannins that act as natural antibiotics, diuretic substances that enhance the elimination of waste products and toxins and alkaloids that enhance mood and give a sense of well-being.

Roots of Modern Allopathic Medicines

Modern allopathic medicine has its roots in ancient medicine, and it is likely that many important new remedies will be discovered and commercialised in the future, as it has been till now, by following the leads provided by traditional knowledge and experiences. It is estimated that natural products and their derivatives represent more than 60 per cent of all the drugs in clinical use in the world. Medicinal plants contribute no less than 25 per cent of the total. Modern medicine usually aims to develop a patentable single compound or a 'magic bullet' to treat specific conditions.[3] Potent drugs derived from f owering plants include *Dioscorea* species-derived diosgenin from which all anovulatory contraceptive agents have been derived; pilocarpine to treat glaucoma and dry mouth, derived from a group of South American trees (*Pilocarpus* species) in the Citrus family; two powerful anticancer agents from the Madagascan Rosy Periwinkle (*Catharanthus roseus*); laxative agents from *Cassia* species and as a cardiotonic agent to treat heart failure from *Digitalis* species.

Of these 119 drugs, 60 per cent of anticancer and 75 per cent of antiinfective drugs approved between 1981 to 2002 could be traced to natural origins. Although discovered through serendipitous laboratory observation, three of the major sources of anti-cancer drugs on the market or completing clinical trials were derived from North American plants used medicinally by Native Americans: the Papaw (*Asimina* species; the Western Yew Tree (*Taxus brevifolia*), effective against ovarian cancer and the Mayapple (*Podophyllum peltatum*) used to combat leukaemia, lymphoma lung and testicular cancer.[4]

A multidisciplinary approach combining natural product diversity with total, combinatorial synthetic and biosynthesis may provide an apt solution to new innovative approaches. Combinatorial chemistry approaches based in natural products from traditional medicine are being used to create screening libraries that closely resemble drug-like compounds. Since most of these compounds are part of routinely used traditional medicines, their tolerance and safety are relatively better known than other synthetic chemical entities entering first in-human studies.

Over the past few years, a large number of lead molecules have come out of the traditional Ayurvedic system of medicine and include *Rauwolfia* alkaloids for hypertension, Psoralens for vitiligo, *Holarrhena* alkaloids for amoebiasis, guggulsterones as hypolipidemic agents, *Mucuna pruriens* for Parkinson's disease, piperidines as bioavailability enhancers, baccosides for mental retention, picrosides for hepatic protection, phyllanthins as antivirals, curcumine for inf ammation, withanolides and many other steroidal lactones and glycosides as immunomodulators. There is also growing evidence to show that old molecules are finding new applications through a better understanding of traditional knowledge and clinical observations. Among such examples are *Curcuma* for diabetes, arthritis and hepatitis. The potential of *Centella* is being re-assessed as an anti-aging agent. Extracts of *Ocimum sanctum* traditionally used against common colds are being re-assessed for their anticancer potential.

European traditions are particularly well known and have had a strong inf uence on modern pharmacognosy in the West, almost all societies have well-established customs, some of which have hardly been studied at all. Importantly, to date, vast majority of people on this planet still rely on their traditional *materia medica* (medicinal plants and other materials) for their everyday health care needs and according to the WHO, over 80 per cent of the world's population-primarily those of developing countries-rely on plant-derived medicines for their healthcare.[5]

The study of these traditions not only provides an insight into how the field has developed but it is also a fascinating example of our ability to develop a diversity of cultural practices. Traditional medicine often aims to restore balance by using chemically complex plants, or by mixing together several different plants in order to maximise a synergistic effect or to improve the likelihood of an interaction with a relevant molecular target. In most societies today, allopathic and traditional systems of medicine occur side by side in a complementary way. The former treats serious acute conditions while the latter is used for chronic illnesses, to reduce symptoms and improve the quality of life in a cost-effective way.

People who use traditional remedies may not understand the scientific rationale behind their medicines, but they know from personal experience that some medicinal plants can be highly effective if used at therapeutic doses. Since we have a better understanding today of how the body functions, we are thus in a better position to understand the healing powers of plants and their potential for their potential as multi-functional chemical entities for treating complicated health conditions.

Reverse Pharmacology

The traditional knowledge-inspired pharmacology related to the reversing the routine 'laboratory-to-clinic' progress to 'clinic-to-laboratories'. Reverse pharmacology is increasingly being studied and is the rigorous scientific approach of documenting clinical experiences and experiential observations into leads by transdisciplinary exploratory studies for translation into drug candidates or formulations through robust preclinical and clinical research. In this process, 'safety' remains the most important starting point and the efficacy becomes a matter of validation. The novelty of this approach is the combination of living traditional knowledge such as Ayurvedic, African or Amerindian and the application of modern technology and processes to provide better and safer leads. A good example that has emanated from Ayurvedic medicine is the treatment of Psoriasis. Psoriasis is one of the most common dermatological disease affecting approximately 2 per cent of the world population with no preventive or curative therapy. Using the reverse pharmacological approach, the botanical drug product 'Desoris' which is an extract of a single plant that effectively modulates cellular function has led to an improvement in psoriatic lesions. This product is being developed to conform to FDA guidelines for botanical drug products. It is now undergoing Phase 3 clinical trials in India.[6]

Increasingly, it is being proposed that drug discovery need not always be confined to the discovery of a single molecule. Many analysts believe that the current 'one drug fits all' approach may be unsustainable in the future. In the management of polygenic syndromes and conditions, there is a renewed interest in multi-ingredient synergistic formulations. Rationally designed polyherbal formulation is being developed as option for multi-target therapeutic and prophylactic applications. This has led to the development of standardised, synergistic, safe and effective traditional herbal formulations with robust scientific evidence that can also offer faster and more economical alternatives.

This approach is being used successfully in Tanzania with the Tanga AIDS Working Group (TAWG) and where indigenous knowledge is being used to alleviate suffering from HIV/AIDS. This group has treated over 4000 AIDS patients with herbs prescribed from local healers. This impact has been most significant in reducing opportunistic diseases accompanying HIV infection. These experiences are important in scientific and rational drug discovery process. A crucial challenge is to lever local and global knowledge systems effectively to resolve development challenges.[7]

Finally, drug discovery and development is known to be extremely complex, technology and capital-intensive process that is facing major challenges with the current target rich-lead poor situation. One of the major causes of attrition in drug discovery has been the toxicity in human trials and it is also recognised that drugs with novel mechanisms have higher attrition rates. Better validated preclinical targets with proof-of-concept of better efficacy and safety of drugs can, mitigate such attrition risks. This is where reverse pharmacology approach, based on traditional knowledge, can be useful in this process and help reduce failure rates.

Threat to Tropical Biodiversity

Drug discovery strategies based on natural products and traditional medicines are re-emerging as attractive options. It is also being recognised that drug discovery and development need not always be confined to new molecular entities but that rationally designed, carefully standardised, synergistic traditional herbal formulations and botanical drug products with robust scientific evidence can also be alternatives. Such examples from the African Herbal Pharmacopoeia already exist and could provide interesting and useful alternatives to allopathic medicines. *Mesembryanthemum tortuosum*, commonly known as Sceletium, used by the Khoi San people as a sedative. Their activity is ascribed to the presence of Mesembrine and other alkaloids which show serotonin re-uptake inhibitors. The plant extract could possess therapeutic applications for anxiety and depression, and other serious mental health conditions. The possibility of the plant as an African alternative to Prazac or St. John's wort (*Hypericum* species) or even *Valerian* species is increasingly being thought.

Yet in spite of this diversity in their chemical composition, there is a real threat to tropical biodiversity. With human settlements, many plants have been introduced intentionally as food crops, ornamentals, forest species and as medicines from many parts of the world. Others have been introduced inadvertently and have become weeds. Some had been introduced to control imported pests, only to become pests themselves; (for example, *Ligustrum robustum* var *walkerii*). In some parts of the world, the latter had been introduced to out compete the Thorny Bramble (*Rubus alceifolius*) in forest plantation. Also several of the introduced exotic plants, such as Chinese Guava (*Psidium cattleianum*), Poivre marron (*Schinus terebinthifolius*) have become naturalised in native forests. Over the years, they have displaced the native plants from their habitat through intense competition.

The regeneration of native species are compromised by exotic seed predators such as rats and monkeys etc. These factors impoverish the indigenous vegetation both genetically and in numbers and the net result is that many species are threatened with extinction. Small Islands States like those of the South West Indian Ocean are blessed with unique vegetation. At the global scale, the f ora of the South West Indian Ocean as well as in other Small Island Developing States (SIDS) constitutes one of the planet's hotspot. Many unique specimens of plants are found within and will benefit science and medicine as they can potentially provide important leads for the development of new medicine or standardised extracts. This unique f ora within as well as in other tropical regions remains highly vulnerable not only to habitat destruction but also to the threat that invasive plants present as well. Respective governments have been alerted to the conservation actions along with the appropriate policies that need to be put in place so as to safeguard this genetic resource.

Endnotes

1 WHO (1992).

2 Burslem *et al.* (2001).

3 Farnsworth *et al.* (1985).

4 Cragg and Newmann (2005).

5 WHO (1999).

6 Vaidya and Devasagayam (2007).

7 Patwardhan and Mashelkar (2009).

References

Burslem, DFRP, Garwood, NC, Thomas SC. 2001. "Tropical Forest Biodiversity - the Plot Thickens." *Science* 291, pp. 606–607.

Cragg, G., Newmann, D.J. 2005. "Biodiversity: A Continuing Source or Novel Drug Leads." *Pure Appl. Chem*, 77, pp. 7–24.

Farnsworth N, Akerele AO, Bingel AS, Soejarto DD, Guo Z. 1985. "Medicinal Plants in Therapy." *Bull. WHO*, 63, pp. 965–981.

Levoye A, Jockers R. 2008. "Alternative Drug Discovery Approaches for Orphan GPCRs." *Drug Discovery Today*, Vol. 13, pp. 52-58.

Patwardhan B., and Mashelkhar R.A. 2009. "Traditional Medicine-Inspired Approaches to Drug Discovery: Can Ayurveda Show the Way Forward?" *Drug Discovery Today*, Vol. 14, Issue: 15-16, pp. 804-810.

Schultes R. E., and Von Reis S. 1995. *Ethnobotany: Evolution of a Discipline*. UK: Routledge Chapman Hall. Pp. 416.

Vaidya A.D.B., and Devasagayam T.P.A. 2007. "Central Status of Herbal Drugs in India: An Overview." *J. Clin. Biochem. Nutr*., Vol. 41, Issue 1, pp. 11-29.

WHO. 1992. *Analysis of Questionnaires on Traditional Medicine*. Geneva: World Health Oragnisation.

WHO.1999. *WHO Monographs of Selected Medicinal Plants*, Vol. 1. Geneva: World Health Oragnisation.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 85-107

Status of Conservation of Native Medicinal Plants of Mauritius and Rodrigues

Vikash Tatayah*

Abstract: Mauritius and Rodrigues are renowned for the unique biodiversity that evolved on these islands, and are conversely notorious for some of the highest global extinction records. Much of the extant plants and animals are seriously threatened, and programmes have attempted to restore biodiversity at both species and ecosystems levels. Plant and habitat restoration programmes have been motivated by biodiversity conservation solely and almost never for ethnobotanic reasons. However, up to 61 per cent of native and endemic plants used in species and habitat restoration have documented medicinal use. Therefore, the plant biodiversity conservation has the added advantage of saving native and endemic medicinal plants.

Keywords: Mauritius, Rodrigues, conservation, medicinal plants.

Introduction

Mauritius and Rodrigues have a very rich natural fauna and flora assemblage for their sizes. The uniqueness of this biodiversity is world renowned. Regrettably the advent of man over four centuries ago has spelt doom, and much of the biodiversity is either extinct or seriously threatened. Concrete actions have been undertaken to save critically endangered plants and animals, and to restore as best as is practically possible some of mainland habitats and islets. The restoration projects have included medicinal plants, though species conservation, ecosystems function, and ecosystems restoration have been the focus of these actions. Conservation of medicinal plants has not been at the forefront of restoration projects, but are, however, a by-product of these.

Natural History of Mauritius and Rodrigues

Pristine Mauritius (1800 km^2; 828m) and Rodrigues (109 km^2; 393m) are 8-10 and 1.5 milion years old respectively.[1] Mauritius and Rodrigues are

* Mauritian Wildlife Foundation, Vacoas, Mauritius. Email: vtatayah@mauritian-wildlife.org

The author wishes to thank all staff of the Mauritian Wildlife Foundation, from Mauritius and Rodrigues, who supplied information towards this article and to Prof. Ameenah Gurib-Fakim and Mr Gabriel d'Argent for invaluable comments on earlier drafts. The article is dedicated to Prof. Gurib-Fakim and her research team for the significant contribution to awareness of the medicinal plants of the Republic of Mauritius and for keeping the tradition of medicinal plant use alive

1100 km and 1450 km east of Madagascar and of volcanic origin, although about a third of Rodrigues, in the south, is made of aeolian deposits. The age of Mauritius and Rodrigues are disputed on the basis of the much higher degree of erosion on Rodrigues, its larger lagoon compared to the actual size of the island, and high relative animal and plant endemicity to the land area, and the high degree of specialisation of some plants and animals. It is also thought that older Rodriguan rocks have not been studied yet. On these bases, Rodrigues could prove to be the oldest of the Mascarene Islands, which includes Mauritius and Reunion. Mauritius and Rodrigues are part of the Republic of Mauritius, which includes 49 and 15 inshore islets respectively, and the remote islands of Agalega (2 madreporitic islands), Cargados Carajos shoals (also known as St Brandon, some 30 sand banks) and the disputed Chagos Archipelago and Tromelin Island.

Mauritius and Rodrigues were covered with several native vegetation types that included a lowland palm rich forest, lowland hardwood forest, mangroves, pan-tropical coastal vegetation, upland canopy forest, mossy forest, heath-Sideroxylon forest and Pandanus marsh.[2] These forests supported at least 680 native f owering plants, of which 47 per cent are endemic to Mauritius and a further 20 per cent to the Mascarenes (see notes). Rodrigues has a much smaller f ora, with 134 native taxa, including 47 endemics and 17 Mascarene taxa.[3]

Plants evolved in isolation from the inf uence of the continental land masses. Due to habitat destruction, degradation and introduction of plant and animal pests since human colonisation four centuries ago, the ecosystems of Mauritius and Rodrigues now rank amongst the most degraded in the world.

Human History of Mauritius and Rodrigues

There are no indigenous people in the Mascarenes. The islands were known to the Arabs in the 12-14th century and to the Portuguese from the early 16th century; however, there is no evidence that they colonised the islands. The Dutch discovered the Mascarenes in 1598 and were the first to settle on Mauritius as from 1638 and abandoning the island by 1710. At the time of their departure, only a handful or so of runaway slaves of Indonesian and African origin remained. The French colonised Mauritius in 1721, and introduced slaves from Africa and Madagascar. After the British conquest of Mauritius in 1810, slaves continued to reach the island from Africa and Madagascar (in particular), but their numbers were declining to a very low level becasuse of plans to abolish slavery, which eventually occurred in 1835. In preparation for the abolition of slavery, indentured labourers from India started arriving in 1834, initially in a trickle, but accelerating by the 1880s; the f ow continued until 1922, when over 454 000 people came to Mauritius.[4] Indentured labourers also came from China. The various forced, tricked and voluntary settlers, as well as fortune-seekers and adventurers now constitute the melting-pot of modern Mauritius, a mixture of Indians (Hindus and Muslims), Africans, Madagascans, Chinese and Europeans.

On Rodrigues, the first settlers, a group of protestant men f eeing from persecution in Europe and hoping to create a new haven arrived in April 1691, but this attempt was short-lived, as these men became lonely, and they quit the island in May 1693.[5] Permanent settlers arrived in 1792, and were made up of Frenchmen and women and slaves from Africa and Madagascar. Some lesser inf ux of British settlers and indentured labourers, continued in the 19th century, and Mauritian civil servants in the 19th and 20th century, but the island remained mainly dominated by descendants and inter-mixed marriages of earlier French settlers and slaves. Mauritians of various ethnic origins continue to arrive in Rodrigues, but the profile of the island is mainly of inhabitants of African descent, though mixed.

Emergence of Medicinal Plant Use in Mauritius and Rodrigues

Before proceeding further, for the sake of clarity it is opportune to define some terms as below.

Native (or Indigenous): Plant or animal that was present prior to arrival of mankind and arrived by natural means, but its geographic location is not limited to one location or country. Natural means includes wind or water dispersal (on water or on rafts of vegetation), brought in by storms, carried by animals on fur or feathers or through faeces.

Endemic: Plant or animal that was present prior to arrival of mankind and arrived by natural means, but is restricted in geographic distribution for example, a mountain, national park or a country. A species may also rarely be said to be endemic to a group of islands (for example, the Mascarenes). In all cases the species is not naturally widespread.

Introduced (or exotic): Species which reached a location through the intervention of man deliberately or accidentally, and not by natural means.

Field gene bank: An ex-situ collection of a rare species which conserves the genetic integrity of the species as live plants. A great advantage of field gene banks is the ready availability of the material for characterisation, evaluation, utilisation and research. Cuttings/grafts are usually taken from plants in the field gene bank to increase the number of plants for further reintroduction into the wild or boosting the original source population. A field gene bank is not an end in itself but part of an overall *ex-situ* or *in-situ* plant conservation strategy.

Human settlers have harnessed the nature for their own survival and progress. The settlers brought their own traditions, cultures, knowledge and practices. As modern medicine was inaccessible to the lower classes, and even to some extent middle and upper classes, due to the isolation of the islands, inhabitants resorted to the best alternative medicines they knew - medicinal plants. The reliance on medicinal plants continues to this day on Mauritius, though has declined tremendously since the advent of independence in 1968 and free modern medical health care. On Rodrigues, this reliance continues to a greater extent, due to lower penetration of modern medicine.[7]

How would European settlers, African and Malagasy slaves, and Indian and Chinese indentured labourers continue to use their traditional medicinal plants or recognise these properties in plants that they encountered in the Mascarenes? The new immigrants from Europe brought medicinal plants from around the world and continued to grow these here on Mauritius for example, *Ayapana triplinervis* ayapana, *Sapindus trifoliatus* Indian soap-tree, *Cissus quadrangularis liane du Dr. Burke*. Fewer plants were introduced from Europe due to difficulties to acclimatise them. Indians brought medicinal plants that had been in use in ayurveda for thousands of years for example, *Cannabina sativa* cannabis. Some plants also had religious values, for example, *Ocimum tenuiflorum* tulsi and *Calotropis gigantea* milkweed during the sea crossing. The Chinese used a mixture of herbs and animal organs, and since they were in commerce and could fairly easily procure these elements, the tendency has been to import medicinal products rather than attempt to introduce plants and animals from China and growing plants locally. Laffont (2001) documents 64 preparations used in Chinese medicine, available as pills and capsules or as a decoction. These are based on around 211 plant (and plant parts) and 16 animal parts and a secret ingredient. Of the plants used, only a dozen or so have been introduced to Mauritius and include common spices and commercially grown plants or commercially traded products of common usage. As for African and Malagasy slaves, their forced translocation to Mauritius did not provide opportunities to introduce medicinal plants.

Native and Endemic Medicinal Plants

The exploitation of plants for medicinal use on Mauritius (and less so on Rodrigues) has been documented by various botanists and researchers over the past centuries for example, Van Dam (1700), Bouton (1857), Daruty (1886), Vinson (1941-2), Sussman (1980), Wong Ting Fook (1980) and Gurib-Fakim and Guého (1994-7) (for a complete list, see Guého and Owadally 1998). Painter naturalists such as Mrs Malcy de Chazal-Moon have left a lasting legacy on the documentation of medicinal plants.[8] Eighteen (28 per cent) of the 65 medicinal plants that de Chazal-Moon painted were either native or endemic.

In addition to the introduction of medicinal plants to Mauritius, African and Malagasy slaves, and to a lesser extent Asian immigrants, recognised native plant species already known to them. Of the approximately 955 taxa of native f owering plants, c.72 per cent are endemic to the Mascarenes; the rest, c. 264 taxa, are more widespread.[9] Of the 263 native fern taxa, only 22 per cent are endemic to the Mascarenes.[10] These non-Mascarene endemics occur throughout the Madagascar sub-region, Afro-Malagasy region, Indo-Pacific region or are pan-tropical, and African and Malagasy slaves and Asians would have recognised them and known their medicinal properties. Notable examples include *Aphloia theiformis* fandamane, *Rhizophora mucronata* mangrove/manglier, *Abrus precatorius* Crab's eye/graine de diable, *Ipomoea pes-caprae,* Beach morning-glory/liane batatran, *Toddalia asiatica* patte de poule piquant and various ferns. In some cases, the new settlers applied the same names to these medicinal plants as in their countries of origin, for example, fandamane and *Jumellea fragrans* fahame, and derived names such as 'patate a durand' for *Ipomoea pes-caprae*.

The endemic plant taxa of Mauritius and Rodrigues have close affinities with the f ora of the Afro-Malagasy and to a lesser extent, Australasian region. Out of the 95 genera of the Mascarenes where affinities are apparent, 89 per cent have affinities with Madagascar and Africa, with 11 per cent probably arriving from the East.[11] The African and Malagasy slaves recognised these close taxonomic affinities between Mauritian endemic plants and endemic Afro-Malagasy species, and they experimented on their medicinal properties as they rightly understood that the Mascarene plants may contain the same active ingredients. Some examples of endemic Mascarene plants that have related species in Madagascar/Africa and genera are known in the latter for their medicinal properties include: *Bakerella hoyifolia* bois fier (in Mauritius), *Foetidia mauritiana* (in Mauritius)

/*Foetidia rodriguesiana* (on Rodrigues) bois puant, and *Psiadia* species (both Mauritius and Rodrigues). Thus, slaves exploited Mascarenes endemic plants as substitutes to the closely related medicinal plants in their own countries, either belonging to the same genus (for example, *Tambourissa* species against 'tambave' – see definitions), or differed sub-specifically only (for example, *Dracaena reflexa* ssp.).

Some of the traditional remedies are unique as there are no equivalents in modern medicine; for example *Tambave* (*tanbav*), the word derived from *tanbavy* of Malagasy origin to designate a condition in babies reported from the western Indian Ocean. Newborns suffer from digestive problems, including colic and diarrhoea, and develop skin rashes. The condition is not recognised by modern medicine, which has nothing similar, and, therefore, the pathogenic organism(s) has not been researched by western medicine. The term is also employed for plants used to alleviate the condition. For a fuller account, see Pourchez (2011)

Transmission of Knowledge

Medicinal preparations are often mixtures of native species or taxonomically closely related native plant species and introduced plants. How would knowledge of these preparations in curing certain health concerns have been spread within the same generation or transmitted to future ones? According to Pourchez (2011), women played a key role in dissemination of medicinal plants, 'from being midwives, nurses, healers and wet-nurse, at the interface of masters and slave, women are at the heart of traditional knowledge'. The knowledge was sometimes family or healers' secrets, or freely shared between and within generations, and transcended social and ethnic barriers, becoming common knowledge. For example, the use of the following native and endemic medicinal plants is widespread or commonly known:[12] In Mauritius, *Erythroxylon* species bois de ronde for gall stones, *Aphloia theiformis* fandamane for fevers and wounds, *Psidia* spp. baume de l'Ile Plate as a pectoral, *Faujasiopsis flexuosa* bois cassant against diabetis and asthma, and on Rodrigues[13] *Elaeodendron orientale* bois d'olive against fish allergies, *Terminalia bentzoë* species *rodriguesensis* bois benzoin against bronchitis and dysentery, and *Hibiscus tiliaceus* var against diarrhoea. Gurib-Fakim and Gueho (1994; 1997) document 193 medicinal plants in use in Rodrigues; 33 (17 per cent) of these are native or endemic to the island. On Mauritius, they documented 443 medicinal plants, including 98 (22 per cent) native/endemic. However, the expansion of modern medicine on Mauritius since the 1960s and on Rodrigues since the 1980s and loss of transmission of traditional knowledge has erosive influences on the use of medicinal plants.[14]

Forest Degradation on Mauritius and Rodrigues

Mauritius has one of the most interesting floras in the world due to its high endemicity. Forty-seven per cent of the 680 species of native flowering plants are endemic to the island. These evolved in isolation from the influence of the continental land masses. Large scale forest clearance for agriculture, infrstructure and urban development since the settlement of Mauritius leaves less than 2 per cent forest of good quality (>40 per cent native cover) (Figure 1).

Figure 1: Deforestation in Mauritius in 1773, 1835, 1872, and 1997

Source: MWF.

A significant proportion of native plants has disappeared, or is on the edge of extinction. According to the World Conservation Union (IUCN), over 150 native species are critically endangered as they are known from less than fifty individuals in the wild. Despite irreversible extinctions of plants and animals, a non-negligible subset of the original biodiversity still subsists both within a network of sanctuaries that include the Black River Gorges National Park, nature reserves (both on the mainland and on offshore islets) and mountain and river reserves, as well as on some private lands.

The effects of historical onslaught on the Mauritian flora is well documented[15] and are still pervasive to this day. However, there is general agreement on the need to save the fragments of the Republic's diversity for future generations. These natural sanctuaries should be foci for a large scale ecological restoration.

The original fauna and flora of Rodrigues is unique in the world. However, it has equally suffered from the onslaught of human induced degradation. Forest clearance, introduction of invasive plant and animal species, predators (for example, rats and cats), exploitation of the island's natural resources, unsustainable agricultural practices, and soil erosion have led to the demise of much of Rodrigues' rich biodiversity. Well over 20 bird species and a host of plants are extinct. The three surviving vertebrates, the Rodrigues Fruit Bat, Rodrigues Fody, and Rodrigues Warbler, are all the IUCN Red Listed endangered species. Surviving plants are reduced to a single individual or a handful of individuals or as small isolated populations.

Rodrigues is suffering from the effects of adverse agricultural practices, which are evident today in terms of low habitat cover, high soil erosion, severe water scarcity, and a critically endangered biodiversity. Projects to reforest areas on Rodrigues have addressed some of the above problems (for example, soil erosion), but the scale needs to be increased significantly. Small reforested areas are supporting the surviving endemic vertebrates of Rodrigues. Regrettably, much of the reforestation has used exotic species, many of which are either invasive or significantly more threatening, or are water thirsty plants. The long-term solution remains large scale habitat restoration, using Rodriguan native species.

The two mainland Nature Reserves of Anse Quitor and Grande Montagne contain some of the last relicts of native forest on Rodrigues, albeit degraded, and have been undergoing restoration since the mid-1980s. These mainland reserves and other relict patches of native plants, as well as islets reserves (Ile Cocos and Ile aux Sables) are now better secured for the future and can increasingly support a growing number of endemic Rodriguan plants and animals. Rodrigues provides the most dramatic loss of biodiversity and also the most envious conservation success stories (for example, *Ramosmania rodriguesii*, the Rodrigues Fruitbat, Rodrigues Warbler and Rodrigues Fody).

Restoration of Vegetation Communities on Mauritius and Rodrigues

Initiatives to restore the vegetation on mainland Mauritius and on offshore islets such as Round Island and Ile aux Aigrettes, and in Rodrigues (Grande Montagne, Anse Quitor, Ile Cocos and Ile aux Sables) began in earnest in the mid 1980s, although the alarm bells were rung as far back as the 1930's[16] and into the 1970s.[17] Restoration projects have involved the removal of animals competitors and predators (rats, cats, goats, rabbits, hare) and invasive plants (for example, *Psidium cattleianum* goyave de chine, *Leucaena leucocephala* acacia, *Flacourtia indica* prune malgache, *Litsea* species bois d'oiseau, *Acacia nilotica*), and restoration with native and endemic plants.

Appendices 1-7 provide a list of species used in habitat restoration in Mauritius and Rodrigues. A proportion of these species have documented ethnobotanic uses as medicinal plants (Table 1).

Table 1: Native Species Used in Habitat Restoration in Mauritius and Rodrigues

Restoration site	Number of recorded native & endemic species propagated for habitat restoration or rare plant conservation	Number & % medicinal plants	Type of activity
Ile aux Aigrettes	64	31 (48 %)	Habitat restoration
Round Island	56	33 (59 %)	Habitat restoration
Upland forest Field Gene Bank (Pigeon Wood)	17	2 (12 %)	Rare plant conservation
Ile aux Aigrettes Field Gene Bank	23	8 (35 %)	Rare plant conservation
Grande Montagne	33	20 (61 %)	Habitat restoration
Anse Quitor	28	13 (46 %)	Habitat restoration
Ile Cocos / Ile aux Sables	21	6 (29 %)	Habitat restoration

Source: Author's compliation.

Table 1 shows that between 48 and 58 per cent of plants used in habitat restoration on Mauritian offshore islets have recorded medicinal uses. This compares with 29 and 61 per cent on Rodrigues mainland and offshore islets. On Mauritius, the field gene banks to conserve extremely rare plants include 12-35 per cent medicinal plants, possibly a ref ection that the knowledge of rare plants as having medicinal properties have eroded faster than more common native and endemic plants.

The figures for medicinal native and endemic species used on Mauritius and Rodrigues for habitat restoration are highly variable, showing that medicinal plant conservation is not a criterion for conservation, but incidental rather.

Conservation of Medicinal Plants in Mauritius and Rodrigues

Actions to save native biodiversity on Mauritius and Rodrigues are world-renowned.[18] Although restoration projects have included medicinal plants, justifiably species conservation, ecosystems function, and ecosystems restoration were at the centre of these actions. In such restoration projects, the urgency is to use pioneer species that can develop fast, for example, *Scaevola taccada* veloutier vert, *Pouzolzia laevigata*, *Hilsenbergia petiolaris* bois de pipe, so as to outcompete exotic speices which may be thinned in later stages. In addition, the priority is to ensure the best representation of native and endemic species regardless of their commercial or ethnobotanic value. Special attention is also given to the conservation of threatened endemic plants. Some native/endemic species have ecosystems functions for example, food plants for fruits and leaves or pollen and/or nectar (for example, *Premna serratifolia* bois de sureau, *Trochetia boutoniana* boucle d'oreille, *Barleria observatrix*, *Turraea casimiriana* bois quivi), shelter for birds and reptiles (for example, *Vetiveria arguta* vetiver indigène), and are usually a focus in subsequent or advanced stages of restoration.

There have only been a handful of deliberate attempts to conserve native medicinal plants, and these have generally been outside of mainstream conservation, for example:

- the medicinal plant section (mainly exotic species but also incorporates a few native species) at Pamplemousses Botanical Gardens since 1996;[19]
- the UNDP-GEF-Small Grants Programme funded projects 'Conservation of Indigenous and Medicinal Plants (MAR/95/G52/I/12)' implemented by the Jeune Chambre Economique de Quatre Bornes (Mauritius) from 1998-2000; and
- 'Cultivation and Propagation of Medicinal Plants (MAR/SGP/OP3/22)' implemented by Association Pour L'Education des Enfants Defavorisés from 2006-7 (and continuing) for both native and exotic species.

Conservation of medicinal plants has not been at the forefront of biodiversity programmes, but is an incidental by-product of the latter. However, the UNDP-GEF-Small Grants Programme funded project "Sustainable Use of Rodriguan Endemic Plants" implemented by the Mauritian Wildlife Foundation from 2000-02, stands out as the first attempt in the Republic of Mauritius to conserve medicinal plants at community level to reduce over-exploitation of relict natural populations. More than 17 medicinal endemic species were propagated, several of which had already been severely over-exploited and were critically endangered.

Conservation Focus of Medicinal Plants

Why have native medicinal plants not been at the centre of conservation on Mauritius and Rodrigues? Possible explanations are given below:

Declining Medicinal Plants Use

As discussed in the previous sections, traditional use and knowledge of medicinal plants have greatly declined with the popularisation and democratisation of modern medicine. The trends are predicted to continue, leading to further declines in use and knowledge of medicinal plants[18], although there are attempts to reverse these trends, for example, through the research and publications of Gurib-Fakim and Gueho (1994, 1995-7, 2002, on going). The reduced use of native and endemic medicinal plants weakens the justification to conserve plants for this purpose.

High Proportion of Introduced Medicinal Plants

Of the 193 medicinal plants used in Rodrigues, 160 (83 per cent) are introduced, which is similar in proportion for Mauritius, 345 (78 per cent) of the 443 medicinal plants (derived from Gurib-Fakim and Gueho 1994 and 1995-1997). These figures show that introduced plants constitute an over-whelming majority of medicinal plants. These species are often widespread and fairly easy to grow in gardens compared to generally more exacting endemic species and thus not candidates for priority conservation. Furthermore, a host of introduced species are invasive and on the contrary, are controlled or eradicated in restoration programmes.

Rarity

285 native and endemic f owering taxa, out of the 671 plants of Mauritius,[21] and 47 of the 76 native taxa of Rodrigues[22] are extinct or locally extinct or Red Listed by the World Conservation Union (IUCN). About 150 endemic Mauritian plants are known from less than 50 individuals in the wild (MWF, unpublished). Although a proportion of rare endemic plants have economic (including medicinal) uses, their conservation will first and foremost be to save them from extinction or further decline. The exploitation of plants for commercial or cultural uses may seriously affect the survival of some endemic species that are already threatened. The unstated policy has been to avoid promoting native and endemic medicinal plants, not to say to discourage their exploitation in general.

Unsustainable Use of Plants

The human history of Mauritius and Rodrigues are characterised by the over-exploitation of natural resources as the norm, generally resulting in extinction (for example, *Aphanapteryx bonasia* Red Rail and *Dugon dugon* Dugong) or extreme rarefaction (for example, *Cryptopus elatus* liane camaron and *Ramosmania rodriguesi* café marron). Only a few instances of sustainable use of natural resources have been observed, for example, *Dictyopsperma album* var. *album* palmiste blanc, even though the species is Critically Endangered in the wild.

There is a fear that promotion of native and endemic medicinal plants will jeopardise biodiversity conservation efforts. Until a decade or so ago, firewood collection was common on Mauritius and was a necessary evil. However, it is regrettable that plant collection in the forest remains a popular pursuit, especially on Mauritius, at the detriment of wild plant populations. This activity also extends to medicinal plant exploitation. In the late 1990s' *Terminalia bentzoë* species *bentzoë* bois benjoin were debarked to death on Le Pouce Mountain, it is believed by herbal practitioners; this practice continues to date at Chamarel forest. On Rodrigues, the rediscovery of *Ramosmania rodriguesi* in 1980 and the remembrance (or imagination) of its medicinal properties led to plant parts being avidly collected.[23] The association with supernatural powers of the plant made matters worse. The last wild individual had to be protected by several gated fences, and later, even on top as black magic practitioners threw various offerings to the tree from above! *Carissa spinarum* is another species seriously threatened on Rodrigues through medicinal exploitation.[24] These examples from Mauritius and Rodrigues demonstrate that native and endemic medicinal plants are threatened by collection for medicinal reasons and an unsustainable harvest will destroy efforts to save biodiversity for other non-exploitative reasons.

The Future

The cafè marron of Rodrigues has an encouraging conservation pathway. All but one of the fences has been removed, so has the roof fence. Several plants have been reintroduced to the Grande Montagne Nature Reserve and are signposted to. The cafè marron is a popular attraction of the Reserve. The species is such a national pride thanks to education efforts that collection for medicinal properties is unlikely in the present state of national pride. However, as hundreds (and possibly thousands) of individuals could be available in the next decade(s), could its sustainable use be envisaged in future after confirmation of its medicinal properties? And, similarly for the rest of the other threatened native and endemic plants of Mauritius and Rodrigues, whose medicinal properties and mode of use will have been established by then. Will an ecologically more astute generation ensure that the best standards of sustainable use of plants is applied and that exploitation of plants on one hand is balanced by conservation of the species and ecosystems on the other? If so, one can envisage a re-emergence of native and endemic (as well as exotic) medicinal plant use. Conservation for biological reasons will support the future of sustainable medicinal plant use. More importantly, the conservation of plants will secure the potential for future biomedical research, leading to the discovery of yet unearthed medicinal properties.

Endnotes

[1] McDougall *et al*. (1965).
[2] Tatayah (2010).
[3] Strahm (1993).
[4] Tatayah (2005).
[5] Leguat (1705).
[6] Dulloo *et al.* (2004).
[7] Pourchez (2011).
[8] Dobie (1989).
[9] Strahm 1993).
[10] *ibid*.
[11] *ibid*.
[12] Gurib-Fakim and Guého, (1995-7).
[13] Gurib-Fakim and Guého, (1994).
[14] Pourchez (2011).
[15] Strahm (1993), Cheke and Hume (2008).
[16] Vaughan and Wiehe (1937).
[17] Proctor and Salm (1975).
[18] Cheke and Hume (2008), Butchart *et al*. (2006).
[19] Rouillard (2010).
[20] Anon (2006).
[21] Bachraz and Tezoo (1997).
[22] Strahm (1989).
[23] *ibid*.
[24] *ibid*.

References

Anon., 2006. National Biodiversity Strategy and Action Plan 2006-2015. Government of Mauritius.

Bachraz, V., and V. Tezoo. 1997. "A Review of Ex-situ Conservation Activities in Mauritius" in Yousouf Mungroo, John Retnon Mauremootoo, Vishnu Bachraz (eds) *Proceedings of the Workshop on Restoration of Highly Degraded and Threatened Native Forests in Mauritius.* Pp.12-19. Mauritius: National Parks and Conservation Service.

Butchart, S. H. M., A.J. Stattersfield and N.J. Collar. 2006. How Many Bird Extinctions Have We Prevented?. *Oryx*, 40: pp. 266–278.

Cheke, A. S. and Hume, J. 2008. *The Lost Land of the Dodo*. London, UK: T & AD Poyser.

Bouton, L. 1857. *Medicinal Plants Growing or Cultivated in the Island of Mauritius*. Trans. Royal Society of Arts and Sciences, Mauritius, new series, 1.

Daruty, C. 1886. Plantes medicinales de l'Île Maurice. Mauritius: General Steam Printing Co.

Dulloo, M. E., I. Thormann, B. Laliberté and Engels J. M. M. 2004. "Genetic Resources Conservation – Experiences from Agricultural Research for Strengthening Collaboration with Botanic Gardens" in E. Robbrecht, A. Bogaerts (eds) *EuroGard III. Papers from the Third European Botanic Gardens Congress and the Second European Botanic Gardens*

Education Congress (BEDUCO II). Pp.83-96. Belgium: National Botanic Garden. Scripta Bot. Belg 29.

Dobie, J. J. 1989. *The Medicinal Plants of Mauritius. Collection of Paintings by Malcy de Chazal (1803-1880)*. Scotland: The Schoolhouse Gallery Publishers.

Guého, J. and Owadally A. W. 1998. Histoire naturelle et sciences connexes a Maurice. Bibliographie couvrant quatre siècles de publication : des hollandais à nos jours (1598-1998). Mauritius: Mauritius Sugar Industry Research Institute.

Gurib-Fakim, A. and Guého, J. 1993. Plantes medicinales de L'île Rodrigues. Editions de l'Ocean Indien and University of Mauritius. Singapore: Chong Moh Offset Printing (Pte) Ltd.

Gurib-Fakim, A. and Gueho, J. 1995-7. Plantes medicinales de Maurice. Vol 1-3. Editions de l'Ocean Indien, University of Mauritius and Mauritius Sugar Industry Research Institute. Singapore: Chong Moh Offset Printing (Pte) Ltd.

Gurib-Fakim, A. 2002. *Mauritius through Its Medicinal Plants*. Mauritius: Editions de l'Ocean Indien.

Laffont, J. P. 2001. Votre pharmacie familiale traditionelle chinoise. Mauritius: Editions de l'Ocean Indien.

Leguat, F. 1708. Voysage et aventure de Francois Leguat et de ses compagnons en deux îles desertes des Indes Orientales. 2 vols. Amsterdam and London: J. L. de Lorme.

McDougall, I., B. G. J. Upton and W. J. Wadsworth. 1965. "A Geological Reconnaissance of Rodrigues Island, Indian Ocean." *Nature*, *206*: pp. 26-27.

Pourchez, L. 2011. Savoirs des femmes: medicine traditionnelle et nature – Maurice, Reunion, Rodrigues. Savoirs locaux et autochtones, 1. Paris: UNESCO.

Procter, J. and Salm, R. 1975. *Conservation in Mauritius 1974*. IUCN: Switzerland.

Rouillard, G. and Guèho, J. 1999. Les plantes et leur histoire à l'île Maurice. Mauritius: MSM Limited.

Rouillard, G. 2010. Histoire du Jardin des Pamplemousses et suggestions pour une visite documentée. Mauritius.

Strahm, W. A. 1993. The Ecology and Conservation of Flora on Mauritius and Rodrigues. Unpublished Ph.D thesis. UK: University of Reading.

Strahm, W. A., 1989. *Plant Red Data Book for Rodrigues*. Germany: Koeltz Scientific Books.

Sussman L. K., 1980. "Herbal Medicine on Mauritius." *Journal of Ethnopharmacology*, 2: pp. 259-278.

Tatayah, R. V. 2005. From Vizagapatnam to Mauritius. Case studies of Telegu Family Settlement. *Journal of Mauritian Studies*. New Series Vol. 2 (2): pp. 66-88.

Tatayah, R. V. 2010. "Biodiversity conservation and Cultural Preservation – Where the Twain Meet." *Journal of Mauritian Studies. 5* (Special Issue): pp. 105-144.

Van Dam P. 1700. *Beschrijvinge van de Oostindische Campagnie*, 2(2): pp. 580-599. (List of medicinal plants).

Vaughan, R. E., and P. O. Wiehe. 1937. "Studies on the Vegetation of Mauritius. A Preliminary Survey of Plant Communities." *Journal of Ecology*, 25: pp. 289-343.

Vinson, L. 1941-2. Quelques plantes medicinales de Mauric. Revue Agricole Île Maurice. 20 : pp. 273-283 ; pp. 329-341 (1941) ; Ibid., 21 : pp. 3-27 (1942).

Wong Ting Fook, W. T. H. 1980. *The Medicinal Plants of Mauritius*. Antenne ENDA. Océan Indien. Doc No. 10.

Appendix 1: Native and Endemic Plants Used in Habitat Restoration on Ile aux Aigrettes

Species	**Status**	**Local name**†	**Natural/ Reintroduced**‡	**Documented local medicinal use***
Abrus precatorius	Native	graine diable	Natural	vs. bronchitis, dysentery, lupus, tuberculosis, gonorrhoea, syphilis, eye infections, ulcers
Aerva congesta	Endemic		Reintroduced	na
Angraecum eburneum	Native		Natural	na
Asparagus umbellulatus	Native	asperge sauvage	Reintroduced	diuretic
Barleria observatrix	Endemic		Reintroduced	na
Boerhavia diffusa	Native	herbe pintade	Natural	na
Caesalpinia bonduc	Native	cadoque	Natural	vs. indigestion, malaria, gonorrhoea, hernia, tooth decay, fish sting, intestinal worms, tambave
Cassytha filiformis	Native	liane sans fin	Natural	vs. skin eruption, dysentery, gonorrhoea, tambave, infestation of the scalp, hair loss
Cassine orientalis	Endemic	bois d'olive	Reintroduced	astringent, vs. dysentery, gonorrhoea, tambave, fish allergy, high blood pressure
Clerodendrum heterophyllum	Endemic	bois cabris	Natural	febrifuge, anti-venereal, vs. dysentery, diarrhoea
Cynanchum staubii	Endemic		Natural	na
Cyperus rotundus	Native	herbe à oignon	Natural	diaphoresis, astringent, diuretic, stomachic, refreshment, vs. fever, indigestion, diarrhoea, dysentery
Cyphostema mappia	Endemic	bois mapou	Reintroduced	vs. poison fish sting, tambave
Dendrolobium umbellatum	Native		Natural	na
Dictyosperma album var. conjugatum	Endemic	palmiste blanc de l'île Ronde	Reintroduced	na
Diospyros egrettarum	Endemic	bois d'ebéne de l'île aux Aigrettes	Natural	na
Diospyros tesselaria	Endemic	bois d'ebéne noir	Reintroduced	na

Appendix 1 continued...

Appendix 1 continued...

Source: Author's compliation.
***Notes*:** † Plants names in italics are those with a strong Afro-Malagasy origin or influence. On the other hand, plant names in normal cases are of European origin or influence.
‡ Natural : still present in 1985 when restoration of the island began, though was in reduced numbers. The species have been propagated for habitat restoration.
Reintroduced : species known to have existed on the island, or strongly suspected to have been originally found there, but were extinct from the island by 1985, and have since been reintroduced.
*From Rouillard and Guého (1999) & Gurib-Fakim and Guého (1995-7)
na : medicinal uses unknown or undocumented.

Appendix 2: Native and Endemic Plants used in Habitat Restoration on Round Island

Species	**Status**	**Local Name†**	**Reintroduced‡**	**Documented local medicinal use***
Aerva congesta	Endemic		Natural	na
Asparagus umbellulatus	Native	asperge sauvage	Natural	diuretic
Badula crassa	Endemic		To be reintroduced	na
Barleria observatrix	Endemic		Reintroduced	na
Carissa spinarum	Endemic (Mascarenes)	bois amer	To be reintroduced	tonic, diuretic, vermifuge, febrifuge, vs dermatosis, gonorrhoea, nephritis
Cassine orientalis	Endemic (Mascarenes)	bois d'olive	Reintroduced	astringent, vs. dysentery, gonorrhoea, tambave, fish allergy, high blood pressure
Clerodendrum heterophyllum	Endemic	bois cabris	Reintroduced	febrifuge, anti-venereal, vs. dysentery, diarrhoea
Coffea myrtifolia	Endemic	cafè indigène	To be reintroduced	na
Cymbopogon excavatus	Native	citronelle indigène	Natural	na
Dictyosperma album var. *conjugatum*	Endemic	palmiste blanc de l'île Ronde	To be reinforced	na
Diospyros egrettarum	Endemic	bois d'ébène de l'île aux Aigrettes	Reintroduced	na
Diospyros melanida	Endemic	bois d'ébène marbré	Reintroduced	na
Diospyros tesselaria	Endemic	bois d'ébène noir	Reintroduced	na
Distephanus populifolius	Endemic		Reintroduced	na

Appendix 2 continued...

Appendix 2 continued...

Dodonaea viscosa	Native	bois de reinette	Reintroduced	purgative, wound healer, vs. distended breast, rheumatism, gout, rheumatism, contusion, ulcer, syphilis, angina, fish poisoning, abcess
Dombeya mauritiana	Endemic		Reintroduced	na
Dracaena concinna	Endemic	bois de chandelle	Natural	na
Erythroxylum hypericifolium	Endemic	bois à balais	Reintroduced	vs. gall stones, fever, colic (similar to *E. laurifolium*)?
Eugenia lucida	Endemic		Reintroduced	na
Erythroxylum hypericifolium	Endemic	bois à balais	Introduced	vs. gall stones, fever, colic (similar to *E. laurifolium*)?
Fernelia buxifolia	Endemic (Mascarenes)	bois de buis	Reinforced	na
Ficus reflexa	Native	affouche à petites feuilles	Reintroduced	astringent, vs. tambave
Ficus rubra	Native	affouche à grandes feuilles	Reintroduced	vs. tambave
Species	**Status**	**Local Name**	**Reintroduced**	**Documented local medicinal use***
Foetidia mauritiana	Endemic (Mau., Reu.)	bois puant	Reintroduced	purgative, diuretic
Gaertnera truncata	Endemic	bois banane	To be reintroduced	na
Gagnebina pterocarpa	Native	acacia indigène	Reinforced	na
Gastonia mauritiana	Endemic	bois de boeuf / bois d'éponge	Reintroduced	na
Helichrysum caespitosum	Endemic	immortelle	To be reintroduced	expectorant, demulcent, vs. inflammation of the mucus, chest infections
Hibiscus fragilis	Endemic	mandrinette	Reintroduced	na
Hilsenbergia petiolaris	Native	bois de pipe	Reintroduced	depurative, vs. tambave, migraine
Homalium integrifolium	Endemic	bois de rivière/ bois cyclone	To be reintroduced	na
Hornea mauritiana	Endemic	arbre à huile	Reintroduced	na
Hyophorbe lagenicaulis	Endemic	palmiste bouteille	Natural	na
Latania loddigesii	Endemic	latanier bleu	Natural	na
Lomatophyllum tormentorii	Endemic	*mazambron*	Natural	purgative, vs. arthritis
Margaritaria anomala	Endemic	bois chenille	Reintroduced	na

Appendix 2 continued...

Appendix 2 continued...

Maytenus pyria	Endemic	bois à poudre	Reintroduced	vs. dysentery, phthisis
Myonima nitens	Endemic	bois pintade	Reintroduced	na
Myoporum mauritianum	Endemic (Mascarenes)		Reintroduced	na
Pandanus vandermeeschii	Endemic	*vacoas*	Natural	na
Premna serratifolia	Native	bois sureau	Reintroduced	depurative, stomachic, pectoral, vs. tambave, fever, eczema, psoriasis
Protium obtusifolium	Endemic	*colophane bâtard*	Reintroduced	diuretic, vs urinary infections
Psiadia arguta	Endemic	baume de l'île Plate	Reintroduced	pectoral, vs. wounds, ulcers, anthrax, bronchitis, asthma
Phyllanthus mauritianus	Endemic		Natural	na
Phyllanthus revaughnii	Endemic		Natural	na
Pyrostria cordifolia	Endemic		Reintroduced	na
Scaevola taccada	Native	veloutier vert	Reintroduced	vs. lionfish stings
Scolopia heterophylla	Endemic (Mascarenes)	bois de bouchon	To be reintroduced	na
Stadmania oppositifolia	Native	bois de fer	To be reintroduced	depurative, astringent, febrifuge, vs syphilis, tambave, intestinal worms
Stillingia lineata ssp. *lineata*	Endemic subspecies (Maur., Reu.)	*fangame*	Reintroduced	na
Tarenna borbonica	Endemic (Maur., Reu.)	bois de rat	Reintroduced	astringent, febrifuge, vs. typhoid
Terminalia bentzoë ssp. *bentzoë*	Endemic	bois benjoin	Reintroduced	astringent, depurative, sudorific, vulnerary, vs. dysentery, gonorrhoea
Tournefortia argentea	Native	veloutier argenté	Reintroduced	vs. lionfish stings
Turraea casimiriana	Endemic	*bois quivi*	Reintroduced	depurative, antipsoric, vs. gonorrhea
Vetiveria arguta	Endemic (Mauritius, Rodrigues)	vètiver	Natural	na
Zanthoxylum heterophyllum	Endemic	*bois catafaille noir*	To be reintroduced	stomachic, tonic, improving mother's milk, vs. tambave, rheumatism, skin irritations

Appendix 2 continued...

Appendix 2 continued...

Source: Author's compliation.
Notes: † Plants names in italics are those with a strong Afro-Malagasy origin or influence. On the other hand, plant names in normal cases are of European origin or influence.
‡ Natural : still present in 1985 when restoration of the island began, though was in reduced numbers. The species have been propagated for habitat restoration.
Reintroduced : species known to have existed on the island, or strongly suspected to have been originally found there, but were extinct from the island by 1985, and have since been reintroduced.
Reinforced : Populations on the island were severely reduced (for example, one individual, or one clump) and were on the verge of extinction on the island by 1985. These species have since been restored through reintroduction or propagation on a large scale.
*From Rouillard and Guého (1999) & Gurib-Fakim and Guého (1995-7)
na : medicinal uses unknown or undocumented.

Appendix 3: Critically Endangered Endemic Plants Grown at Pigeon Wood (Upland Mauritius, Black River Gorges National Park) for the Rare Plant Nursery and Field Gene Bank

Species	Local name†	Recorded no. of plants or clumps in the wild	Documented local medicinal use*
Acanthophoenix cf. rubra	palmiste piquant	10	na
Carissa spinarum	bois amer	5	astringent, vs. dysentery, gonorrhoea, tambave, fish allergy, high blood pressure
Chassalia boryana	bois corail	18	na
Chionanthus boutonii	bois sandal	1	na
Croton vaughanii		1	na
Dictyosperma album var. *album*	palmiste blanc	5	na
Dombeya mauritiana		1	na
Dombeya sevathianii		5	na
Elaeocarpus bojeri	bois dentelle	3	na
Eugenia bojeri	bois clou	4	na
Ficus densifolia	affouche	3	na
Hubertia ambavilla var. *ambavilla*	ambaville	4	na for Mauritius. From Reunion – syphilis, tambave, intestinal worms, rheumatism, gout, diuretic
Pandanus carmichaelii	*vacoas*	1 clump	na
Pandanus pyramidalis	*vacoas*	10	na
Pîlea umbellata		5 clumps	na
Sideroxylon majus	bois de fer bâtard	1	na
Zanthoxylum heterophyllum	*catafaille noir*	4	stomachic, tonic, improving mother's milk, vs. tambave, rheumatism, skin irritations

Source: Author's compliation.
Notes: † Plants names in italics are those with a strong Afro-Malagasy origin or influence. On the other hand, plant names in normal cases are of French origin or influence. *From Rouillard and Guého (1999) & Gurib-Fakim and Guého (1995-7). na : medicinal uses unknown or undocumented.

Appendix 4: Critically Endangered Endemic Plants Grown on Ile aux Aigrettes for the Rare Plant Nursery and Field Gene Bank

Species	Local name	Recorded number of plants or clumps	Documented local medicinal use*
Aerva congesta		1 patch	na
Angraecum eberneum		<20	na
Badula crassa		2	na
Barleria observatrix		57	na
Carissa spinarum	bois amer	1	stomachic, tonic, improving mother's milk, vs. tambave, rheumatism, skin irritations
Chionanthus ayresii	bois de santal	<50	na
Dichondra repens		1 population	na
Dictyosperma album var. *conjugatum*	palmiste blanc de l'île Ronde	1	na
Euphorbia viridula		1 clump	na
Lomatophyllum tormentorii	*mazambron*	Approx. 300	purgative, vs. arthritis
Lycium mascarenense		<50	na
Ochrosia borbonica	bois jaune	1	depurative, febrifuge, tonic, vs. dysentery, tambave
Olax psittacorum	bois perroquet	1	na
Oldenlandia sieberi var. *sieberi*		3 clumps	na
Olea europa var. *africana*	olivier	<50	na
Phyllanthus revaughnii		1 clump	na
Psiadia arguta	baume de l'île Plate	1 population	pectoral, vs. wounds, ulcers, anthrax, bronchitis, asthma
Senecio lamarkianus	bois chèvre	6	depurative, refreshment, pectoral, vs. skin rashes, dysentery, colic
Tambourissa quadrifida	bois tambour	<50	emmnagogic, vs. skin infection, tambave
Trochetia boutoniana	boucle d'oreille	<20	na
Urena lobata var. *Sinuata*	guimauve indigéne, herbe à panier	1	emmolient, vs. gut inflammation, bladder diorders
Zanthoxylum heterophyllum	*catafaille noir*	34	stomachic, tonic, improving mother's milk, vs. tambave, rheumatism, skin irritations
Zornia revaughnii		1 population	na

Source: Author's compliation.
Notes: *From Rouillard and Guého (1999) and Gurib-Fakim and Guého (1995-7)
na : medicinal uses unknown or undocumented.

Appendix 5: Native and Endemic Plants Used in Habitat Restoration on Grande Montagne (Rodrigues)

Species	Local name	Documented local medicinal use**
Antirhea bifurcata	bois goudron (endemic to Mauritius and Rodrigues)	tonic, astringent, vs. haemorrhage, chronic diarrhoea, haemorrhage
Carissa spinarum	bois de ronde	vs. kidney stones, urinary problems, gonorrhoea, intestinal, worms, fever, bronchitis, lung infections, gout
Cassine orientalis	bois d'olive	astringent, emetic, vs. gonorrhoea, urinary infections, allergies
Clerodendrum laciniatum	bois cabris	vs. skin infections, venereal diseases, fever
Dictyosperma album var. *aureum*	palmiste bon	na
Diospyros diversifolia	bois d'ébène	na
Dodonaea angustifolia	bois gournable	diuretic, vs. angina, rheumatism, contusions, ulcers, gall stones
Doricera trilocularis	bois chauve-souris	na
Dracaena reflexa var. *angustifolia*	bois de chandelle	vs. sore throat, dysentery, diarrhoea,
Eugenia rodriguesensis	bois de fer	vs. colics, indigestion, bladder inflammations
Fernelia buxifolia	bois bouteille	na
Ficus rubra	affouche à grandes feuilles	astringent, vs. wart, convulsions in infants
Foetidia rodriguesiana	bois puant	vs. gonorrhoea, dysentery
Gastonia rodriguesiana	bois blanc	na
Hibiscus liliiflorus	mandrinette	vs. coughs
Hyophorbe verschaffeltii	palmiste marron	na
Latania verschaffeltii	latanier jaune	vs. gonorrhea
Lomatophyllum lomatophylloides	*mazambron*	vs. muscular pains, low menstrual discharge
Mathurina penduliflora	bois gandine	vs. insomnia, eczema
Obetia ficifolia	figue marron	na
Olea lancea	bois cerf	na
Pandanus heterocarpus	*vacoas*	aphrodisiac
Pittosporum balfourii	bois carotte	vs. heavy menstrual discharge
Pleurostylia putamen	bois d' olive à petites feuilles	na
Poupartia castanea	bois lubine	na
Premna serratifolia	bois de sureau	vs itchiness and eczema
Psiadia rodriguesiana	bois de ronde	na
Scyphochlamys revoluta	bois mangue	vs. colic, stomach pains, bleeding gums
Senecio boutounii		na
Sideroxylum galeatum	bois de fer	na
Terminalia bentzoe ssp. *rodriguensis*	bois benjoin	vs. colds, cough, bronchitis, dysentery
Turraea laciniata	bois à balais	vs. migraine, head-ache
Vepris lanceolata	patte de poule	vs. lung infections, rheumatism, wounds

Source: Author's compliation.
Notes: ** From Gurib-Fakim and Guého 1994; Strahm 1989.
na : medicinal uses unknown or undocumented.

Appendix 6: Native and Endemic Plants Used in Habitat Restoration at Anse Quitor (Rodrigues)

Species name	**Local name**	**Documented local medicinal use****
Antirhea bifurcata	bois goudron	tonic, astringent, vs. haemorrhage, chronic diarrhoea, haemorrhage
Asparagus umbellulatus	asperge sauvage	na
Canavalia rosea	liane cocorico	na
Carissa spinarum	bois de ronde	vs. kidney stones, urinary problems, gonorrhoea, intestinal worms, fever, bronchitis, lung infections, gout
Cassine orientalis	bois d'olive	Astringent, emetic, vs. gonorrhoea, urinary infections, allergies
Clerodendron laciniatum	bois cabris	vs. skin infections, venereal diseases, fever
Dictyosperma album var. *aureum*	palmiste bon	na
Diospyros diversifolia	bois d'ébène	na
Dodonaea viscosa	bois gournable	diuretic, vs. angina, rheumatism, contusions, ulcers, gall stones
Doricera trilocularis	bois chauve-souris	na
Eugenia rodriguesensis	bois de fer	vs. colics, indigestion, bladder inflammations
Fernelia buxifolia	bois bouteille	na
Ficus rubra	affouche à grandes feuilles	astringent, vs. wart, convulsions in infants
Foetidia rodriguesiana	bois puant	vs. gonorrhoea, dysentery
Gastonia rodriguesiana	bois blanc	na
Hyophorbe verschaffeltii	palmiste marron	na
Latania verschaffeltii	latanier jaune	vs. gonorrhea
Mathurina penduliflora	bois gandine	vs. insomnia, eczema
Myoporum mauritianum		na
Pandanus heterocarpus	*vacoas*	aphrodisiac
Pleurostylia putamen	bois d'olive à petites feuilles	na
Premna serratifolia	bois sureau	na
Sarcanthemum coronopus		na
Scolopia heterophylla	goyave marron	na
Terminalia bentzoe ssp. *rodriguesensis*	bois benjoin	vs. colds, cough, bronchitis, dysentery
Thespesia populnea	*mahoe*, Sainte Marie	na
Tournefortia argentea	veloutier blanc	na
Turraea laciniata	bois balais	vs. migraine, head-ache

Source: Author's compliation.
Notes: ** From Gurib-Fakim and Guého 1994; Strahm 1989.
na : medicinal uses unknown or undocumented.

Appendix 7: Native and Endemic Plants Used in Habitat Restoration on Île Cocos and Île aux Sables (Rodrigues)

Species	**Local name**	**Documented local medicinal use****
Asparagus umbellulatus	asperge sauvage	na
Canavalia rosea	liane cocorico	na
Cassine orientalis	bois d'olive	astringent, emetic, vs. gonorrhoea, urinary infections, allergies
Clerodendrum laciniatum	bois cabris	vs. skin infections, venereal diseases, fever
Dictyosperma album var. *aureum*	palmiste bon	na
Dodonaea viscosa	bois gournable	diuretic, vs. angina, rheumatism, contusions, ulcers, gall stones
Fernelia buxifolia	bois buis	na
Ficus rubra	affouche à grandes feuilles	astringent, vs. wart, convulsions in infants
Gastonia rodriguesiana	bois blanc	na
Hyophorbe verschaffeltii	palmiste marron	na
Latania verschaffeltii	latanier jaune	vs. gonorrhoea
Lycium tenue		na
Mathurina penduliflora	bois gandine	vs. insomnia, eczema
Myoporum mauritianum		na
Pandanus heterocarpus	*vacoas*	aphrodisiac
Pisonia grandis	*bois mapou*	na
Premna serratifolia	bois de sureau	na
Sarcanthemum coronopus		na
Terminalia bentzoe ssp. *rodriguesensis*	bois benjoin	vs. colds, cough, bronchitis, dysentery
Thespesia populnea	*mahoe*, Sainte Marie	na
Tournefortia argentea	veloutier blanc	na

Source: Author's compliation.
Notes: ** From Gurib-Fakim and Guého 1994; Strahm 1989; na : medicinal uses unknown or undocumented.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 109-118

Medicinal Plants from Reunion Island

Emmanuelle Girard-Valenciennes*, Isabelle Grondin*,
and Jacqueline Smadja*

Abstract: The strategy of the Chemistry Laboratory of Natural Substances and Food Sciences, (LCSNSA) has always been to explore the potential of natural products from Reunion Island and the Indian Ocean area. For many years, the separation, purification, structure elucidation and biological evaluation of new molecules extracted from plants have been the favourite target of the laboratory because of their pharmaceutical, nutritional and cosmetic uses. In a context where medicinal plants are still widely used, especially in the French overseas territories, with a cultural, geographical and economical environment rapidly changing, a trans-disciplinary study of this particular biodiversity is fully relevant. In Reunion Island, contrary to many tropical countries, there is a real choice between modern and traditional medicine. More than a medical treatment, traditional medicine is a form of aid and an indispensable complement to western medicine. Many tea-herbalists sell various medicinal plants on the market places and propose several preparations such as decoctions, infusions, etc. Moreover, Reunion Island is one of the biodiversity hotspots of the world and offers a reservoir for the identification of new molecules for a multitude of applications. So, in the field of medicinal plants, the main objective of our lab's work is to discover, characterise and eventually design selective bioactive compounds from Reunion plant species for the evaluation of the potentialities in species with highest value.

Keywords: Medicinal plants, bioactive compounds, traditional pharmapoeia, phytochemical screening, alkaloids, cytotoxicity, Reunion Island.

Introduction

The strategy at the Chemistry Laboratory of Natural Substances and Food Sciences (LCSNSA) has always been to explore the potentialities of natural products from Reunion Island and the Indian Ocean area. Three major classes of bioactive molecules for many years have been the favourite target

* Authors are affiliated to Laboratoire de Chimie des Substances Naturelles et des Sciences des Aliments (LCSNSA) - Faculté des Sciences et Technologies Université de La Réunion – France. Email: smadja@univ-reunion.fr (Corresponding Author).

The LCSNSA is grateful to Le Conseil Régional de La Réunion, Centre de Recherche et de Veille sur les maladies emergentes dans l'Océan Indien (CRVOI), La Fédération Environnement-Biodiversité-Santé de l'Université de La Réunion (FBS-UR), Le Secrétariat d'Etat à l'Outre-Mer (SEOM) for financial support and to Les Amis des plantes et de la Nature (APN), L'Office National des forêts (ONF), Le Parc National de La Réunion (PNR), L'UMR C_53 Peuplements Végétaux et Bioagresseurs en Milieu Tropical de l'Université de la Réunion (UMR PVBMT) for collection collaboration.

of the LCSNSA. The first class, for pharmaceutical uses, includes bioactive molecules extracted from plant, marine organisms or microorganisms. The second class, for dietetical and nutritional uses, concerns vegetal oils, fresh fruits and vegetables, co-products of the sugar cane (molasses) and microorganisms. The third class, for cosmetic uses, is related to essential oils, aromatic extracts and vegetal oils.

The two main steps of our work are extraction, where the aim of this step is to develop economical, green (without solvent) and ecological (less energy consumption) techniques of extraction. The second step involves separation, purification and identification of bioactive compounds. The aim of this step is the research of bioactive molecules in the fields of food, therapeutics and cosmetics. The methodology involves extraction, isolation, structure elucidation and biological evaluation of new molecules.

Work Focus

In a context where medicinal plants are still widely used, especially in the French overseas territories, with a cultural, geographical and economical environment rapidly changing, a trans-disciplinary study of this particular biodiversity is fully relevant. In Reunion Island, contrary to many tropical countries, there is a real choice between modern and traditional medicine. More than a medical treatment, traditional medicine is a form of aid and an indispensable complement to western medicine. Many tea-herbalists sell various medicinal plants on the market places and propose several preparations such as decoctions, infusions, etc. Moreover, Reunion Island is one of the biodiversity hotspots of the world and offers a reservoir for the identification of new molecules for a multitude of applications.

In the field of medicinal plants, the main objective of our lab's work is to discover, characterise and eventually design selective bioactive compounds from Reunion plant species for the evaluation of the potentialities in species with highest value.

The LCSNSA work on medicinal plants started in 1987 with the setting up of phytochemical tests in support of R. Lavergne's Ph.D. botanical thesis. Indeed, this botanical study was completed by a chemical screening on approximately 300 plant species of Reunion Island. This screening, made up of classical qualitative tests, has enabled to detect, with the help of general reagents, various categories of compounds most likely to be contained in medicinal plants. Thus, the study made a list of 86 plants with alkaloids, 32 plants with sterols and triterpenes, 123 plants with saponins, three with cyanogenic glycosides and 243 plants with phenolic compounds, and among them, 66 plants with phenols (general search of phenols), six with coumarins, 20 with f avonoids (strictly speaking), 26 with f avans, one with anthocyans, 23 with proanthocyanidols, 99 with tannins and three with anthraquinones and/or anthraquinonic heterosides.[1] Those preliminary results are the starting point of the entire lab's works on medicinal plants.

Thus, a number of academic works began on medicinal plants which have been a few or not studied and which present positive results to the qualitative tests for the detection of alkaloids have been selected. The first list of plants was formed by thirty-six species, but finally, only twenty-four of them were adopted. They were chosen at first for the easiness of their harvesting and for their availability, considering the requested quantities. The results provided Ph.D. thesis, scientific papers, communications and posters.[2]

Subsequently, the evaluation of biological activities (anti-viral, anti-oxidant, anti-fungal, anti-bacterial, anti-malarial, anti-inf ammatory) of plants from Reunion Island was undertaken and continues still today. Since then, the works did not stop increasing as evidenced by the publications produced.[3]

Presentation of an Ongoing Work: The Phytochik Project (2009-2011)

This project focusses on biodiversity and emerging viruses in the Indian Ocean: selection of natural drug candidates to fight the Chikungunya virus (Acronym: Phytochik).

Recently, the emergence of Chikungunya virus (CHIKV) infections in the Indian Ocean Islands has created a serious public health issue in the region because of the lack of selective antiviral drugs for the treatment or prevention of infection with this highly pathogenic virus. An international scientific consortium (PHYTOCHIK project supported financially by CRVOI)[4] has been set up to discover, characterise and eventually design selective antiviral agents against emerging viruses, in particular the CHIKV, associating teams in the Indian Ocean (La Reunion, Mauritius, Madagascar), France (ICSN-CNRS and AFMB), and Belgium (LVC-RIMR). Crude and processed material prepared and characterised in this programme may also be made available for subsequent studies dedicated to other pathogens of interest that need similar attention as the CHIKV virus does (for example, Dengue viruses, Rift Valley Fever virus, etc.).

Reunion Lab Work in Phytochik Project[4]

In April 2009, Reunion lab work has begun firstly by the collection of plants through a cooperative network of botanist collaborators. The harvests have been made with proper care to the biological patrimony presented by the exceptional biodiversity of the island. The plant species have been selected partly for their known ethnopharmacological properties (against Chikungunya and other antiviral diseases).

Taxonomically authenticated and classified in a photographic library, 180 species have been collected in one year as well on highlands as on seaside of the island at different sites such as Colorado, Plaine des Palmistes, Forêt de Bébour, Forêt de Bélouve, les Avirons, Forêt de Mare Longue, Langevin, Saint-Philippe, Grand-Etang. The selected plant parts (leaves and trunk bark) have been oven dried and ground following a standard process. The 180 species belonging to 57 families representing 117 genera and corresponding to four batches have been stored in 320 powder f asks in air-conditioned rooms. Among the families, some of them included several species such as the Rubiaceae family with 16 species, the Euphorbiaceae family with 15 species or also the Myrtaceae one with 13 species evaluated.

All plant parts have been extracted with ethyl acetate solvent given 320 AcOEt extracts. For that, extractions using ASE 300 System (Accelerated Solvent Extraction) have been performed. Compared to techniques such as Soxhlet and sonication, ASE generates results in a fraction of time. In addition to speed, ASE offers a lower cost per sample than any other techniques by reducing solvent consumption by up to 90 per cent. The Accelerated Solvent Extractor ASE 300 makes automated extractions in minutes in sample cell sizes up to 100 ml and in a collection of bottle 250 ml under an operating pressure 1500 PSI (100 Bar).

After the extraction stage, the crude extracts have been submitted to a small cartridge polyamide filtration to remove tannins then weighed and stored in appropriate vials. Finally, the samples have been sent to specific partners in Europe for the evaluation of cytotoxicity and selective antiviral activity.

Evaluation of Cytotoxicity

The screening for cytotoxicity has been made at the Institut de Chimie des Substances Naturelles in Gif-sur-Yvette and at the Laboratory for Virology and Chemotherapy, Rega Institute for Medical Research, Katholieke Universiteit Leuven in Belgium on the filtered extracts distributed into 96-well mother plates.

Cytotoxicity has been evaluated on different cancer cell lines: MRC-5 cells (Human Fetal Lung Fibroblast Cells) and KB Cells (Human carcinoma of the nasopharynx) using the MTT assay, which is a well characterised, cheap, and widely used assay that measures cell proliferation. The principle of the MTT assay is that the living proliferating cells can reduce the MTT (thiazoyl blue tetrazolium bromide) to the purple crystal formaza and deposit it in cytoplasm, allowing the use of a colorimetric method to detect cell proliferation.

Alternatively, MTS can be used, which is based on the same principle: metabolically active cells produce reducing power (NADH and NADPH) which allows intracellular reduction of yellow, soluble MTS (3-(4,5-dimethylthiazol-2-yl)-5-(3-carboxymethoxyfenyl)-2-(4sulfofenyl)-2H-tetrazolium) into a brown, soluble formazan derivative. The MTT assay and the MTS assay are colorimetric assays for measuring the activity of enzymes that reduce MTT to formazan dyes.

Sixteen positive cytotoxic plant extracts belonging to ten families have been detected in batches two and three. Ten families (Apocynaceae, Araliaceae, Asteraceae, Celastraceae, Clusiaceae, Euphorbiaceae, Loganiaceae, Lauraceae, Myrsinaceae, and Rubiaceae) gave the best response including 16 species[5] (8 leaves extracts and 8 bark extracts).

Evaluation of Antiviral Activity

The evaluation of antiviral activity has been realised at the Laboratory for Virology and Chemotherapy, Rega Institute for Medical Research, Katholieke Universiteit Leuven in Belgium which has a long-standing experience in the identification of compounds with selective antiviral properties in virus-cell based assays.

Medium- to high-throughput screening for the identification of hits was performed in 96-well microtiter plates. Following addition of the potential antiviral compounds to virus-infected cells, microtiter plates were incubated for seven days, a time at which 100 per cent of virus-induced cytopathic effect could be observed in untreated, infected cell cultures. Virus-containing supernatant was removed and replaced which 75µL of a 5 per cent MTS solution. Plates were incubated for 1.5 to 2 hours after which the color change from yellow to brown, caused only by metabolically active cells (cells that have not been destroyed by the virus due to inhibition by the added compound), was quantified at a wavelength of 498 nm. Whenever possible, a CC_{50} (concentration in µg/ml at which

50 per cent inhibition of cell metabolism in uninfected, treated cell is obtained), EC_{50} and EC_{90} (concentration in µg/ml at which respectively 50 per cent and 90 per cent inhibition of virus-induced cytopathic effect in infected, treated cells was obtained) were calculated. To exclude false positives, microtiter plates containing potentially active compounds, are checked microscopically for abnormalities.

Nine families (Flacourtiaceae, Euphorbiaceae, Fabaceae, Euphorbiaceae, Myrtaceae, Celastraceae, Ericaceae, Sapindaceae, and Malvaceae) gave the best response including 13 species (eight leaves extracts and five bark extracts).

In a second time, the extracts possessing selective antiviral activity have been fractionated employing a standardised protocol using automated chromatographic methods to generate nine fractions which have again been distributed into 96-well mother plates at the Institut de Chimie des Substances Naturelles in Gif-sur-Yvette.

After this fractionation stage, the nine fractions obtained per positive extract have been submitted for evaluation of antiviral screening (inhibition of the replication of CHIKV) at the Laboratory for Virology and Chemotherapy, Rega Institute for Medical Research, Katholieke Universiteit Leuven in Belgium.

At present, eight extracts[6] were confirmed positives. However, further ascertainments are still necessary to detect the natural drug candidates to fight the Chikungunya virus before concluding. So, the work is still in progress.

Some Other Ongoing Works

Various pluridisciplinary works are often conducted in parallel by differents and complementary teams. For example, a study about Plant Registration to french Pharmacopoeia, financially supported by SEOM (Secrétariat d'Etat à l'Outre-Mer) in collaboration with APLAMEDOM (Association pour les PLantes Aromatiques et MEdicinales de La Réunion) since 2005 for fiveteen medicinal plants including: - *Hubertia ambavilla* var. *ambavilla* (L.) – Asteraceae - *Jumellea fragrans* (Thou) Schltr. – Orchidaceae - *Terminalia bentzoe* (L.) – Combretaceae - *Ayapana triplinervis* (Vahl.) – Asteraceae.

Another work in progress is the ATEM project (2010-2011) about the validation of medicinal extract effects from plants used in traditional pharmacopoeia to cure diabetes, supported financially by SEOM (Secrétariat d'Etat à l'Outre-Mer) which gathers together APLAMEDOM (Association pour les PLantes Aromatiques et MEdicinales de La Réunion), CYROI (Plateforme technique du CYROI), GEICO (Groupe d'Etudes sur l'Inf ammation Chronique et l'Obésité de l'Université de la Réunion), UMR PVBMT (UMR C_53 Peuplements Végétaux et Bioagresseurs en Milieu Tropical de l'Université de la Réunion).

Another one is the contribution to the realisation of a book about Poisonous plants from Reunion Island written by Marc Riviere, retired Pharmacist, member of APN (Les Amis des Plantes et de la Nature).

The main guideline of the works, that are carried out by these various actors, follows a common concern: preservation and valorisation of the island outstanding biodiversity. Collaborations with organisations like Reunion National Parc, Mascarin National Botanical Conservatory or National Board of Forestry, are essential to start the works for some actors, particularly those undertaken by the universitary teams. These organisations issue collection authorisations or, simply provide rare and protected plants.

Conclusion and Perspectives

The results obtained on several medicinal species about their biological activities (antibacterial, antifungal, antioxidant, antimalarial, antiviral, and anticancer) encourage us to carry on and deepen our work on Reunion plant species. Our main objective is to discover new drug candidates, new compounds having preventive characteristics on certain diseases, new food supplements on nutritional and physiological prevention and new active compounds in cosmetology.

Currently, the LCSNSA carries on some studies with researchers from Mauritius, Madagascar and Comoros in aromatic and medicinal plant field. However, these works need to be extended to all the Indian Ocean countries through strong collaborations for a better knowledge of plant species from this area. These common works would allow to highligt the biological activities of the outstanding species growing in this area, to compare the properties of same species and to constitute a database to gather together information about plants, active extracts and compounds originating from all sites.

Endnotes

[1] Lavergne *et al.* (1989), Smadja *et al.* (1989), Vera *et al.* (1990), Smadja *et al.* (1992), Smadja *et al.* (1993).

[2] Bourrel (1995), Valenciennes *et al.* (1997), Valenciennes *et al.* (1999a), Valenciennes *et al.* (1999b), Smadja *et al.* (2000) ; Valenciennes, Emmanuelle (a) Etude D'Hétérocycles Azotés - Contribution à l'étude de la réaction d'imino-Diels-Alder asymétrique - Synthèse de décahydroquinoléïn-4-ones - Etude de plantes médicinales endémiques et indigènes de l'Ile de La Réunion-Recherche d'alcaloïdes.

[3] Poullain (2003), Poullain *et al.* (2004), Poullain *et al.* (2004a), Poullain *et al.* (2005), Valenciennes (2006a), Valenciennes *et al.* (2006b), Valenciennes *et al.* (2006c), Poullain (2007), Valenciennes *et al.* (2007), Techer *et al.* (2011), Smadja *et al.* (2011) ; Poullain, Cyril (b) Contribution à l'étude des plantes endémiques et indigènes de La Réunion – Recherche d'activités biologiques et de principes actifs dans 75 plantes.

[4] Valenciennes (2010), Smadja *et al.* (2010), Leyssen *et al.* (2011).

[5] As Phytochik is a confidential project, the species name cannot be revealed.

[6] As Phytochik is a confidential project, the species name cannot be revealed.

References

Bourrel,C., E.Valenciennes and J.Y. Conan. 1995. "Analyse chimique et recherche des alcaloïdes de *Euodia borbonica* var. *borbonica*". *The Journal of Nature*, *7* (1) ; 25-30.

Lavergne, R.1989. Tisaneurs et plantes médicinales indigènes de La Réunion

Leyssen, P., M. Litaudon, J.-C. Guillemot, P. Rasoanaivo, J. Smadja, A. Gurib-Fakim, B. Canard, F. Gueritte 2011. "Phytochik. Biodiversity as Source of Selective Inhibitors of Chikv replication". 24th International Conference on Antiviral Research (ICAR), Kempinski Hotel Zografski Sofia, Bulgarie - (http://isar.phrm.cf.ac.uk/node/78), Antiviral Research, *90*, 2, A36-A37.

Poullain, C., E. Girard- Valenciennes and J. Smadja. 2003. "Medicinal Plants Endemic and Indigenous to Reunion Island II. Evaluation of Their Biological Activities". International Symposium of Ethnobotany, Medicinal Plants, Folk Traditions (History, Pharmacology, Ethnomedicine); La Paz, Bolivie, 16-18 September.

Poullain, C., E. Girard-Valenciennes and J. Smadja. 2004. "Plants from Reunion Island: Evaluation of Their Radical Scavenging and Antioxidants Activities". *Journal of Ethnopharmacology*, *95* ; 19-26.

Poullain, C., E. Girard-Valenciennes and J. Smadja. 2004a. "Contribution à l'étude des plantes endémiques et indigènes de La Réunion". 3ème Colloque International sur les Plantes Aromatiques et Médicinales des Régions d'Outre-mer, Cayenne, Guyane, France, 21-23 September

Poullain, C., E. Girard-Valenciennes & J. Smadja. 2005. "Medicinal plants endemic and indigenous to Reunion Island III. Pharmacological potential of two endemic medicinal plants: Hypericum lanceolatum subsp. angustifolium and Croton mauritianus". IVth International Symposio Ethnobotany Disciplines with emphasis on Ethnomedicine ; Palenque, Mexique.

Poullain, C., E. Girard-Valenciennes, K. Ndjoko, K. Hostettemann and J. Smadja. 2007. "Plants from Reunion Island, II: Evaluation of Their Antifungal activities". *The Journal of Nature, 19*: 27-36.

Smadja, J. 2010. "Medicinal plant potentialities from Reunion Island. 2èmes rencontres de la Recherche Hospitalo Universitaire à La Réunion". *Journées scientifiques du Cyroi,* Saint-Denis.

Smadja, J. 2011. "Les plantes aromatiques et médicinales à La Réunion. aux XXXèmes Journées des huiles essentielles de Digne les Bains, Congrès International PAM 2011". *Actes de colloque Association pour la promotion des Plantes à Parfums,* Aromatiques et Médicinales.

Smadja, J. and R. Vera 1992. "Essais préliminaires sur quelques plantes de La Réunion". *Plantes Médicinales et Phytothérapie, 4* : 212-242.

Smadja, J., and E. Girard-Valenciennes. 2000. "Activités biologiques de quelques plantes médicinales de La Réunion". *Premières Rencontres Internationales Plantes Médicinales – Région Outre-Mer de Saint-Denis de La Réunion,* 1-5 Octobre, France,

Smadja, J., R. Vera, A. Balayer, and J.Y. Conan 1993. "Essais préliminaires sur quelques plantes médicinales de l'île de La Réunion." *5th Napreca Symposium on Natural Products,* Madagascar.

Smadja, J., R. Vera, and J.Y. Conan.1989. "Essais préliminaires sur quelques plantes à flavonoïdes de La Réunion". *Plantes médicinales et Phytothérapie, 4* : 251-257.

Techer, Sophie., C. Robert-Da Silva, E. Girard-Valenciennes, E. Bourdon, P. Clerc, J. Smadja and I. Grondin. 2011. "Activité cytotoxique et pouvoir antioxydant de dix-sept plantes endémiques ou indigènes de l'île de la Réunion". *aux XXXèmes Journées des huiles essentielles de Digne les Bains, Congrès International PAM 2011*, Actes de colloque Association pour la promotion des Plantes à Parfums, Aromatiques et Médicinales.

Valenciennes Girard, E., J. Smadja and J.Y. Conan. 1999a. "Plantes à propriétés fonctionnelles de l'Ile de La Réunion". *XVIIIèmes Journées Internationales de Digne les Bains*, France.

Valenciennes, E., J. Smadja and J.Y. Conan. 1999b. "Screening for Biological Activity and Chemical Composition of *Euodia borbonica* var. *borbonica* (Rutaceae), a Medicinal Plant in Reunion Island". *Journal of Ethnopharmacology, 64* (3) : 283-288.

Valenciennes, Girard, E.,and J. Smadja. 1999c. "Medicinal Plants, Endemic and Indigenous to Reunion Island: Study of Plants with Alkaloids". International Symposium Ethnobotanics, Medicinal Plants, Folks, Traditions, History and Pharmacology, Costa Rica.

Valenciennes, E., J. Smadja and J.Y. Conan. 1997. Coumarines des feuilles de *Euodia Borbonica var. borbonica* (Rutaceae, XVIèmes *Journées Internationales des Huiles Essentielles de Digne-les-Bains,* France, 3-6 septembre

Valenciennes, E., J. Smadja. 2007. "Medicinal and aromatic plant potentialities from Reunion Island". *VIth International Symposio Ethnobotany Disciplines*, Lima, Pérou. *Actes de colloque* sur CdRom.

Valenciennes, Girard, E, N. Fruteau De Aclos and J. Smadja. 2006c. "Evaluation des activités antioxydantes, antiradicalaires et inhibitrices de l'acétylcholinestérase de cinq fougères de La Réunion". *4ème Colloque International sur les Plantes Aromatiques et Médicinales des Régions d'Outre-mer*, Punaauia, Tahiti, France.

Valenciennes, Girard, E., and J. Smadja. 2006b. "Aspects historiques et sociaux de la medicine traditionnelle à La Réunion". *Ethnopharmacologia, 37 :* 24-30.

Valenciennes, Girard, E., C. Poullain and J. Smadja. 2006a. "Etude d'une Rutacée médicinale de La Réunion: *Melicope Borbonica* (Bory) T.G. Hartley syn Euodia Borbonica var. borbonica (Bory) Engler". *Ethnopharmacologia*, 37 ; 53-58.

Valenciennes, Girard, E., P. Clerc, I. Grondin, A. Marvilliers, M. Litaudon, F. Gueritte, P. Leyssen and J. Smadja. 2010. “Medicinal Plant Potentialities from Reunion Island”. 8th International Symposio Ethnobotany Disciplines, Lisbon – Portugal.

Vera, R., J. Smadja, and J.Y. Conan. 1990. “Essais préliminaires sur quelques plantes à alcaloïdes de La Réunion”. *Plantes médicinales et Phytothérapie*, *1* : 50-65.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 119-124

Value Addition to Aromatic Plants in Comoros

Mohamed Said Hassani*

Abstract: The Comoros Archipelago markets ylang ylang essential oil, vanilla pods and cloves. During these last years, the prices of these commodities have slumped on the world market. While the Comoros Islands are known to have a rich and varied f ora – second next to Madagascar in terms of endemic species, the potential for the exploitation of the f ora has remained untapped. Thus, further exploration of the indigenous and endemic f ora could unlock the potential of the aromatic plants currently being used in traditional medicine. It is also an undeniable fact that the preservation and diversification to the value-addition of aromatic plants can allow the Comoros Archipelago to make a very important impact on livelihoods especially to the women folks who are the primary agriculturalists.

Keywords: Vanilla, ylang ylang, clove, comoros, preservation, diversification, aromatic plants, Comoros.

Introduction

The Comoros archipelago consists of four islands (Grande Comore or Ngazidja, Mohéli or Mwali, Anjouan or Nzuwani, and Mayotte or Maore) aligned along a northwest-southeast axis at the northend of the Mozambique Channel, between Mozambique and the island of Madagascar. The Comoro Islands present a potential of a great interest from the point of view of biological diversity as well to the level of the f ora as of fauna. The Comorian f ora consists of 120 families, 118 genera and 132 species (50 endemic).

This f ora is specific with regard to the multiplicity of the microclimates and the nature of grounds. As for the fauna, she is composed of mammals: 17 species (two species and three subspecies endemic), of birds: 98 species (35 endemic subspecies) and reptiles: 24 species (10 endemic). The Coelacanth fish (Latimeria chalumnae) belonged to this faunistic wealth. These islands are in second place behind Madagascar, on endemism in

* Faculté des Sciences et Techniques, Université des Comores, Moroni Comores Centre National de Documentation et de Recherche Scientifique (CNDRS), Moroni Comores. Email : msaidhassani@gmail.com

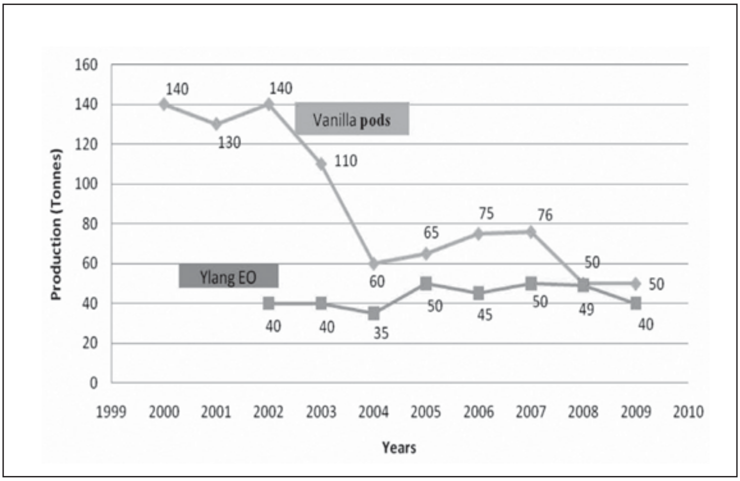
the Indian Ocean. Many species are threatened by agriculture, poaching and hunting.

In 2004, 34 regions were classified as highly rich in biological variety and at the same time, as critical zones for the life conservation. The Comoros Archipelago with Madagascar, Seychelles, Maurice (including Rodrigues) and La Réunion constitute one of the region's 34 hotspots of biodiversity.

Paradoxically, the Union of the Comoros is also one of the poorest countries in the world. The biodiversity is more threatened by the poverty associated with the population growth, the production modes adopted for several decades and the dangerous agricultural practices for the natural environment. This allowed the implementation of a sustainable development policy of which one of the axes is the valorisation of natural substances, in particular essential oils.

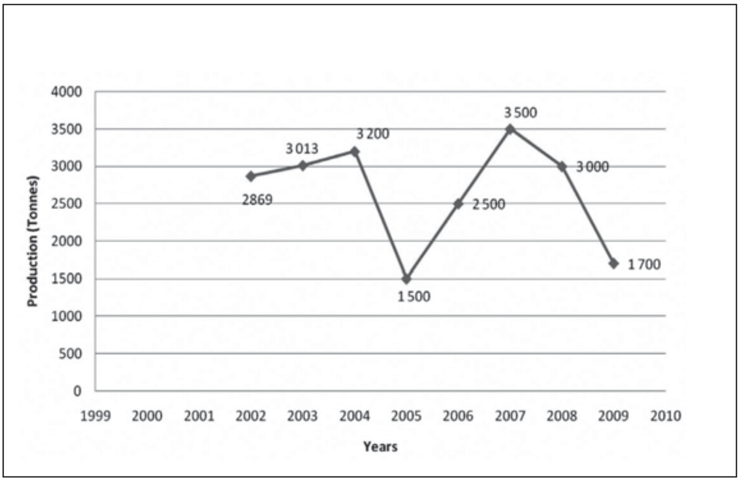
During these last years, the prices of these commodities have slumped on the world market. This can be partly attributed to the poor networking of the main producers and those badly affected are those lower down the ladder. The Figures 1 and 2 show a decrease in the production of vanilla, ylang and cloves because of the slump in the world market.[1] This affected livelihood of producers in Comors.

Figure 1 : Production's Evolution : Vanilla and Ylang



Source : Author's compilation.

Figure 2 : Production's Evolution : Cloves



Source : Author's compilation.

Experiments

***Laggera alata* var. *alata* (D. Don) Sch. Bip. Ex Oliv. (Asteraceae)**[2]

Synonyms:

Blumea alata (D. Don) DC

Conyza alata (D. Don) Roxb

Erigeron alatum D. Don

Botanic:

Herbaceous plant (from 0.3 to 2.5 m) stem annual, slightly woody at the base

Localisation :

Ngazidja (Grande Comore)

***Ocotea comoriensis* Kostermans (Lauraceae)**[3]

Description botanique :

Tree usually 20 m high

Localisation :

Maore (Mayotte), Ndzuwani (Anjouan) and Ngazidja (Grande Comore)

Traditional use:

The wood is especially priced for cabinet making, wheelwright series, boat building,
interior trim and mortars

Plectranthus amboinicus **(Lour) Spring. (Lamiaceae)**[4]

Synonyms:

Plectranthus aromaticus Benth

Coleus amboinicus Lour.

Coleus aromaticus Benth.

Botanical description:

Perennial herb, strongly aromatic grass

Localisation :

Comoros Islands

Traditional use:

- Roots: activity antipaludique[5]
- Leaves: activity antitussive[6]
- Decoction of the whole plant (triple use):[7]
  - sedative of the abdominal colics
  - medication dysuria
  - laxative

Results

Chemical analysis of essential oils

The major components of essential oils are:

Laggera alata var. alata : β-caryophyllene (30.5%), a-muurolene (21.2%) and a-caryophyllene (16.2%)[8]

Ocotea comoriensis:[9]

- bark : caryophyllene oxyde (11.3%), a-ylangene (8.2%) and epi-a-cadinol (6.1%)
- leaves: β-eudesmol (21.6%), caryophyllene oxyde (8.5%) and b-selinene (6.7%)
- fruits: α-cadinol (15.9%), epi-a-cadinol (14.9%), d-cadinene (10.8%) and isobornyle acetate (9.0%).
- seasonal variation of the bark essential oils gives:
  - caryophyllene oxyde (11.3%), a-ylangene (8.2%) and epi-a-cadinol (6.1%) (fruiting period – April)
  - camphène (18.1%), α-pinene (13.7%), bornyle acetate (13.8%) and β-pinene (13.7%) (vegetative rest period – september)

Plectranthus amboinicus: carvacrol (23.0%), camphor (22.2%), D-3-carene (15.0%) and cis-ocimene (8.4%).[10]

Biological activities of essential oils

Ocotea comoriensis (vegetative rest period – September) :

- *antioxydant activity*: 33.1 ìg/mL (DPPH test)
- *anti larval activity*: 125 ppm (Aedes aegypti larvaes)
- *antimalaria activity*: 10 ìg/mL (Plasmodium falciparum)[11]

Plectranthus amboinicus

- antibacterial activity:[12]
    - IMC = 0.2% sur Escherichia coli
    - IMC = 0.1% sur Staphylococcus aureus

Conclusion

The Comoros Archipelago f ora is far from being studied completely. The few scientific data available on the aromatic plants of this f ora carry hope. Consequently, the studies of the Comoros Archipelago f ora would deserve to be continued by multiplying in particular the essential oils activity tests according to the time and of the space.

Sustainable development envisage a production with clear priorities which are: the poor basic needs, preserving the environment, the economic progress with the implementation of the standards, and the social justice. A conservation and diversification policy of the value addition to aromatic plants can help the Comoros archipelago to fire greater profits for the purpose of improving the communities living conditions and in particular the women.

Endnotes

1 BCC (2000-2009).
2 Said (2010).
3 *ibid.*
4 *ibid.*
5 Kaou (2008).
6 Said *et al*. (1995).
7 Adjanahoun *et al*. (1982).
8 Said *et al*. (2005).
9 Said (2010) ; Menut *et al.* (2002).
10 Said (2010).
11 Menut *et al.* (2002).
12 Said (2010).

References

Adjanohoune E., Ake Assi L., Ahmed A., Eyene J., Guinko S., Kayonga A., Keita A., Lebras M., 1982.Contribution aux études éthnobotaniques et floristiques aux Comores, Rapport, ACCT.

Kaou A. M., Mahiou-Leddet V., Hutter S., Ainouddine S., Hassani S., Yahaya I., Azas N., Ollivier E., 2008. "Antimalarial Activity of Crude Extracts from Nine African Medicinal Plants." *J. Ethnopharmacol*., 116, pp. 74-83.

Menut C., Bessiere J. M., Said Hassani M., Buchbauer G., Schopper B., 2002. "Chemical and Biological Studies of *Ocotea Comoriensis* Bark Essential oil." *Flavour and Fragrance Journal, 17*, pp. 459-461.

Rapports de la Banque Centrale des Comores (BCC) 2000-2009.

Said Hassani M., 2010. Valorisation de quatre plantes endémiques et indigenes des Comores. Thèse de doctorat, Université de la Réunion.

Said Hassani M., Said Abdallah B., Zrira S., Benjilali B., 2005. Chemical Composition of the Essential Oil of *Laggera alata* var. *alata* (D. Don) Sch. Bip. Ex Oliv. (Asteraceae) from Comoros Islands Part I. *Journal of Essential Oil – Bearing Plants*, 8(1), 15-18.

Said Hassani M. and Yahaya I., 1995. Programme Tramil-Comores. Rapport final. Programme. Moroni. Comores.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 125-129

Support to the Basic Sciences in Developing Countries: Importance of Scientific Networks

Peter Sundin*

Abstract: The International Science Programme (ISP) at Uppsala University, Sweden, since 1961 has been devoted to long-term support for building capacity in scientific research and higher education in developing countries in the Basic sciences. An increased domestic capacity for research and higher education in the Basic sciences has a long-term impact on development. In the larger perspective support to the Basic sciences is generally low or neglected, despite their importance for sustaining applied sciences and quality science education. Regional and interregional cooperation may be a fruitful approach to overcome many constraints, adding value to participating scientists and their institutions. Therefore, ISP support to regional collaboration and the formation of scientific networks was initiated already in the early 1980s. Currently, nine chemistry networks are supported, in the fields of analytical chemistry, biotechnology, environmental chemistry, natural products chemistry, and technical and analytical support and training. The activities carried out by the networks are diverse. For support to networks to continue in the future the demands will increase to demonstrate benefits, added value, achievements, impacts, and sustainability.

Keywords: Regional and Interregional Cooperation, impact, sustainability, Scientific Networks.

Introduction

The Swedish policy for development cooperation 2010-2014 stresses the need to strengthen and develop scientific research in developing countries as a means for strategically combating poverty (Swedish Ministry of Foreign Affairs, 2009). The International Science Programme (ISP) at Uppsala University, Sweden, is devoted to long term support for building capacity in scientific research and higher education in developing countries in the Basic sciences[1], since 1961 in the field of physics, and since 1970 and 2002 in chemistry and mathematics, respectively.

* International Science Programme (ISP), Uppsala University, Sweden.
Email: peter.sundin@isp.uu.se

In ISP's 50 years of experience, an increased domestic capacity for research and higher education in the Basic sciences has a long-term impact on economic growth and poverty alleviation, driven by an increasingly knowledge-based society. A country's domestic competence in the Basic sciences is crucial for:

- an increased quality of education, at all levels,
- the development of scientific, critical thinking based on reproducible evidence,
- the development of applied sciences to meet local needs,
- the development of technology, innovation, and engineering on a local ownership basis,
- the adoption of a sustainable use of natural resources,
- the engagement in business and global trade at a level of knowledge which matches global partners, industry and investors, and
- the development of scientific excellence on own terms.

Scientific Networking to Overcome Constraints

In the larger perspective support to the Basic sciences is generally low or neglected, both by developing country governments and their development partners.[2] Overall funding of research and development in general has traditionally been much lower in the developing countries (0.2 per cent of GDP) than in the OECD countries (2 per cent of GDP).[3] More recent figures show a similar situation.[4] Furthermore, bilateral development partners - if they support science research at all - mostly limit support to a small number of fields with focus on Applied Sciences.[5] However, although interdisciplinary and applied research is important in solving a number of development challenges, without a strong fundament of Basic sciences it is difficult to sustain applied sciences and quality science education. In perspective of the low rate of funding for research and training in the Basic sciences in most developing countries, regional and interregional cooperation may be a fruitful approach to overcome many constraints, adding value to participating scientists and their institutions by: generating complementary scientific activities, giving access to advanced equipment, and increasing the human capital needed for good standard postgraduate education.

ISP Support to Chemistry Networks

For the reasons given, ISP support to regional collaboration and the formation of scientific networks was initiated already in the early 1980s, and has expanded considerably in the following years. The following scientific networks in chemistry are being supported or have been supported by the International Programme in the Chemical Sciences (IPICS) at ISP:

- AFASSA (Africa-Asia-South America coordinating group for natural products research), interregional, IPICS supported 2003 - 2009.
- ALNAP (African Laboratory for Natural Products), IPICS support started in 1996.
- ANCAP (African Network for the Chemical Analysis of Pesticides), IPICS support started in 2001.
- ANRAP – (Asian Network of Research on Antidiabetic Plants), IPICS support started in 1994.
- Cassava Safety Network, IPICS supported 1993 – 2001, after which support continued to two of the research groups in the network, one in Malawi (until 2010) and one in Nigeria (until 2005).
- FOSNNA (Food Science and Nutrition Network for Africa), IPICS supported 2001 - 2009.
- LANBIO (Latin American Network for research in Bioactive natural compounds), IPICS support started in 1991.
- LANFOOD (Latin American Network for Food Research), IPICS supported 1994 - 2007.
- LATSOBIO (Latin American Solid Phase Biotechnology Network), IPICS supported 2003 - 2007.
- MOLCAS (The Cassava Molecular Diversity Network), interregional, IPICS supported 1999 - 2008.
- NABSA (Network for Analytical and Bioassay Services in Africa), IPICS support started in 1995.
- NAPRECA (Natural Products Research Network for Eastern and Central Africa), IPICS support started in 1988.
- NITUB (Network of Instrument Technical Personnel and User Scientists of Bangladesh), IPICS support started in 1994.
- R.A.Biotech (Réseau ouest-africain des Biotechnologies ; West-African Biotechnology Network/ABN), IPICS support started in 2008.
- SARBIO (Southern African Regional Cooperation in Biochemistry, Molecular Biology and Biotechnology), IPICS supported 1995 - 2010.
- SEANAC (Southern and Eastern Africa Network for Analytical Chemistry), IPICS support started in 2005.

Diversity in Networking Activities

Activities organised by the supported networks are multifaceted and include the following:

- Arranging conferences, workshops, summer schools, and training courses,
- Providing possibilities for regional and interregional short-term exchange of researchers and research students,
- Providing an academically strong environment for regional Master and PhD education,
- Arranging common training of Master and PhD students, and technical personnel,
- Accomplishing scientific cooperation in common projects yielding multi-authored publications,
- Providing access to advanced instrumentation which few institutions can afford to procure and maintain,
- Repairing and maintaining instruments with network members, and,
- Harmonising higher education curricula between countries in a region,

To highlight the importance, diversity and achievements of scientific networks in the developing world, an International Conference on Regional and Interregional Cooperation to Strengthen Basic sciences in Developing Countries was arranged by ISP 1-4 September 2009, in Addis Ababa, Ethiopia, together with Swedish Sida, Addis Ababa University, and under the auspices of the African Union Commission.[6] Several examples are given on significant accomplishments by scientific networking in the fields of chemistry, mathematics, and physics, strengthening the Basic sciences in the context of scarce funding and limited resource allocation. In addition to the benefits listed above, at this meeting it was pointed out that scientific networks are important to address local and regional problems and for developing multidisciplinary research; and also for spreading risks and gains.

Future Support to Scientific Networks

For ISP support to scientific networks to continue, the following factors will be increasingly important. The collaboration benefits and added value must be made clear, for example in terms of complementarity, multidisciplinarity, co-publication, harmonisation of higher education curricula, and shared intellectual and instrumental resources. The cooperative strength must be demonstrated, for example in terms of arranging meetings, workshops, conferences, supporting network nodes, exchanging and training of scientists, students, and technical staff; creating and maintaining a critical mass for scientific progress.

The achievements must be convincing, for example, in terms of quality publications, contributions to international conferences, awarding student degrees, keeping and maintaining technical resources, and reaching out to society including governments, industry, and international organisations. The long-term impacts must be shown, for example, in terms of inf uence on policy and practices. The cooperation must be sustainable, for example, in terms of attracting contributions from several organisations, and strategies must be in place for adapting activities to future needs.

Endnotes

1. Lindqvist (2001).
2. Thulstrup (1995).
3. Hasselgren and Nilsson, (1990).
4. NationMaster (2011); World Bank (2011).
5. Thulstrup (1995).
6. Kiselman (2011).

References

Hasselgren, L. & Nilsson, J. S. 1990. *Reflections on the Role of Basic Sciences in Third World Countries. SAREC Report* 1990:1. Stockholm: Gotab.

Kiselman, C. (ed.). 2011. Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries, Addis Ababa, Ethiopia, 1-4 September 2009. Acta Universitatis Uppsaliensis, 88, 2011. http://uu.diva-portal.org/smash/record.jsf?pid=diva2:393463&rvn=1 (accessed 15 July, 2011)

Lindqvist, T. (ed.). 2001. International Science Programme, Uppsala University 1961-2001. Historical Review and Participants´ Experiences. Acta Universitatis Uppsaliensis, 71, 2001.

NationMaster. 2011. Economy Statistics > Research and development expenditure > % of GDP (most recent) by country. http://www.nationmaster.com/graph/eco_res_and_dev_exp_of_gdp-economy-research-development-expenditure-gdp

Swedish Ministry of Foreign Affairs. 2009. Research for Development - Policy for Research in Swedish Development Cooperation and Strategy for Sida's Support for Research Cooperation. Government Offices of Sweden. http://www.sweden.gov.se/content/1/c6/14/60/03/eab96d0b.pdf (accessed 14 July, 2011)

Thulstrup, E. W. 1995. "A Key to Development: Strengthening Science Based Fields in Third World Universities," in von Schleebrügge, Karin (ed.) *Research for Development: SAREC 20 Years*. PP. 79-90. Stockholm: Swedish Agency for Research Cooperation.

World Bank. 2011. Research and development expenditure (% of GDP). http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS (accessed 14 July, 2011)

Special SIDS Forum

This section includes inputs from the practitioners, healers and those engaged in the conservation of traditional knowledge and traditional plant varieties from and Small Island Developing States (SIDS) in the Indian Ocean region. We hope these inputs will provide insights into the traditional medicinal systems which are still being practised successfully.

- Managing Editor

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 133-135

Role and Recognition of Local and Indigenous Practitioners' Knowledge: Perspective from Union des Comores

Ali Ahmed*

Introduction

The consumption of medical plants has increased among the people of the Indian Oceans. In Comoros, traditional healers and newly graduates practice their own medical consultation due to many reasons. Some long-term risks in this area could be over exploitation of medicinal plants by the pharmaceutical industries and disappearance of some species. Solutions to these problems could be valorisation and securisation of these fields. Some issues that are being worked in Comoros and similarly in other states of Indian Ocean include: creation of centre, publication of survey and book as well as study of medicinal plants. The contribution of international organisation has helped in the integration of traditional medicine and strengthening the role of traditional practitioners and significance of medicinal plants. The geographical position and favourable climatic conditions of the islands of Indian Ocean aid the production, development and exploitation of medicinal plants and their therapeutic properties.

Currently, these plants are utilised in the treatment of various diseases and as extracts in pharmaceutical industries in the form of infusions and decoctions.

In Comoros, a state that is part of SIDS (Small Island Developing States), traditional healers and graduates from the field of medicine, practice their own medical consultation due to the following reasons:

- Poor health care facilities in the public sector,
- Aging infrastructure and medical equipment,
- Inadequate management of the health system,
- Side effects of imported drugs,
- Low health care budget,

* Inspecteur Général de l'Education, Ministère de l'Education Nationale, Ouani-Bwedzani, Anjouan, Union des Comores. Email: aliahmed1119@hotmail.com

- Lack of specialised staff,
- Less access of drugs especially to the poor community,
- High illiteracy and low standard of education, and
- Increasing population level in some of the islands of Comoros.

Traditional Healers

The traditional healers present in cities or rural areas employ the richly diverse cultures and traditional medicines to treat their patients. They are ostentatious of their knowledge but also very attentive to the 'cries' of their patients. It is very surprising to observe that these traditional practitioners provide consultation with minimal fees. These aspects ref ect the role and recognition on local and indigenous practitioners' knowledge.

Some traditional healers have inherited knowledge from their ancestors (from father or mother to son or daughter), while others have been gifted and cannot be explained with reference to social anthropology. The therapeutic use of medicinal plants is a social and natural phenomenon as they have been used for various centuries and thus are being commercialised in pharmaceutical industries. The long-term risks of such practices could be misuse of the medicinal plants by pharmaceutical industries and extinction of some species due to deforestation.

The solution to the above problems, could be: cultivation of selected species over large areas, facilitation of access to phyto-medicines to the poor, and introduction of medicinal plants in the school curriculum.

These issues are being worked out in Comoros and other islands of the Indian Ocean. Some examples are as follows:

- Creation of CNDRS (National Centre for Documentation and Scientific Research) in 1980.
- Publication of the survey findings by Professor Adjanohoun ethnobotany at the University of Bordeaux and the book entitled:' Contribution aux Etudes ethnobotaniques et f oristiques aux Comores, Médecine traditionnelle et Pharmacopée' (ACCT 1982).
- PhD thesis in Medicine, on 'Possibilité d'utiliser les plantes médicinales pour les soins de santé Primaire aux Comores', Faculty of Medicine, University of Bordeaux (in 1982).
- 'La chimique des plantes endémiques des Comores' by Mohamed Said Hassani (CNDRS) and Alain Petit Jean (Faculty of Science, La Reunion, work is in Progress).

- Study of aromatic and medicinal plants (Work is in progress at CNDRS).

In other islands of the Indian Ocean, the same model of research in traditional medicine and pharmacopoeia exists:

- A national ministry or department is responsible for health policies.
- A national research and regional centres employing social scientists, chemists, botanists, and technicians in herbal medicine working with a budget at their disposal, with support for laboratory equipment, and, accessories, programmes having clearly defined objectives and results.
- Research on medicinal plants, under the sponsorship of the ACCT and the supervision of Professor Adjanohoun, University of Bordeaux have led to various publications, in each of our islands; other works related to traditions medicines have also been published.

Conclusion

The people in Indian Ocean adopted traditional medicine from ancient practices and would like to pursue the use of medicinal plants for the following generation. WHO has contributed in the integration of traditional medicine in primary health care and thus has reinforced the role of traditional practitioners and the importance of medicinal plants. The geographical position and favourable climatic conditions make the islands of the Indian Ocean an ideal centre for the production, development and exploitation of medicinal plants and their therapeutic properties.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 137-144

Biodiversity and Traditional Knowledge in Reunion Island: Case of "*Competition Zerbaz péi*"

Héloïse Patiama*, Isabelle Duriez-Benefix*, Stéphanie Brillant*, Claude Marodon* and Jean-Claude Pieribattesti*

Introduction

The preservation of the traditional knowledge is a major stake for native peoples. In the Reunion Island, the annual education project - "zerbaz péi" organised by the APLAMEDOM aims at making an inventory of the family practices on aromatic and medicinal plants. "*Zerbaz péi*" refers to the use of healing plants, called collectively "zerbaz" or herbal teas, is a member of the cultural heritage of The Reunion Island.

From time immemorial, plants were the pioneers of the ground conquest. They form one of the compounds of the biodiversity and show to be a sure source, but not less tarissable, for the discovery of molecules with medicinal action. Indeed, 50 per cent of modern medicines of prescription arise from compounds extracted from vegetable species; and 80 per cent of the world population uses traditional medication with plant.[1]

The conservation of healing plants represents a world at stake. They are all the more important as they are endemic, rare and fragile. Biopiracy and demographic pressure constitute two major threats. It is necessary to guard the spirit that the aromatic and medicinal plants (AMP) of a given region are rich in knowledge, in know-how, in traditional values and in history of these overseas territories.[2]

The Convention on Biological Diversity (CBD) recognises the importance of the traditional knowledge in a given cultural system. The Global Strategy for the Plants Conservation (GSPC), organised by the CBD, calls, in particular, for the preservation of the knowledge and the traditions of the native and local communities.[3]

---

* APLAMEDOM Reunion, The Reunion Island. Emai: contact@aplamedom.org.

In the context of the erstwhile French colonies, AMPs are facing a number of challenges. They are absent in the official French Pharmacopoeia while they are in daily use, in a traditional way and contribute to the general health and well being of the population. This is evident from the framework of a local, traditional, empirical pharmacopoeia (thus subjected to scientific validation) and passed on in an oral way as in the Reunion Island[4]. The Association for the AMP in The Reunion Island (Association pour la Promotion des Plantes Médicinales D'Outre Mer) APLAMEDOM, is working on the evaluation, development and promotion of the use of medicinal plants in the Reunion Island. The first mission of the association is focused on ethnopharmacology. It is a matter of collecting data on AMP mixtures according to their traditional therapeutic effects in order to scientifically validate and promote their uses, or to provide necessary recommendations.[5]

The competition "*zerbaz péi*" is an annual educational project, organised for past five years by the APLAMEDOM. It consists in making a herbarium of healing plants, by students accompanied with a investigation in their circle of acquaintances on the empirical manners of chosen plants (without documentary supports).[6]

Plants and Peoples' History in the Reunion Island[7]

In the middle of the 17th century, the first occupiers, colonists arrived from Madagascar. Then, on account of the slave trade, immigrants from different nations were brought to this island. Thus, the Reunion Island society had been constituted by successive waves of immigrants coming from various origins: Europe, Madagascar, Africa, India, China, Indian Ocean, and even Malaysia and their descents and the interbreeding of the successive generations. Every community came with their knowledge, their faiths, their worships and their and recipes plants which later on became essential parts of the history of the Reunion Island.

The use of plants to the Reunion Island enables us to understand the history of the colonisation of the island. Plants in the island can be categorised into two categories: those already present on the island, including the endemics and the natives; and those brought from outside, the exotics.[8]

In 1946 the island became an overseas department of France. Till then, the island had rudimentary medical structures. For majority of the population plants constituted the only source of medicine. The evolution of the traditional medicine can be understood in terms of the diseases and epidemics of import, nutritional deficiencies, and parasitic infections that aff icted the population. The traditional medicine and the associated practices evolved from experiences and observations than from experiments. It is, thus, an answer for the needs of the patients at different stages in life. It is also a means to answer a need in terms of care and well-being[9]. A good example is the "*saisissement*" or emotional shock infusion which uses the rosemary (*Rosmarinus officinalis L.),* native of the Mediterranean Basin. This AMPs shows a particular use because it is necessary "*to seal*" (expose brief y over a brisk heat) the rosemary if we want the herbal tea to be effective. This is based on observations and evidence based on the experiences of patients than on any scientific investigation.

Another factor that has inf uence on traditional medicinal practices is the religion and the associated rites, which are often associated with care and faith. However, we will not discuss this further as this was brought in only to point out this fact.[10] The geographical situation of the Reunion Island is in a strategic point. Today, it has modern infrastructures similar in the countries of the North, but has the socio-cultural identity of the countries of the South.[11]

The Reunion Island Pharmacopoeia is the result of the complex socio-cultural dynamics and historical experience of the population. It is necessary to underline the fact that traditional medicines are used to treat emergent viral infections (chikungunya or dengue) or modern metabolic diseases (as the diabetes or the hypercholesterol in the blood). As this oral inheritance evolved, there have also been changes in the family structure, the housing environment, the mode of life, hygiene, etc.[12]

APLAMEDOM and the Competition "*Zerbaz Péi*"

The importance of traditional knowledge, and the need to preserve the oral heritage are the reasons for the APLAMEDOM's initiative called "*zerbaz péi*." At the beginning, it was a simple educational tool which has been introduced by the ethnobotanist, Dr. Roger Lavergne, specialised in Applied Tropical Botany. Professor to CES secondary school Juliette Dodu, in the 1980s, he asked students to develop a herbarium of healing plants. "*Zerbaz Péi*" was reorganised and widened to all schools under the Academy (Regional Education Authority) of the Reunion Island. The loss of the knowledge on the medicinal use of the specific plants to the Reunion Island is alarming. Most students know about *tizaners* (herbalists) or belong to herbalists' families. The oral knowledge is passed on from generation to generation. The idea to set up a tool of inventory appeared for two reasons:

- urgency to re-transcribe and list the popular knowledge on the use of healing plants; and
- make young people understand the case for the intergenerational dialogue, and to become aware of their cultural and f oral heritage while participating in a collective and educational action.

The objective was to catalog and build an inventory of the popular knowledge through the organisation of a competition of herbariums among students in the primary and high schools throughout the entire island. The participants would develop a herbarium consisting of traditionally used medicinal plants and provide answers to a questionnaire on the traditional use of the chosen plant, without using the other means as books or internet.

During presentation the student appears as an investigator with a member of his family or a person of his circle of acquaintances who knows the healing capacity of these plants. Together, they answer a questionnaire on the medicinal use of a plant. Every student selects a plant used in his family or in his circle of acquaintances and performs the questionnaire by means of a person who knows well that particular plant. Every student builds a sample herbarium of the chosen plant. From this the teacher chooses 10 for participation in the competition. A jury, chaired by Dr. Roger Lavergne and consisting of experts in domains, the botany, the linguistics, the herbal medicine, the biology and the ethnology, determines the best herbarium and the best investigation. The winners receive prizes and monetary rewards for the class for use in education.

APLAMEDOM in 2011 organised the 5th edition of "*Zerbaz péi*" with the continuous support of its partners and sponsors: herbalists, National Botanical Academy and permanent center of initiatives for the environment, Herbarium of University of the Reunion Island, General Council, Reunion Regional Government, the Academy (Regional Education Authority) of the Reunion Island, and the Ministry of Culture and Communication.

The competition is important as this gives incentives to protect, to enrich, to pass on knowledge and cultural heritage, and to sensitise the future generations towards the protection of biodiversity of their island.

Moreover, very often, this educational work is coupled with the other activities concerning the sustainable development and the environment. A primary school teacher is entrusted with this task. This initiative is complementary to the Reunion Island Strategy for the Biodiversity (RSB), set up by the Regional Department for the Environment and the National Strategy of Education in the Sustainable Development.[13]

The environmental issue is taken up in order to sensitise, and thus to inculcate interest in the protection of the f ora, and to stress the importance of better management of biodiversity. Furthermore, the project also has an economic dimension. Therefore, knowledge brought forth through competitions can help in the development of products from AMPs. The scientific study of the plant will help in realising economic benefits.

"*Zerbaz péi*" had relaunched the link between family and school. It is not the school which will be the source of knowledge here, but indeed the family. The student is sent back within his family in order to collect some information that he/she will discuss in a school framework. All information collected, thanks to the competition "*zerbaz péi*", offers a multiple source of subsequent applications. The competition favoured the intergenerational link, and so enhanced the value of previous generations and that of "gramounes" (elderly) among the young generations. The usage of the Creole language by students helped us to list of the vernacular names used. It also led to:

- a better knowledge of the f ora and the associated traditional practices by the current generations;
- undertaking studies to validate the traditional manners, and gain a better knowledge of the local pharmacopoeia;
- creating a database on the traditional manners from the Reunion Island within the association APLAMEDOM;
- disseminating information on AMP: herbariums are grouped together on an exhibition certified by the DIREN[14] biodiversity in 2010; and
- putting validated knowledge through a publication (Azalées Editions –August, 2011).

Moreover, one of the objectives of APLAMEDOM is to disseminate the outcomes of evaluation among the local public. The results and the book are available from APLAMEDOM. This publication describes the 25 plants which were the most referred to in the competition. Perhaps these plants are also the ones which are most widely used by the inhabitants of the Reunion Island.

The book classifies the plants by vernacular name. Every index card of plant contains: 1) traditional practices and uses, and 2) the current knowledge on the plant, its composition, its potential for toxicity as validated by scientific experiments.

Table 1: Outcome of Competition *Zerbaz Pei*

Period	(2006-2011)
Classes	247
Boards herbariums and inquiries	2 200
Listed plants	145

Source: APLAMEDOM.

On the basis of the five years of experience, APLAMEDOM has developed a methodology for the implementation of this competition. This can be replicated elsewhere easily. So in 2012 we propose to conduct the competition in Mauritius, Mayotte, and Madagascar.

Conclusion

Can the preservation of the traditional knowledge, be a source for discovery of new medicines?

The approach of the ethnopharmacologists is twofold: they not only catalogue and list traditional remedies, but also validate their biological efficiency to verify the claims of traditional medicine or prove other wise.[15] This scientific validation is necessary because the assertions, which come from traditional practices, can be misleading and create problems if unverified (by biochemistry or clinical approaches or by an authorisation of sale in the market for products designed from AMPs). Combining traditional wisdom and its validation by science establishes a link between tradition and modernity.

The research on the plants also help in combating biopiracy which remains a contentious issue, in spite of the implementation of the Convention on Biological Diversity (CBD).[16]

The "Declaration of Bélem" by the International Society for Ethnobiology (ISE) at the end of 1980s, was the first Declaration by an international scientific organisation which recognised the needs and rights of indigenous communities. It raised questions of technical, ecological, political, economic importance (compensation to the people for the use of their knowledge), legal (recognition of the rights of the communities) and also the rights to culture (maintaining cultural and linguistic identity). Several initiatives have been undertaken since then, and among these Article 8j of CBD and the Indigenous Voices at the United Nations are the most important ones.[17]

Endnotes

1. Stratégie mondiale pour la conservation des plantes - CDB.
2. http://www.evb.ch/fr/p25000720.html; http://www.evb.ch/fr/p17228.html
3. Stratégie mondiale pour la conservation des plantes - CDB ; Savoir, innovations et pratiques traditionnelles - CDB.
4. http://www.naturemania.com/naturo/plantesDOMTOM.html
5. Savoir, innovations et pratiques traditionnelles - CDB ; www.aplamedom.org
6. Savoir, innovations et pratiques traditionnelles - CDB; www.aplamedom.org
7. Jean (1993).
8. Laurence. (2000).
9. *ibid.*
10. Jean (2000) ; Jacques (2001).
11. Beaulieu (2003) ; Watin (2008).
12. Watin (2010).
13. http://160.92.130.124/FCKeditorFiles/File/ActionsDIREN/Biodiversite/Strategie_Reunionnaise_Biodiversite.pdf; http://www.education.gouv.fr/cid205/l-education-au-developpement-durable.html
14. DIREN Directory environment and ecology.
15. http://www.neo-planete.com/2009/03/30/jaques-fleurentin-l%E2%80%99ethno-pharmacologie-au-service-de-l%E2%80%99homme/; Fleurentin (2007).
16. Stratégie mondiale pour la conservation des plantes – CDB ; http://www.evb.ch/fr/p25000720.html ; http://www.evb.ch/fr/p17228.html ; Savoir, innovations et pratiques traditionnelles - CDB
17. Darell (1997) ; http://www.iddri.org/Activites/Ateliers/La-protection-des-savoirs-locaux-des-experiences-africaines-et-europeennes/;http://www.cbd.int/traditional/intro.shtml ; http://www.un.org/esa/socdev/unpfii/fr/index.html

References

Beaulieu, A. 2003. *Guérir à The Reunion island.* Presses de l'Université de Paris VII – Denis Diderot, UF d'Anthropologie, Ethnologie et Sciences des Religions, coll. Ethnologie(s) en Herbes.

Darell, A. Posey. 1997. in Graham Dutfield (ed.). *Le marché mondial de la propriété intellectuelle*. Centre de recherches pour le dévelopement international (CRDI) et WWF Consulté le 13/07/2011:http://ethnobiology.net/global-coalition/declaration-of-belem/

Harmattan, L. 1997. *Médicine traditionnelle, religion et divination chez les Seereer Siin du Sénégal. La connaissance de la nuit.* Paris : Préface de Pierre ERNY..

Jacques, Fleurentin. 2007. *Les plantes qui soignent: tradition et thérapeutiques*. Editions OUEST-France.

Jacques, Mabit. 2001. "L'alternative des savoirs autochtones au tout ou rien thérapeutique". *Psychotropes*, 7 : 7-18.

Jean, Benoist. 1993. *Anthropologie médicale en société créole*. Paris: Les Presses universitaires de France, Les champs de la santé.

Jean, Benoist. 2000. *Une petite bibliothèque d'anthropologie médicale. Une anthologie*. A.M.A.D.E.S., Diffusion Karthala:,[Tome I] Paris : 335-336 & 363.

Laurence, Pourchez. 2000. *Grossesse, naissance et petite enfance en société créole*. Editions Karthala et CRDP Réunion.

Watin M. 2008. "Généralisation des communications et changement social à The Reunion Island " in Ghasarian C. (ed.) *Anthropologies de The Reunion Island*, Archives Contemporaines.

Watin M. 2010. "The Reunion Island, Une Société en Mutatio". In Wolff E. (ed.) *Anthropos-Economica* . Univers Créoles.

A propos de l'article 8j, la Convention pour la Diversité Biologique (CDB). Consulté le 18/07/2011 http://www.cbd.int/traditional/intro.shtml

Consulté le 13/07/2011: www.aplamedom.org

Consulté le 13/07/2011. http://160.92.130.124/FCKeditorFiles/File/ActionsDIREN/Biodiversite/Strategie_Reunionnaise_Biodiversite.pdf

Consulté le 13/07/2011: http://www.education.gouv.fr/cid205/l-education-au-developpement-durable.html

Consulté le 13/07/2011: http://www.neo-planete.com/2009/03/30/jaques-fleurentin-l%E2%80%99ethno-pharmacologie-au-service-de-l%E2%80%99homme/

Compte-rendu de la table ronde organisée par l'IDDRI (Institut du Développement Durable et des Relations Internationales), en collaboration avec l'Institut français de la biodiversité (IFB), dans le cadre de la COP6, qui a eu lieu à La Haye (Pays-Bas), du 8 au 19 avril 2002. Consulté le 13/07/2011: http://www.iddri.org/Activites/Ateliers/La-protection-des-savoirs-locaux-des-experiences-africaines-et-europeennes/

Déclaration de Berne, " *Les ONG critiquent la biopiraterie de l'Université de Lausanne*", Consulté le 13/07/2011: http://www.evb.ch/fr/p25000720.html

Déclaration de Berne, " *Articles de la Convention sur la diversité biologique en lien avec la biopiraterie*", Consulté le 13/07/2011: http://www.evb.ch/fr/p17228.html

Interview de Jacques Fleurentin a Kevin Le Geun pour Neoplanete

Représentation des peuples autochtones à l'Organisation des Nations Unies. Consulté le 18/07/2011 : http://www.un.org/esa/socdev/unpfii/fr/index.html

Stratégie mondiale pour la conservation des plantes - CDB

Savoir, innovations et pratiques traditionnelles – CDB, Consulté le 13/07/2011: http://www.naturemania.com/naturo/plantesDOMTOM.html

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 145-150

Modelling Sustainable Valuation of Biodiversity in Madagascar: Case Study of Aromatic and Medicinal Plants

Séverine Blanchais*

Introduction

Dramatic setbacks to the agenda set forth by the United Nations regarding preservation of biodiversity on a global scale were recently emphasised by the Conference on Biodiversity in Nagoya. Member states have fallen well short of stated objectives (Extinctions are currently occurring at a rate which is 1000 times greater than during any other period in the history). More worryingly, global degradation of ecosystems related to a loss of biodiversity has resulted in significant socio-economic consequences (these economic costs could reach 6 per cent of the GDP per year according to G-8 economists). Since the role of national governments in conservation efforts has been recognised as inherently limited, more emphasis has been recently put on the role of civil society, and especially private sector, to ensure preservation of biodiversity and environmental protection. The report on the economic impact of ecosystems and biodiversity submitted in Nagoya gives guidelines as far as the implication of the private sector in this field is concerned. "No Net Loss, Net Positive Impact" should then be normal business practice. And investment in biodiversity should be done to compensate for adverse impact that cannot be avoided. The implications of such recommendations are obvious for Madagascar, the island being indeed a haven of biodiversity, especially for aromatic and medicinal plants (AMPs).

In Madagascar, for the past 15 years, the NGO Man and the Environment, alongside its partners from the private sector, has been working to develop the production of AMPs (with particular attention being paid to essential oils –EO) in accordance with the principles of fair trade. At the same time, research institutes and international buyers have recently expressed an increasing interest in this initiative. They have subsequently

* 'Man and the Environment', Antananarivo, Madagascar Email: direction@mate.mg

sought to develop and implement methods for the sustainable extraction of such natural resources. However, the main weak point was that such efforts have failed to fully consider the consequences of such programmes on the local population. In fact, they have not even considered whether such development projects could be viable on the long-term without the active participation of local communities.

We are currently facing a global ecological crisis and a loss of biodiversity that is occurring faster than never before. This simple fact questions our choice of society or civilisation, by placing the link between environmental conservation, social equity and economic growth in the heart of the debates. These issues are often contradictory, subject to shifting and regulatory systems pretty complex to understand, both nationally and internationally. However, as mentioned by Mr. James Alix Michel, President of Seychelles (IUCN Global Survey Island): "The islands are the best indicators of the effectiveness of international environmental policy. Humanity could measure its success or failure on the islands in the first place."

Madagascar, the fourth island in the world by its size, is a main "reservoir" of biodiversity and endemic species. It is, therefore, an area of great importance for the development of pragmatic approaches that would demonstrate the feasibility of implementing sustainable valuation of biodiversity for the well being of the population and improvement of their living conditions, while putting an end to a century of massive and continuous deforestation.

Man and the Environment

Created in 1993 by Olivier Behra and Ramandimbison, the "Man and the Environment", an NGO, has been focusing from the start on both sustainable development and protection of Malagasy biodiversity, while involving the local underprivileged population. The NGO works on a few specific areas which are very rich in terms of biodiversity, but also host numerous endangered species. Its activities are implemented with the goal of demonstrating that environment conservation and human development can go hand in hand. A dozen of programmes are now running over five geographical areas, covering more than 60 000 hectares and implicating a population of about 11000 people. The programmes then fall into three categories: environment, social, and support to local economic development. The NGO aims to set up an ethical framework to promote the various fields of its activities and a relevant process to monitor/assess their impacts.

Two major research programmes have recently been settled with the Antananarivo University (Department of economics, related to University of Roma "Sapienza", and department of anthropology) to analyse, develop and apply case studies, methodologies and instruments for designing and optimising integrated policy measures and local management included: Environmental conservation, sustainable utilisation of the components of biodiversity, poverty alleviation, preservation and promotion of traditional knowledge, innovation and practices, and fair and equitable sharing of benfits arising from the utilisation of biodiversity/genetic resources.

Environmental Achievements

- Conservation and monitoring of 60 000 hectares representing five ecologic areas and their specific ecosystem.
- Monitoring of fauna / f ora biodiversity and breeding of 58 endangered plant species (IUCN) in our nurseries.
- 274 hectares of forests restored in 2010-2011. Two orchidariums, several gardens and botanical gardens have also been created.

Social and Governance Achievements

- Schools and school canteens are involved in our programs, alongside day-nurseries, that allow women to work.
- Two healthcare centre have been built and health committees created.

Economical Achievements

- 298 jobs have been created, the majority of them on the intervention sites with local recruitment.
- Production of essential oil and valorisation of Aromatic and Medicinal Plants (AMP).
- 262 plants of interest have been indentified in three of our intervention sites; out of which 31 are intensively promoted. For instance, just looking at the experimental reserve of Vohibola in 2010, 833kg of essential oil (cinnamon bark and niaouli) are produced using two distillation units, employing 92 women for collecting leaves, and four people in charge of distillation.

Production Control and Organic Fair Trade

We've been granted three labels and certifications in organic fair trade; they are regularly renewed to comply with the request for full traceability of products, and specifications of independent international certification. This approach requires massive technological transfer in production management: distiller recruited locally, best practice for leaf picking and meeting specifications of certification agencies, "bush labs" and balm production, oil press, extraction. Health committees have also been created for an active collaboration with the main local actors of traditional medicine. The aim of these committees is to formalise the process for protecting knowledge and develop a participative approach in the production and commercialisation of AMP. The collaboration between the NGO and these organisations is a guarantee of mutual understanding and progressive capacity building of all stakeholders in order to produce quality ethnobotanical information and promote good practices both for the production, transformation and use of AMP.

This initiative is supported by the Malagasy Ministry of Health which is actively looking for new proposals to improve sanitary situation through the whole national territory: its human, technical and financial capacities are presently too much weak to satisfy the increasing needs of a population that is now reaching 20,000,000 people.

Key Factors of Sustainability

The following factors contributed to our success over the last ten years:

- The production is integrated in the broader scheme of ecosystem conservation.
- An active programme is set up for promotion of new fields of activities.
- Implication of local communities producing raw materials (leaves-picking, or culture) and reinforcement of their skills and abilities.
- Creation of units which allow transformation of raw materials locally.
- New collaborations and partnerships for Research and Development.
- New partnerships with private sector (Aroma Forest, cosmetic labs)

In the near future, we should also consider the following orientation: strengthening links and synergies between our programmes, ensuring that valuation of aromatic and medicinal plants is not only contributing to local economical development, forest conservation, but also towards:

- improving the health situation through an integrated approach involving actors of traditional healthcare and local use of "improved" traditional medicine, within a safe legal and medical framework;
- developing tourism through the creation of activities related to specific knowledge of the pharmacopoeia and traditional lifestyles;

- strengthening social cohesion, which stand as a main factor for development, through a strong cultural identity and shared values: the respect of the people and the nature; and
- promoting dignity and sense of initiative, through developing a new confidence in the community about its own ability and potential.

Issues to be Considered

How to understand both the potential and limitations of community management? The establishment of basic conditions for a balanced relationship between producers/operators of medicinal and aromatic plants, traditional knowledge holders and other stakeholders in the sector requires considerable need for capacity building at all levels of intervention. The need to set up management structures and implement consultation also raises questions in terms of loss of social cohesion, representation of themselves and the concept of leadership both from stakeholders and beneficiaries points of view.

The local integration of the process in terms of adaptation and appropriation also requires more methodological references to socio-cultural or anthropological fields (development of practical understanding of systems of values, perceptions and representations). Collaborating with owners of traditional knowledge leads us to consider other important issues: where do their knowledge, their implication, and their expectations start and end?

As far as sharing benefits is concerned, it is a complex problematic to determine the nature and amount of services or retribution that local communities are expecting. Monetary aspects should be limited as much as possible as it seems that presently, revalorisation of the status of traditional healers is a real priority, as well as capacity building to ensure their correct understanding of the technical, scientific and administrative context and requirements. Helping them to be recognised by authorities and population, and providing them with appropriate technical assistance and equipments so they can "do their job" in the best possible conditions, appears to be a major trend of our collaboration for the coming years.All these issue need to be considered if we want to implement in an appropriate way the recommendations from major international conventions.

Proposals and Expectations

All our achievements, however, cannot be sustained, improved and distributed without a strong collective willingness of biodiversity conversation from international stakeholders: civil society, NGOs, private sector and governments.

The international trend and demand for sustainable products and services, and for ethical channels is the basis for the necessary economic changes that will help preserving global natural resources and ensure the rights of workers, producers and holders of traditional knowledge.

Nowadays, industry and distribution can play a major role in consumer education. At the same time, politics, fundraisers and stakeholders are developing new systems of monitoring economic performance, including social and environmental impacts. The private sector must be actively committed in raising awareness of audience about stakes and problems linked to a sustainable management of natural resources.

Meanwhile, sharing information and experience between actors and decision makers should be urged to allow the formalisation of methodologies of intervention that need to be simple, pragmatic and adapted to the cultural framework

Conclusion

In this time of changes, various solutions emerge for ensuring the protection of our common heritage, the planet Earth and its biodiversity. Many examples demonstrate that our natural wealth may contribute to the well being of the community, respecting the people and their culture.

However, these approaches require considerable change in our economic practices, and the regulatory frameworks that govern them. A new philosophy has to be implemented in joint projects and partnerships between all stakeholders. In this context, we need to address some weak points in the negotiation channels. They are difficult and limited access to information for people in rural and remote areas, huge gap between traditional social organisations and modern administration and business practices. Addressing these issues is the only way to ensure that future generations will be able to enjoy our natural and cultural heritage, while fully appreciating both its huge potential and extreme fragility.

RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review
Vol. 13 No. 3, pp 151-154

Perspectives

We have added a new column 'Perspectives' in the ABDR. This issue has the 'Perspectives' by Dr. S. K. Mohanty, Senior Fellow, RIS.

Regional Cooperation in Biodiversity and Biotechnology in Indian Ocean Rim: Challenges and Opportunities for IOR-ARC Countries

Dr. S. K. Mohanty

S. K. Mohanty*

As has emerged from this special issue of ABDR, the IOR region is rich in biodiversity, particularly with medicinal plants and marine biodiversity. But marine biodiversity is endangered on account of many factors including climate change, unsustainable exploitation of resources, etc. among others. Current literature shows that there is considerable knowledge gap in the areas of marine biodiversity among IOR countries.[1] While there have been initiatives to address this issue, more efforts are required at the national and regional levels to take advantage from the use of these resources by the Member countries.

Biodiversity and associated traditional knowledge, particularly, the traditional medicinal knowledge is an area which is important for the regional economies. The countries have to protect them from misappropriation and also use the existing knowledge and resources in a most efficient manner to improve health and well-being of peoples in the region and contributing to innovations. As has become clear from the special editorial by Dr. Ameenah Gurib-Fakim and the articles in this special issue, there is scope for regional cooperation. Some countries are rich in having traditional knowledge, and they may need support to develop their capacity to catalogue, digitise and use them more efficiently for conservation. Some countries may need assistance

*Senior Fellow, RIS. Dr. S. K. Mohanty is Chairman of the Indian Ocean Rim Academic Group (IORAG). IOR-ARC is an inter-governmental association of 19 countries of the IOR region. Email: skmohanty@ris.org.in

in capacity building, particularly in the Small and Medium Enterprise sector so that there can be value addition, to generate employment and to overcome challenges while producing for the global market. In certain countries, conservation efforts have to be prioritised. These diverse needs call for more cooperation and coordination among Member countries in trade, conservation and sustainable use.

There are some important initiatives which may be explored for this purpose, for instance the Indian Ocean Rim Association for Regional Co-operation (IOR-ARC) was established in 1997 to surge economic activities among member cuntries. At present it has 19 members, five dialogue partners and one observer. In the last IOR-ARC meeting of the Council of Ministers at Bengaluru, Seychelles rejoined as a Full-f agged Member of the Association. Since its inception, IOR-ARC moved ahead with many initiatives on diverse fields, *inter alia*, trade, investment, services, and science and technology, etc among others.

In 2009, GDP of the region was US $2777.3 billion with a total population of 1970.4 million, growing impressively at the rate of 6.5 per cent per annum during the period 2004-07. The broad macro parameters of the region economies are reasonably sound. The resilience of these economies has been remarkable as they have weathered and bounced back in strength since the first Asian crisis of 1999. These countries constitute a heterogonous group in terms of sizes of economy, differences in resource endowments, openness, trade and investment liberalisation. But intra-regional trade is often affected by structural problems among Member counties and further integration would accelerate economic growth in the region. This woud, in turn, enhance its status among the global regional groups and would help member countries to adopt comprehensive development strategies to address problems like underdevelopment and poverty. There are many areas where cooperation among Member countries can go a long way in benefiting from synergies existing within the region. Such cooperation should be extended to various sectors including manufacturing, natural resources, services, and other intangible assets.

As most of the countries of this grouping are also signatories to various conventions relating to conservation and biodiversity, coordination in terms of policy making and implementation is necessary. In fact, biodiversity and traditional knowledge are two areas where the countries can learn from each other besides launching regional initiatives for common benefit and mutual gain.

Evidences show that at present there is not much cooperation among the member countries on these issues. The remedy could be to take the first steps by launching initiatives with a focus on a small scale so that they can be expanded rapidly after being tested for few years. For example, two or three countries/Small Island Developing States can come together to map traditional knowledge, biodiversity, status of industries relying on biodiversity/medicinal plants so that they can examine the options before them in conservation and sustainable use of these resources.

Although traditional knowledge and biodiversity are valuable as such, value addition and consolidation of knowledge can help in protecting them, in fighting against biopiracy and in getting a better picture of the state of the art. For example, India's experience on Traditional Knowledge Digital Library (TKDL) can be relevant for many countries rich in traditional knowledge but lacking capacity in terms of expertise in Information Technology. TKDL captures the knowledge from various sources in digital format and is used by patent offices. But as the knowledge so captured is catalogued and organised, it can be used to arrive at the state of the art also so that potential leads can be identified. As knowledge is captured from different sources and traditions, compiling and cataloguing it helps is arriving at a holistic perspective on traditional knowledge.

A recent RIS study indicates that biotechnology has taken deep roots in many countries[2] within a period of a decade and half. While many countries have applied it in agriculture some others have ventured in health biotechnology with large investment in the sector. Here too the capabilities of the countries vary and not all countries can afford to invest or commit huge resources in this sector. But that need not deter them from harnessing biotechnology for national benefit as they can benefit from experiences of other countries. There is immense scope for initiating capacity building programmes in this area. Biotechnology is also a sector where incentives in cross-border investments can play an important role stimulating the nascent biotechnology industry.

Therefore, biodiversity, traditional knowledge and biotechnology offer ample scope for cooperation and collaboration within the IOR region. Integrating these within the framework of regional cooperation could be a challenge because they do not fit well within the current frameworks that are focused on trade, investments and goods. But it is possible to overcome the present impediments by having specific agreements in these areas in the broader regional cooperation framework. A beginning can be made by selecting a group of Member countries with a comprehensive agreement for collaboration in this area. This can be experimented with a small group of countries to begin with and can be expanded to a large group at a latter stage. Simultaneously bilateral initiatives could be initiated to facilitate cooperation in specific sectors.

Sectors like biodiversity, traditional knowledge and biotechnology offer ample scope for bilateral and regional cooperation in the IOR region, but they involve both challenges and opportunities. For harnessing the regional synergies, more initiatives are required.

Endnotes

1. Wafar M, Venkataraman K, Ingole B, Ajmal Khan S, Loka Bharathi P. (2011). “State of Knowledge of Coastal and Marine Biodiversity of Indian Ocean Countries.” PLoS ONE 6(1): e14613. doi:10.1371/journal.pone.001 4613
2. Chaturvedi, Sachin and Srinivas, Krishna Ravi. *Survey on Biotechnology Capacity in Asia-Pacific: Opportunities for National Initiatives and Regional Cooperation.* A Report prepared for UNESCO, Office, Jakarta and Regional Bureau for Science in Asia and the Pacific; and Research and Information System for Developing Countries, New Delhi. (Forth Coming).

Asian Biotechnology and Development Review (ABDR)

SURVEY FORM

Name:____

Organisation:____

Division:____

Address:____

City:______________________Country:______________________

Phone: ______________________Fax______________________

E-mail:____

ADDITIONAL INFORMATION

ABDR has turned out to be not only a valued source of information for the readers, but the readers could be a valuable information source for the *ABDR* as well. Therefore, we would be pleased if you fill in the additional information requested below. This will allow us to contact the right person/organisation in the right field at the right place, when needed. In this way, we hope to enlarge the geographic coverage of the articles in the *ABDR* and improve their quality.

1. **Your main sector** (Tick one or more):
   - ❑ Agriculture/Biodiversity
   - ❑ Health
   - ❑ Environment
   - ❑ Other, please specify
   - ❑ Intellectual property protection
   - ❑ Trade Related Issues
   - ❑ Biosafety

2. **Type of organisation you are involved in:**
   - ❑ NGO/Grass-roots organisation
   - ❑ (International) public organisation/government
   - ❑ University/college/school
   - ❑ Private industry

3. **Your preference in receiving ABDR issues**
   - ❑ Hard copy (as you receive now)
   - ❑ Electronic copy through email

Please do write to us if you would like *ABDR* to cover other areas of related interest. You may specify those areas

____

____

Please return this entire form to:Managing Editor

RIS

Research and Information System for Developing Countries

Core 4 B, Fourth Floor, India Habitat Centre

Lodhi Road, New Delhi - 110 003 (INDIA)

Tel.: 91-11-24682177/80 Fax: 91-11-24682173/74

Email: ravisrinivas@ris.org.in Website: www.ris.org.in

Asian Biotechnology and Development Review (ABDR)

ORDER FORM

For subcribers in India, Other Developing Countries and Rest of the World

	Annual		Single Issues	
	Institutional	Individual	Institutional	Individual
India	❑ Rs. 800	❑ Rs. 500	❑ Rs. 400	❑ Rs. 250
Other Developing Countries	❑ US$ 60	❑ US$ 30	❑ US$ 30	❑ US$ 15
Rest of the World	❑ US$ 95	❑ US$ 45	❑ US$ 48	❑ US$ 23

Tick as appropriate

❑ I/we would like to subscribe to **Asian Biotechnology and Development Review** and my payment instructions are given below.

❑ I/We would not like to receive **ABDR.**

❑ I/We would like to receive **ABDR** but am unable to pay the subscription charges.

Name: ______________________________

Company/Institution: ______________________________

Address: ______________________________

____

City: ____________________ State/Province: ____________________

Zip/Postal Code: ______________________________

Country: ____________________ e-mail: ____________________

Subscription Total: US$ / Rs.

Method of Payment

❑ Purchase order enclosed

❑ Bill me. Phone Number required

Phone: ____________________ Signature: ____________________

Send your order to Publication Officer along with the DD drawn in favour of Research and Information System and payable at New Delhi.

RIS

Research and Information System for Developing Countries

Core 4 B, Fourth Floor, India Habitat Centre
Lodhi Road, New Delhi - 110 003 (INDIA)
Tel.: 91-11-24682177/80 Fax: 91-11-24682173/74
Email: publication@ris.org.in Website: www.ris.org.in

Guidelines for Contributors

1. ABDR is a refereed multi-disciplinary international journal. Manuscripts can be sent, preferably as email attachment, in MS-Word to the Managing Editor, Asian Biotechnology and Development Review, Research and Information System for Developing Countries (RIS), Core 4B 4th Floor, India Habitat Centre, Lodi Road, New Delhi 110003, India (Email: ravisrinivas@ris.org.in; Tel. +91-11-24682177-80; Fax: +91-11-24682173/74). Submissions should contain institutional affiliation and complete mailing address of author(s). All submissions will be acknowledged on receipt.
2. Manuscripts should be prepared using double spacing. The text of manuscripts should not ordinarily exceed 7,000 words. Manuscripts should contain a 200 word abstract, and key words up to six.
3. Use 's' in '-ise' '-isation' words; e.g., 'civilise', 'organisation'. Use British spellings rather than American spellings. Thus, 'labour' not 'labor'.
4. Use figures (rather than word) for quantities and exact measurements including percentages (2 per cent, 3 km, 36 years old, etc.). In general descriptions, numbers below 10 should be spelt out in words. Use thousands, millions, billions, not lakhs and crores. Use fuller forms for numbers and dates— for example 1980-88, pp. 200-202 and pp. 178-84.
5. Specific dates should be cited in the form June 2, 2004. Decades and centuries may be spelt out, for example 'the eighties', 'the twentieth century', etc.

References: A list of references cited in the article and prepared as per the style specified below should be appended at the end of the article. References must be typed in double space, and should be arranged in alphabetical order by the surname of the first author. In case more than one work by the same author(s) is cited, then arrange them chronologically by year of publication.

All references should be embedded in the text in the anthropological style–for example '(Hirschman 1961)' or '(Lakshman 1989:125)' (Note: Page numbers in the text are necessary only if the cited portion is a direct quote).

Citation should be first alphabetical and then chronological–for example 'Rao 1999a, 1999b'.

More than one reference of the same date for one author should be cited as 'Shand 1999a, 1999b'.

The following examples illustrate the detailed style of referencing:

(a) Books:

Hirschman, A. O. 1961. *Strategy of Economic Development*. New Haven: Yale University Press.

(b) Edited volumes:

Shand, Ric (ed.). 1999. *Economic Liberalisation in South Asia.* Delhi: Macmillan.

(c) Articles from edited volumes:

Lakshman, W. D. 1989. "Lineages of Dependent Development: From State Control to the Open Economy in Sri Lanka." in Ponna Wignaraja and Akmal Hussain (eds) *The Challenge in South Asia: Development, Democracy and Regional Cooperation,* pp. 105-63. New Delhi: Sage.

(d) Articles from Journals:

Rao, M.G., K. P. Kalirajan and R. T. Shand. 1999. "Convergence of Income across Indian States: A Divergent View". *Economic and Political Weekly,* 34(13): pp. 769-78.

(e) Unpublished Work:

Sandee, H. 1995. "Innovations in Production". Unpublished Ph.D thesis. Amsterdam: Free University

(f) Online Reference:

World Health Organisation. 2000. "Development of National Policy on Traditional Medicine". Retrieved on March 31, 2011 from http://www.wpro.who.int/sites/trm/documents/Development+of+National+Policy+on+Traditional+Medicine.htm

- **Traditional Roles and Future Prospects for Medicinal Plants in Health Care**
  Ameenah Gurib-Fakim

- **Status of Conservation of Native Medicinal Plants of Mauritius and Rodrigues**
  Vikash Tatayah

- **Medicinal Plants from Reunion Island**
  Emmanuelle Girard-Valenciennes, Isabelle Grondin and Jacqueline Smadja

- **Value Addition to Aromatic Plants in Comoros**
  Mohamed Said Hassani

- **Support to the Basic Sciences in Developing Countries: Importance of Scientific Networks**
  Peter Sundin

Special IOR Forum

- **Role and Recognition of Local and Indigenous Practitioners' Knowledge: Perspective from Union des Comores**
  Ali Ahmed

- **Biodiversity and Traditional Knowledge in Reunion Island: Case of "*Competition Zerbaz péi*"**
  Héloïse Patiama, Isabelle Duriez-Benefix, Stéphanie Brillant, Claude Marodon and Jean-Claude Pieribattesti

- **Modelling Sustainable Valuation of Biodiversity in Madagascar: Case Study of Aromatic and Medicinal Plants**
  Séverine Blanchais

Perspectives

- **Regional Cooperation in Biodiversity and Biotechnology in Indian Ocean Rim: Challenges and Opportunities for IOR-ARC Countries**
  S. K. Mohanty

RIS
Research and Information System for Developing Countries
Core IV-B, Fourth Floor, India Habitat Centre
Lodhi Road, New Delhi-110 003, India.
Ph. 91-11-2468 2177-80, Fax: 91-11-2468 2173-74-75
Email: publication@ris.org.in, Website: www.ris.org.in