

Kapisen

Plant Conservation Action group



ISSN: 1659-7346

September 2014

Issue 17

Newsletter



The evolutionary history of Seychelles plants

Evolution of Seychelles flora

It would be difficult to communicate if we could not name things. However, the scientific study of naming and classifying plants and animals into groups - Taxonomy - is not an easy topic for most people. For one thing, Latin names are difficult to remember and seem to change from time to time, particularly more recently. So what is going on?

In the past, plants were described and named on the basis of their morphology. Species with a similar form and appearance were grouped together. More recently, new techniques are being used, based on the differences between the DNA (genome) of two species - the more similar the genes, the more closely related the species are. This phylogenetic work using molecular techniques is increasingly used to study also Seychelles plants and sometimes comes to different conclusions than older studies. In the pages of this Kapisen issue (p. 8, p. 16, p. 18 and p. 19) we show how recent research is revealing fascinating stories about our biodiversity heritage, and also helping to guide conservation actions. We learn that the Seychelles granitic islands flora is indeed very special (p. 5). In response to readers' suggestions, we provide brief 'In a Nutshell' summaries for each of the main articles (p. 3), intended for busy readers and those who prefer a simpler version.

One thing you may notice about the articles is that they are written by overseas botanists. Part of the reason for this is that there are no facilities in Seychelles to do genetic analysis, and therefore analyses are done elsewhere. Unfortunately, many taxonomic name changes are made without any consultation of local botanists; and until recently we often did not know that the name had changed until a visiting researcher told us. So it is important that scientists working on Seychelles plants collaborate with local botanists, follow proper procedures for collection of plant samples (e.g. getting the necessary research and collection permits) and acknowledging the assistance of local scientists. Experience in Mauritius (Florens 2013) has shown that researchers can sometimes cause more harm than good in terms of rare plant conservation.

Increasingly, local taxonomic experience is being built up, mainly as a result of the GEF-SGP funded 'Herbarium Project' (see Kapisen 13, 14, 15). In this Kapisen issue we highlight the important work of the Seychelles National Herbarium in reviewing current collections (p. 10), discovering and describing new species (p. 23) and creating new user-friendly aids

for the identification of species (p. 13). Even the Activity Page (p. 12) is based on the work of the Herbarium staff and will show you some of the skills need by a plant taxonomist!

Also in this issue, our usual PCA News (p. 21), Notes from the Field, with the main item being the naming of two new endemic fern species after local Seychellois botanists (p. 23), and the New Literature section (p. 26). Do email us with any comments and suggestions you may have.

Editorial Team: Katy Beaver, Eva Schumacher and Christoph Kueffer

Reference

Florens FBV (2013) Research safeguards protected areas: the important role of governments. *Trends Ecol Evol* 28 504-505

Cover photo: The tiny flowers of the Seychelles endemic orchid *Malaxis seychellarum* can be purple, yellow or green (B Senterre).

All photos not credited: contributed by PCA

The digital pdf version of Kapisen can be downloaded:
www.pcaseychelles.org/kapisen.html
www.geobot.ethz.ch/publications/books/kapisen

Email: pca.seychelles@gmail.com

Tel: 4241104 or 2574619

Content

In a Nutshell	3
Unique Endemic Flora	5
Vakwa (Pandanaaceae)	8
Biodiversity Data	10
Activity Page	12
Interactive Identification Keys	13
Kapisen (Northia)	16
Lalyann Potao (Nepenthes)	18
Bwadfer (Vateriopsis)	19
PCA News	21
Notes from the Feld	23
About PCA	25
New Literature	26

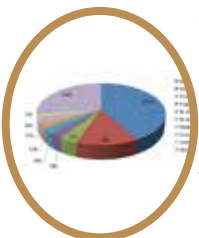
In a Nutshell – A Kapsen digest for the busy reader

**What makes Seychelles endemic flora unique?** (p 5)

1. Recent scientific studies have greatly increased our understanding of the evolutionary history of Seychelles flowering plants, but the place of many endemic Seychelles plants in the tree of life remains poorly understood.
2. About 60 endemic flowering plants are currently recognized for the granitic Seychelles islands. The resulting relatively low endemism of about one fifth probably stems from a) the important contribution of a large indigenous lowland and coastal flora to the total species count, and b) frequent dispersal between Seychelles, Madagascar and other islands in the Western Indian Ocean; especially during ice ages when there were more and larger islands, leading to high connectivity.
3. Recent phylogenetic studies confirm that many Seychelles species are uniquely important to understand plant evolution. Many are very old, often the oldest of the group of plants they belong to, or they are relicts of groups that disappeared elsewhere and therefore do not fit well into current plant classification.
4. The Seychelles flora is taxonomically very 'harmonic'. It almost perfectly samples the whole plant diversity: often there is one species per genus, one genus per family, and one family per plant order, and the plant orders are uniformly distributed across the whole tree of plant life. This might have less to do with the continental origin of Seychelles granitic islands than the small size of the islands, which makes divergent speciation difficult.
5. The history of many Seychelles species goes back to the ancient Gondawana supercontinent. This and more recent regular dispersal result in close affinities of Seychelles with other Western Indian Ocean floras, especially Madagascar. But there are also more far-reaching relationships, for instance the closest relatives of Kolofant (*Soulamea terminalioides*) are found in New Caledonia in the Pacific.

**Pandanaceae in the granitic Seychelles islands** (p 8)

1. Pandanaceae (screw-pines or 'vakwa' in Creole) are easy to distinguish by their long leathery leaves with prickly margins, usually spirally arranged at the end of branches. They can have various uses.
2. There are four species in granitic Seychelles. Analysis of the structure and genetics of each species shows that *Martellidendron hornei* (Vakwa parasol) is the oldest species and belongs to a genus unique to the region of Madagascar and Seychelles with only 6 species. Its conservation is therefore particularly important for the evolutionary history of Seychelles flora.
3. *Pandanus balfourii* (Vakwa bordmer) is part of a group of species that colonised nearly all the Old World tropical islands, especially South East Asia and the Pacific, although its presence in the Western Indian Ocean may be more recent. Its fruit is able to float for long periods in the ocean.
4. *Pandanus multispicatus* (Vakwadmontanny) and *Pandanus sechellarum* (Vakwa maron) are clearly related to Malagasy and Mascarene species. Their presence is probably linked to two independent ocean dispersal events between Western Indian Ocean islands.

**Seychelles' flowering plants and ferns – the number of specimens** (p 10)

1. Herbarium specimens are the basis for knowledge of the flora of any area, including Seychelles. The knowledge of species is dynamic, so it is important to have reference specimens and to know where they are held.
2. There have been many collections of plant specimens in Seychelles over the years, deposited in various herbaria around the world. But there are still gaps in collecting efforts.
3. Of the documented collections (6006 specimens) the majority is in Seychelles (4356), with other important holdings in Kew (London; 1138) and Paris (297). A further 2-3 thousand specimens, mainly from collections at Kew and Paris, are still to be entered in the database of the Seychelles herbarium.
4. The Seychelles National Herbarium currently holds specimens of 61% of all Seychelles flowering plants and ferns (1475 species and subspecies). Monocotyledons are less well represented. Exotic species are the least collected group. Only 52% of outer island species are represented compared with 68% of the inner islands.
5. Efforts to enlarge the Seychelles National Herbarium collection are supported by some key partners, e.g. Paris herbarium, which has repatriated around 600 specimens since 2011. Regional partnerships need to be developed and Seychellois students involved in taxonomic revisions.



Interactive keys to aid identification (p 13)

1. What do you do when you find an organism you don't know? Look in an identification book? Ask a local expert? Another method is to use a traditional identification key, in which a sequence of choices is made about two possible variations in a number of specific characters present in a group of organisms.
2. A simple example is given for Seychelles stick insects, of which there are 5 endemic species. These same stick insects are then used to demonstrate the creation of a more sophisticated computer-based tool for identifying organisms, known as an Interactive Key.
3. In an interactive key, once it is created using computer software, the user can freely choose the sequence of characters, rather than having to follow a particular pathway. Once a choice is made about a particular character, species which do not have this character variation are eliminated. Other characters are then selected until finally only one species remains.
4. Interactive keys should be developed for other local organism groups, especially those that remain difficult to identify by non-specialists (e.g. caecilians, frogs, freshwater crabs, grasses, ferns).



Northia ('Kapisen'), an isolated genus lost in the middle of the ocean (p 16)

1. *Northia seychellana* (or 'Kapisen', previously known as *Northea hornei*) is the only known species in the genus, which is endemic to the Seychelles.
2. It was previously thought to be related to a pan-tropical group of Sapotaceae. However, recent genetic information shows that *Northia* is isolated not only in the middle of the Indian Ocean, but also in terms of its relationship to the rest of the Sapotaceae family.
3. The geological history of Seychelles archipelago makes the evolution of *Northia* particularly interesting.
4. It is possible that some distant relatives evolved between Madagascar and Africa but that the ancestors of *Northia* rafted away on the Indian subcontinent (subsequently evolving further and colonising eastern Asia and Indonesia), while leaving *Northia* behind on the Seychelles geological plateau.



The carnivore *Nepenthes pervillei* ('Lalyann potao') (p 18)

1. The granite inselberg (glacis) habitat is a hostile and very nutrient-poor environment for most plants, but Lalyann potao (*Nepenthes pervillei*) not only survives here but has the ability to attract, kill and digest animals to sustain its growth.
2. The pitcher-shaped traps are modified leaves. The pitcher produces nectar which attracts insects to the rim. If the rim is wet the insect slips and falls into the liquid at the bottom; if the rim is dry the insect slips on waxy crystals which line the inside and again falls into the liquid and drowns.
3. The "lid" of the pitcher acts as an umbrella only, preventing dilution of the liquid contents by rain.
4. Digestive enzymes then dissolve the prey and nutrients are absorbed, much like in a stomach.
5. Certain bacteria, mites and mosquito larvae can live in the liquid without being digested.
6. The Seychelles pitcher plant has many typical features of the group but there are certain characters and genetic evidence which suggest it is a lonely survivor from an earlier age, not closely related to those in South East Asia, India or even to the 2 species in Madagascar. More research is required to confirm that its history goes back to the very early evolution of pitcher plants.



Not on a wing or a prayer (*Vateriopsis seychellarum* - 'Bwadfer') (p 19)

1. Bwadfer (*Vateriopsis seychellarum*) belongs to an important family of tropical hardwood trees, the dipterocarps (Dipterocarpaceae). Once common on Mahé, Bwadfer was heavily exploited for its excellent timber. Now only about 132 adult trees remain and it is considered a Critically Endangered species.
2. Bwadfer is the only species of *Vateriopsis* in the world, i.e. the genus is unique to Seychelles. It is also the only species of the Dipterocarpoideae sub-family outside of the main range from South Asia to New Guinea and is not related to the African-Madagascan sub-family.
3. Most species of Dipterocarp have fruits with wings, whereas Bwadfer has a rather ordinary looking fruit (see photos on pages 19 and 20). So Bwadfer might help us to understand the evolution of winged fruits in this family.
4. Genetic and fossil evidence supports the idea that the dipterocarps first evolved on the super-continent of Gondwana (of which Seychelles granitic islands were once a part).

What makes Seychelles endemic flora unique?

Christoph Kueffer, ETH Zurich
kueffer@env.ethz.ch

As botanists working in Seychelles we are proud of the uniqueness of the Seychelles flora. But what makes Seychelles plants special? In recent years the evolutionary history of many plant species from the Seychelles and the Western Indian Ocean has been studied with modern methods. I review in this article some of the stories that this new data tells us about the flora of the granitic Seychelles islands.

How many endemic species are there?

Seychelles is often compared with hotspots of endemic species such as Hawaii where about 90% of native species are endemic. However, the Seychelles flora has in fact a relatively low fraction of endemic species. Most native Seychelles plants also occur elsewhere; they are indigenous not endemic species. At present, 'only' about 60 endemic flowering plants are recognized for the granitic Seychelles islands¹. We have 'lost' some endemic species because they were found to occur in other places as well – for instance Mapou granbwa (*Pisonia sechellarum*) in the Comoros archipelago – or because their taxonomy changed – for example, Bwa kasandmontanny (*Timonius sechellensis*) is now considered a synonym of the widespread Southeast Asian species *Timonius flavescens*. Given that 268 native species are currently recognized (Senterre et al. 2013), about every fifth Seychelles species is endemic to the granitic Seychelles (22%). Why do the isolated and ancient islands of the Seychelles not have a higher proportion of endemic species? I suggest that there are two main explanations, and both make the low endemism of the flora an interesting feature rather than a disappointment.

First, low endemism seems to be a general pattern for many small islands. Ascension in the Atlantic or Pitcairn in the Pacific for instance have floras with a similarly low endemism. The reasons are probably

¹ I excluded endemic subspecies, such as Bwa merl, *Aphloia theiformis* and Bwa zoliker, *Pittosporum senacia*; and three species that occur also on Aldabra. These are endemic species of the Seychelles as a political unit but not as a biological region.



Figure 1 Fruits of the jellyfish tree (*Medusagyne oppositifolia* (C Kaiser).

that the mostly indigenous lowland and coastal species contribute a large proportion to the total flora, and the speciation of new species is rare on small islands (see below). In Seychelles, the lowland flora might be particularly large because during the ice ages when sea level was recurrently lower, the Seychelles granitic islands were exposed as a micro-continent of more than 40,000 km² of mostly lowland and coastal habitat. In addition, at these times a number of other large islands emerged from beneath the sea level in the vicinity of the Seychelles, which facilitated the dispersal of species from Madagascar and the Mascarenes (Mauritius and La Réunion) to Seychelles. Indeed, Seychelles shares many species with other islands in the Western Indian Ocean region, and in particular with Madagascar (see below). Thus, Seychelles large indigenous flora might at least partly be a reminder of a past mini-continent and reveal an exciting aspect of Seychelles botanical history. There might also be other explanations, for instance some endemic species might have died out without us knowing; new endemic species are still being discovered (see page 23), and some of the species considered indigenous might have been brought by humans to Seychelles and are in fact alien species.

The Seychelles flora is a unique memory of plant evolution

Because Seychelles formed part of the ancient Gondwana super-continent millions of years ago, we think of Seychelles flora as being very old. However, the first observation that a taxonomist might make when looking at the evolutionary tree of the Seychelles endemic plants (Figure 2) is that the earliest groups of flowering plants – in particularly

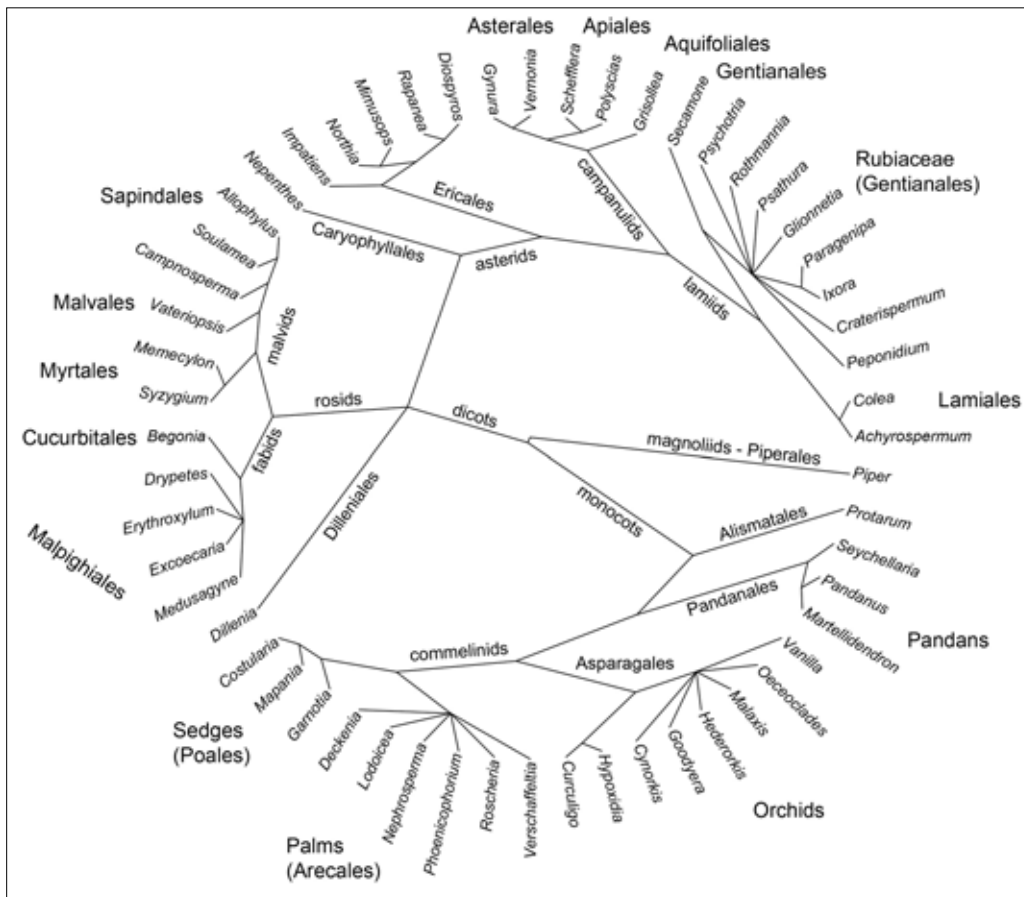


Figure 2

Evolutionary relationships of all flowering plant genera with endemic species on the granitic islands of the Seychelles.

the magnoliids – are conspicuously missing from the Seychelles flora. There might be an endemic pepper species (*Piper silhouettanum*) in Seychelles that belongs to these early flowering plants, but this species is not well known and is unlikely to be a very old *Piper* species. This observation adds an ironic twist to Seychelles botanical history because many of the alien species belong to these oldest flowering plant groups; for instance cinnamon, nutmeg, ylang-ylang, soursop, peppers, or avocado. In terms of evolutionary history, one could say that Seychelles flowering plant flora was never as ancient as now thanks to the novel plants brought in by us.

For understanding how ancient the Seychelles flora is, the absence of early flowering plants does not, however, tell us much because the well-represented monocots and many old dicot groups go also very far back in the evolutionary tree. Indeed, recent research confirms that many Seychelles plants are very old. For instance, the jellyfish tree (*Medusagynne oppositifolia*) – although it belongs currently 'officially' to the Ochnaceae family – represents according to the most recent data again an endemic Seychelles family (*Medusagynaceae*) (Figure 1) that goes back some 70 million years (Xi et al. 2012). Equally, Larourout dilenn maron (*Protarum sechellarum*) diverged some 75 million years ago from its closest

relatives (see Bogner and Renner, Kapsen 3, pp. 7-9). The Seychelles pitcher plant (*Nepenthes pervillei*) might be the oldest remaining species of its genus (see p. 19), and the same might be the case for Bwadfer (*Vateriopsis sechellarum*) in its Asian subfamily of dipterocarps (see p. 20). And many of the Seychelles plants seem to be the last remains of the plant groups they formerly belonged to, for instance Kapsen (*Northia sechellana*, see p. 17) or Bwa grolapo (*Grisollea thomassetii*); and Bwa rouz (*Dillenia ferruginea*) belongs to one of the most isolated plant orders of the dicots. Among pandans, Vakwa parasol is from a pandan genus (*Martelliidendron*) present only in Madagascar and Seychelles that diverged from other pandans 30 million years ago (see p. 9). Thus, many Seychelles plants sit at very strange places in the kinship tree of plants – often they seem to be relicts of early moments in the evolution of particular plant groups, and therefore taxonomists often struggle to fit them into the classification of the other plants. This makes them uniquely valuable for understanding the course of plant evolution. If a botanist could travel back in a time machine but could only bring home a few plants; Seychelles plants might well be his or her chosen selection!

One sample from each group



Figure 3 Fruits of the Kolofant tree (*Soulamea terminalioides*) (K Beaver).

A botanical garden might also consider using Seychelles flora as the basis of its collection. It almost perfectly samples the whole plant diversity: often there is one species per genus, one genus per family, and one family per plant order, and the plant orders are uniformly distributed across the whole tree of plant life (Figure 2). When there are several species in a genus, they often represent different colonization events of the Seychelles, and when there are several genera per family they come from different branches of the family tree. Coco-de-mer belongs to a different tribe than the other palms, Vakwa parasol is from a different genus than the other pandans, and Kapisen is in a different group within the Sapotaceae than Bwadnat (*Mimusops sechellarum*) or the indigenous Bwa monper (*Planchonella obovata*, formerly *Pouteria*).

An important reason for this very 'harmonic' distribution of species across higher taxa is that speciation of multiple species – the famous radiations found in other islands – is almost absent from Seychelles. There are three Bwa bannann species (*Polyscias*), and possibly the Hypoxidia and Curculigo species represent another small 'radiation' of multiple species in Seychelles. But for the other genera with multiple endemic species it is either not known whether they speciated in Seychelles (*Canthium* or now *Peponidium*, *Mapania*, *Psychotria*) or there is evidence that this is unlikely (*Pandanus*, p. 9). Four of the endemic palm genera cluster in one group in the tree of life, but they are more likely to be relicts from very old speciation events than a more recent radiation within Seychelles. This lack of

radiations is typical for small islands. They are too small to allow for geographic separation between plant populations as a basis for speciation (so-called allopatric speciation). Endemic species in Seychelles have thus either formed through continuous change of the same species (without dividing up into multiple species, so-called anagenesis) or its ancestor elsewhere died out (relict species).

Where are the closest relatives of Seychelles plants?

Lastly it is interesting to ask where the relatives of Seychelles endemic plants can be found. For the great majority, the closest relatives are found in the Western Indian Ocean, and in particular in Madagascar. For instance, *Seychellaria* and *Grisollea* are two genera that are endemic to the Western Indian Ocean, and many of the other indigenous and endemic plants of the Seychelles are either also present or have their closest relatives in Madagascar or other Western Indian Ocean islands including Sri Lanka (Bwa kalou – *Memecylon eleagni*). According to recent research it appears for example that the Bwa dir species (*Canthium*) belong to two different genera (*Peponidium* and *Pyrostria*) which have their centre of distribution in the Western Indian Ocean region (Razafimandimbison et al. 2009). Several species that are widespread in the Western Indian Ocean are interesting because they formed only different subspecies but not separate endemic species on the different islands. Bwa merl (*Aphloia theiformis*) for instance is considered to be the only species of a family (Aphloiaceae) that occurs only in the Western Indian Ocean and some places in southern Africa, with different endemic subspecies on different islands. Is this because dispersal of these plants was very frequent between the different islands in the region?

Besides these relationships within the region and often with Africa to the west, many of the old Gondwanan species (introduced above) have their closest relatives in the East, for instance the Pitcher plant, Bwadfer and Kapisen. An interesting Eastern relationship is Kolofant (*Soulamea terminalioides*) (Figure 3), which is from a genus in which all other species are in New Caledonia and the Pacific. The unique position of the Seychelles flora between Africa and Asia has been known for long, but recent results further illuminate this special biogeographic place between two biological worlds.

Thanks to recent research, we do learn more and more about the fascinating evolutionary history of

the Seychelles. Conspicuously, in almost every new publication, the authors call the Seychelles plant an enigmatic species, in other words a species that they had difficulty to deal with and understand. There is clearly a need for more studies about the evolutionary history of Seychelles flora. Seychelles flora has many more secrets and insights about the evolution of plant diversity to tell!

References

- Razafimandimbison, S.G., Lantz, H., Mouly, A., Bremer, B., 2009. Evolutionary trends, major lineages, and new generic limits in the dioecious group of the Tribe Vanguerieae (Rubiaceae): insights into the evolution of functional dioecy. *Annals of the Missouri Botanical Garden* **96**: 161-181.
- Senterre, B., E. Henriette, L. Chong-Seng, J. Gerlach, J. Mougale and G. Rocamora. 2013. Seychelles Key Biodiversity Areas - Output 6: Patterns of conservation value in the inner islands. Consultancy Report, Ministry of Environment-UNDP-GEF project, Victoria, Seychelles.
- Xi, Z., Ruhfel, B.R., Schaefer, H., Amorim, A.M., Sugumaran, M., Wurdack, K.J., Endress, P.K., Matthews, M.L., Stevens, P.F., Mathews, S., 2012. Phylogenomics and a posteriori data partitioning resolve the Cretaceous angiosperm radiation Malpighiales. *Proceedings of the National Academy of Sciences (PNAS)* **109**: 17519-24.

Biogeography, conservation and diversity of Pandanaceae in the granitic Seychelles Islands

Martin W. Callmander

Missouri Botanical Garden and Conservatoire et Jardin botaniques de la Ville de Genève

Martin.callmander@mobot.org

Sven Buerki

Royal Botanic Gardens, Kew

S.buerki@kew.org

Pandanaceae (screw-pines or “Vakwa” in Creole) are easily distinguishable by their long leathery evergreen leaves with prickly margins, usually spirally arranged at the end of branches. Stems often bear leaf scars and stilt roots at their base. The reproductive structures are on separate plants (the family is therefore “dioecious”). The male flowers are very simple with no petals and are particularly ephemeral. The female flowers are pineapple like and develop into distinctive fruits made of tightly arranged sections or drupes (containing the seeds). Screw-pines are used for various purposes and are commonly grown as ornamental plants. In south-east Asia, leaves of *Pandanus amaryllifolius* are used for cooking, adding a specific aroma to chicken and green food colouring to desserts. In Micronesia, especially on the atolls, the fruits of *Pandanus tectorius sensu lato* are eaten cooked as a major source of starch. In Seychelles,



Figure 1 *Martellidendron hornei* (Balf. f.) Callm. & Chassot at the Mare aux Cochons in Mahé (M Callmander).

the elongated roots of *Pandanus sechellarum* were once cut lengthwise into 4 (“lati”) and used in the construction of decorative house walls.

According to recent molecular and morphological analyses the Old World tropical monocotyledon Pandanaceae family includes five genera and >700 species (Buerki et al., 2012). The five genera are: *Sararanga* (2 spp. in the Philippines, New Guinea, and the Solomon Islands), *Martellidendron* (6 spp. in Madagascar and the granitic Seychelles Islands), *Freycinetia* (ca. 200 spp. in Asia, Indo-Malaysia, Australia and the Pacific Islands), *Pandanus* (ca. 450 spp. in the paleotropics) and the newly described



Figure 2 *Pandanus multispicatus* Balf. f. on a „glacis“ at the Trois Frères nature trail (M Callmander).

genus, *Benstonea* (60 species mainly in south-east Asia, but also in India, Australia and the Pacific Islands), named in honour of Benjamin Stone, who contributed immensely to the taxonomy of the family (Callmander et al., 2013).

Four species of Pandanaceae (three *Pandanus* and one *Martellidendron*) occur in the granitic Seychelles Islands (Mahé, Praslin, Silhouette, La Digue and Curieuse). Biogeographical inferences support three independent colonisations of Pandanaceae in the granitic Seychelles Islands (Gallaher et al, in review). *Pandanus multispicatus* and *P. sechellarum* show strong morphological and phylogenetic relationships with Malagasy and Mascarene species, whereas *P. balfourii* belongs to a lineage of sea-dispersed species distributed across Old World tropical islands. Finally, *Martellidendron hornei* is sister to the Malagasy taxa of this genus and belongs to a different lineage in the family (Buerki et al., 2012). The Seychelles' "Vacoa" or "Vakwa" have therefore different origins and age, but all dispersed to these islands via long distance dispersals using ocean currents.

"Vakwa Parasol" or "Horne's Pandanus" – *Martellidendron hornei* – is an emblematic and impressive species, critical to most granitic Seychelles landscapes in wetter areas at mid elevation (Figure 1). *Martellidendron hornei* is currently considered as Vulnerable in the IUCN Red List (IUCN, 2014). Based on preliminary dating inferences, this genus diverged from the ancestor of *Benstonea* and *Pandanus* in the Late Oligocene to Early Miocene, c. 30 Mya ago (Gallaher et al., in review) making this species the oldest Pandanaceae of the Seychelles. Protecting this unique native plant would therefore greatly contribute to the conservation of the evolutionary history of the Seychelles.

"Vakwa Bordmer" – *Pandanus balfourii* – is found in coastal areas on boulders, marshy and sand areas (Matatiken & Dogley, 2006). It is part of a group of species that colonized nearly all the Old World tropical islands, especially in the Pacific (where it is called *Pandanus tectorius sensu lato*) and South-East Asia (where it is called *Pandanus odoratissimus sensu lato*). This wide distribution is primarily due to the ability of the fruit to float for long periods on the oceans. The presence of this lineage on the Western Indian Ocean islands (also found on Aldabra and the Comoro Archipelago) is probably geologically relatively recent (less than 15 Mya ago) (Gallaher et al., in review)

The last two endemic species of the granitic Seychelles, "Vakwadmontanny" – *Pandanus multispicatus* – and "Vakwa maron" – *Pandanus sechellarum* – are common species on rocky outcrops (glacis) at low to mid-elevation where the former often forms dense thickets (Matatiken & Dogley, 2006) (Figure 2). Both species are currently considered as Near Threatened in the IUCN Red List. Several healthy and stable subpopulations are found. These two species have clear morphological affinities with Malagasy and Mascarene species and belong to the same subgenus: *Pandanus* subg. *Vinsonia*. The presence of these two endemic species is probably linked to two independent Ocean dispersal syndromes between the Western Ocean Islands.

References

- Buerki S., M.W. Callmander, D.S. Devey, L. Chappell, T. Gallaher, J. Munzinger, T. Haevermans & F. Forest (2012). Straightening out the screw-pines: a first step in understanding phylogenetic relationships within Pandanaceae. *Taxon* 61(5): 1010-1020.
- Callmander, M. W., P. P. Lowry II, F. Forest, D. S. Devey & H. Beentje. (2013). *Benstonea* Callm. & Buerki (Pandanaceae): characterization, circumscription, and distribution of a new genus of screw-pines, with a synopsis of accepted species. *Candollea* 67: 323-345.
- Gallaher T., M.W. Callmander, S. Buerki & S.C Keeley (in review). A long distance dispersal hypothesis for the Pandanaceae and the origins of the *Pandanus tectorius* complex. *Molecular Phylogenetics and Evolution*.
- IUCN (2014). *The IUCN Red List of Threatened Species*. Version 2014.2. <<http://www.iucnredlist.org>>.
- Matatiken D. & D. Dogley (2006). Guide to endemic Palms and Screw-pines of the Seychelles granitic Islands. Plant Conservation Action group, Victoria, Seychelles, 45 pp.

Basic data on the biodiversity of Seychelles: an assessment of the number of specimens historically collected for its vascular flora

Bruno Senterre & Charles Morel
PCA Members + Seychelles National Herbarium
bsenterre@gmail.com

Herbarium specimens are the base for any knowledge on the flora of a region, for example for the plant species occurring in Seychelles. And this knowledge is a dynamic one because the conception of these species depends on how scientists regroup such specimens according to their similarities, and further review species conceptions as new discoveries are made. Consequently, any further development of the knowledge on the conceived species (conservation status, invasiveness, origin, etc.) depends on specimens as verifiable references. For example, newly introduced invasive species can occasionally be misidentified when reference specimens are not compared, and consequently their invasiveness can be misidentified. It is therefore useful to know the total number of herbarium specimens collected in Seychelles. In this article, we provide details regarding the main international repositories holding some of the Seychelles historical plant specimens, and we look into differences between distinct groups of plants and between islands of Seychelles, emphasizing the gaps in collecting effort, and therefore the potential gaps in taxonomic knowledge.

The history of botanical explorations in Seychelles has been summarized in several documents (Baker 1877; Summerhayes 1931; Wise 1998). The main historical collections were made by : M. Bojer (1840;

K¹), A. Pervillé (1841; K, P), J. Kirk (1862-1866; K), E.P. Wright (1867; BM, K), J. Horne (1871, 1874; 700 specimens; K), A.F.W. Schimper (1899; 140 specimens; B?), H.P. Thomasset & P.R. Dupont (1900-; K), J.S. Gardiner (1905, 1908; K), D. Vesey-Fitzgerald (1936-1939; BM, K), C. Jeffrey (1960-1962; SEY, K), D.R. Stoddart (1968-1980; K), J. Proctor (1970, 1972, 1973; SEY, K), F.R. Fosberg (1970; SEY, K, US), S.A. Robertson (1975-1981; 800 specimens: SEY, K), F. Friedmann (1981-1986; P), C.S. Awmack (1997; 180 specimens; SEY), and B. Senterre (2008-; ca. 1700 specimens; SEY) (Senterre *et al.* 2010: 15).

To get a complete list of the specimens historically collected in the Seychelles, we compiled those cited by Robertson (1989), who listed specimens present at SEY (1800) and K (760). For ferns, we entered all specimens cited by Tardieu-Blot (1960). Finally, we entered all specimens currently present in the Seychelles National Herbarium (SEY) and those available online for Paris (P) and Kew (K).

In total for vascular plants (i.e. including flowering plants, conifers, and ferns, and excluding mosses, algae, and fungi), we recorded 6006 specimens, of which 4356 are present at SEY, 297 at P and 1138 at K. We estimate that about 2000-3000 specimens are missing from our database (mostly those of Horne and Friedmann deposited at K and P). Currently, the Seychelles National Herbarium hosts specimens representing 901 species of vascular plants, out of a flora of 1475 species (and subspecies), i.e. 61 % (Table 1). In general, monocotyledons (herbs, palms, orchids, etc.) are less represented compared to other groups. Exotic species are the least collected group (Figure 1). The flora of the outer islands is less represented in the herbarium (211 species

¹ Herbaria where the specimens have been deposited are represented by their acronym (Thiers 2010): B = Berlin; BM = British Museum; K = Kew; P = Paris; SEY = Seychelles; US = Washington DC.

Table 1 Number of taxa (species, subspecies and varieties) recorded in the vascular flora of Seychelles ('All') and represented by specimens in the Seychelles National Herbarium ('SEY').

Group	unknown		endemic		indigenous		exotic		Total	
	ALL	SEY	ALL	SEY	ALL	SEY	ALL	SEY	ALL	SEY
Dicotyledon	2	1	71	58	166	138	734	441	973	638
Monocotyledon	75	40	36	24	96	68	159	31	366	163
Gymnosperm							9	0	9	0
Fern	2	0	17	17	93	73	15	10	127	100
Total	79	41	124	99	355	279	917	482	1475	901

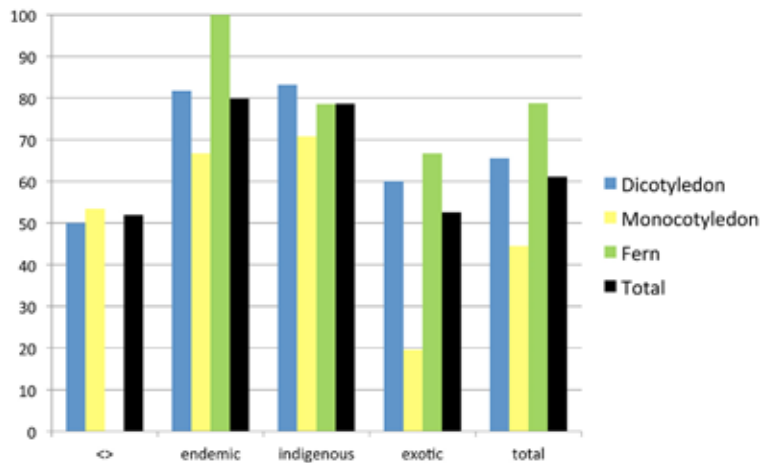


Figure 1 Proportions (%) of the Seychelles flora represented by reference specimens at the Seychelles National Herbarium. Values are calculated based on Table 1; '< >' corresponds to species of unknown origin status.

with specimens out of 407 species for the flora, i.e. 52%), compared to the flora of the inner islands (831 species represented by specimens out of 1221 species, i.e. 68%). Considering specimens from all repositories, the most sampled islands by far are Mahé and Silhouette (Figure 2). Some islands where key biodiversity areas have been identified (Senterre *et al.* 2013) are particularly poorly sampled and would deserve more attention, e.g. Félicité (43 specimens), La Digue (32 specimens). More details on gaps of exploration are provided in the recent key biodiversity areas study (Senterre *et al.* 2013).

In conclusion, there is still work to do in terms of specimen collection in Seychelles considering that our local reference collection includes only 61% of the existing species. Encouragingly, this effort to enlarge the Seychelles National Herbarium is supported by some key partners, e.g. the herbarium of Paris, which has been repatriating duplicates of Seychelles specimens (ca. 600 numbers since 2011), including some type specimens (those used to define scientific names). Such collaboration and exchanges need to be carefully maintained and further developed with other partners within the region (e.g. La Réunion, Madagascar, Mauritius), towards the development of a regional flora. This can be facilitated by the involvement of Seychellois students in small taxonomic revisions, e.g. Labiche-Barreau & Senterre (2012), and exchanges between universities. Finally, duplicates of newly collected specimens should be sent as a priority to these collaborating herbaria overseas, especially Paris where most of the Seychelles historical collections are already found.

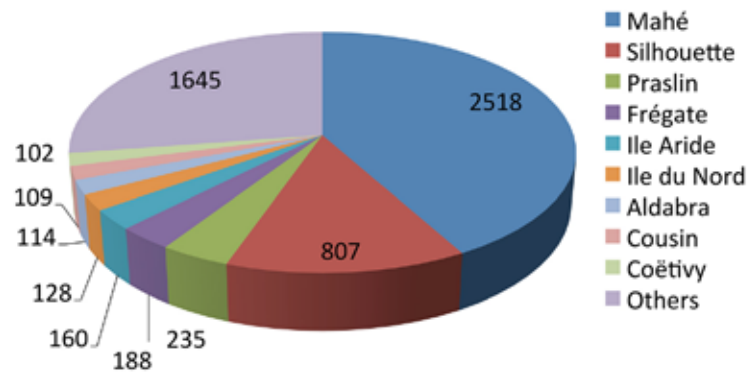












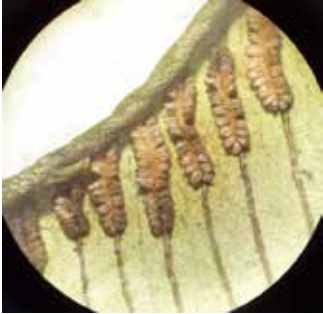

Figure 2 Number of specimens collected per island, including all herbarium repositories.

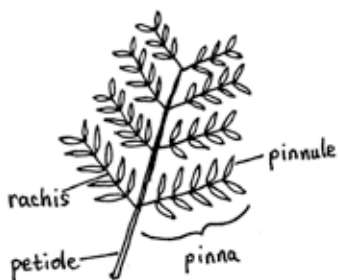
Literature cited

- Baker, J.G. 1877. *Flora of Mauritius and the Seychelles - A description of the flowering plants and ferns of those islands*. London: Reeve & Co., 557 p.
- Labiche-Barreau, N. and B. Senterre. 2012. Impact of the Herbarium Project on local expertise in plant identification: the example of Acanthaceae. *Kapisen* 13: 14-15.
- Robertson, S.A. 1989. *Flowering plants of Seychelles (An annotated checklist of angiosperms and gymnosperms with line drawings)*. Kew: Royal Botanic Gardens, 327 p.
- Senterre, B., E. Henriette, L. Chong-Seng, J. Gerlach, J. Mougil and G. Rocamora. 2013. Seychelles Key Biodiversity Areas - Output 6: Patterns of conservation value in the inner islands. Consultancy Report, Ministry of Environment-UNDP-GEF project, Victoria, Seychelles.
- Senterre, B., G. Rocamora, J. Bijoux, J.A. Mortimer and J. Gerlach. 2010. Seychelles biodiversity metadatabase. Output 5: Priority Gap Analysis on Seychelles' Biodiversity knowledge and information. Consultancy Report, Ministry of Environment-UNDP-GEF project, Victoria, Seychelles, 270 pp.
- Summerhayes, V.S. 1931. An enumeration of the Angiosperms of the Seychelles Archipelago. *Trans. Linn. Soc.* 19: 261-299.
- Tardieu-Blot, G. 1960. Les fougères des Mascareignes et des Seychelles. *Notulae Systematicae* 16: 151-201.
- Thiers, B. (2010 -accessed 1 September 2013). Index herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden. New York Botanical Garden. URL <http://sweetgum.nybg.org/ih/>.
- Wise, R. 1998. *A Fragile Eden*. Princeton University Press, 192 p.

Spot the difference!

The two new species of 'Baton mosenyer' fern (see p. 23) were not easy to detect in the Mahé forests! One of them had not been seen for 100 years; the other was not recognised as being a different species until 2011. See if YOU can see the differences between the 3 species. Could you become a good taxonomist....?

	Baton mosenyer (<i>Angiopteris madagascariensis</i>) (a relatively common indigenous forest fern)	Baton mosenyer-d-granbwa (<i>Angiopteris chongsengiana</i>) (a rare new species found in mist forest ravines)	Pti baton mosenyer (<i>Ptisana laboudalloniana</i>) (last seen 1911, recognised now as a new species)
1 frond with several pinnae			
The end of one pinna			
Part of the rachis			
Sporangia (spore sacs)			



Part of 1 pinnule

1 fern frond

Photos: I Fabre, B Senterre, C Morel, K Beaver, G Gendron

Solution on page 15.

Towards interactive keys for identification: the case of the stick insects of Seychelles

Elvina Henriette ¹ and Charles Morel ²

¹ Biodiversity Consultant

² National Herbarium Curator, Seychelles

elvinahenr@gmail.com

What do you do when you come across an organism or a specimen of unknown identity? Some of us will consult an identification guide, if available, or a more detailed flora like the 'Flora of Seychelles' (Friedmann 1994), or, if it is an insect, we might ask a knowledgeable local person such as Pat Matyot.

Another method is to use a key, such as the one below (Figure 1), which is based on a simple key developed by Pat Matyot and illustrates the process to identify the Stick insects of Seychelles. Each number at the left of the key gives possible variations (states) of a particular character. To identify the species, the user starts at character 1, and selects the character state that best describes the specimen: 'Wings present' or 'No wings present at all'. Each state points to a taxon (scientific name) or to another number. In the latter case, the key sends the user to number 2 where the states of a new character are examined, and the appropriate one selected ('Spines present on upper surface of abdomen' or 'No spines present on upper surface of abdomen'). This process is continued until a species name is reached. Such a key is said to be "dichotomous" (there are two choices at each point).

The intention here is clearly to be "user-friendly", i.e. "easy" characters are used and technical terms are avoided, so that any interested person who is not a taxonomist can use the key to identify specimens.

Compare this with the following extract from a key to identify the micro-moths of the Philippines, primarily intended for fellow taxonomists:

- | | |
|--|---|
| 1. Forewing with transverse fascia furcate below | 2 |
| Forewing with transverse fascia not furcate | 3 |

Apart from such traditional identification tools, there are now sophisticated tools that have been developed, such as Interactive keys created using computer software. The user can freely choose the sequence of characters to be used, according to what can be observed on a given specimen or in the field. Following the example above, if the user selects "wings absent", the interactive key will remove from the selection all species which do not have wings. Further characters are then selected to eliminate species until only one taxon remains (Coleman *et al.* 2010; Dallwitz *et al.* 2013; Spooner and Chapman 2013).

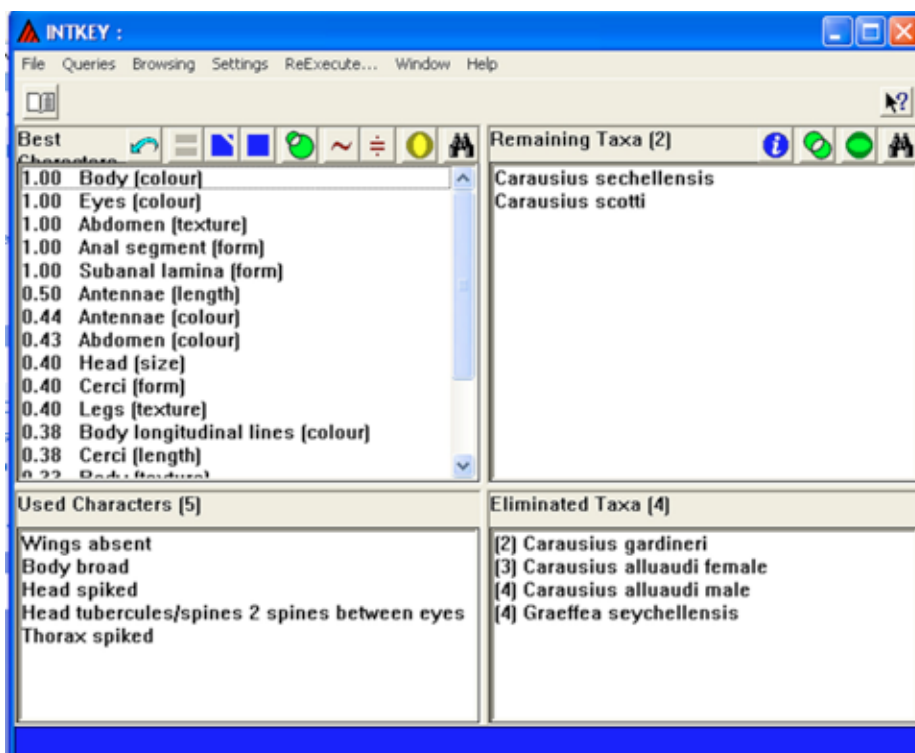
Several software tools exist to create interactive keys. We have been using one called DELTA to create an interactive key for the identification of the Seychelles Stick insects. The Seychelles has five endemic species of Stick insects (Bolivar and Ferriere 1912, Table 1). Silhouette is the only island with all five species, one of which, *Carausius scotti* is endemic to Silhouette. *C. sechellensis* is the most widespread, being present on Mahé, Praslin, La Digue, Silhouette and Félicité. (Matyot 1992; Senterre *et al.* 2013). The stick insect species have distinctive differences (Table 1) but some also vary within the species. For example, *C. gardineri* has variable colours (brown, black, green and presence or absence of pale brown patches); *C. sechellensis* and *C. gardineri* have larval stages that are different from the adults; in *C. alluaudi* the sexes are different colours. There are also more specialised differences, and the ecology, behaviour and distribution of the species are also in need of further research.

- | | |
|--|--|
| 1. Wings present | <i>Graeffea sechellensis</i> |
| No wings present at all | 2 |
| 2. Spines present on upper surface of abdomen | <i>Carausius scotti</i> (on Silhouette only) |
| No spines present on upper surface of abdomen | 3 |
| 3. Eyes black (female 10 cm long or more;
male often brick red in colour) | <i>Carausius alluaudi</i> |
| Eyes NOT black (female LESS than 10 cm long;
male NOT brick red)..... | 4 |
| 4. Two little spines at the top of the head, between the eyes | <i>Carausius sechellensis</i> |
| NO spines at top of head between the eyes | <i>Carausius gardineri</i> |

Figure 1 A simple traditional identification key for the Seychelles Stick insects by Pat Matyot.

Table 1 A selection of characters and states of characters for identification of the five species of Stick insects

Taxon	<i>Carausius alluaudi</i>	<i>Carausius gardineri</i>	<i>Carausius scotti</i>	<i>Carausius sechellensis</i>	<i>Graeffea seychellensis</i>
Presence of wings	Absent	Absent	Absent	Absent	Present
General body texture	Smooth	Smooth	Spiked	Granulated/ tuberculated/ spiked	Smooth
Body thickness	Slender	Slender	Broad	Broad	Slender
Body colour	Male red, female brown	Light to dark brown, black, greyish black, larvae green	Orangish-brown/ yellowish- brown, black at articulations	Brown/beige	Yellowish-brown/ reddish brown
Head tubercles/ spines	Absent	Absent	2 spines between eyes; or 2 smaller spines on the occiput	2 spines between eyes	Absent
Eye colour	Black	Red	Black	Beige/Brown	-
Antennae length	Longer than forelegs	Longer than forelegs	Longer than forelegs	Long, reaching forelegs	Short, not reaching end of forelegs
Thorax texture	Smooth	Smooth	Spiked	Granulated/ tuberculated/ spiked	Smooth
Abdomen texture	Smooth	Smooth	Smooth	Spiked	Smooth
Anal segment form	Compressed; roof-like	Roof-like	Compressed; roof-like	Roof-like in male; semicircular, sinuous in female	Keeled
Cerci	Long, incurved	Long, incurved	Short, incurved	Short, thick, slightly incurved	Long, narrow, lanceolate

**Figure 2**

The use of IntKey to generate an interactive key for the five species of Stick insects. The 'Best character' pane shows the characters that can be chosen by the user. The 'Used character' pane shows the characters that the user has chosen to identify the specimen. The 'Eliminated taxa' shows the taxa that do not meet the character chosen by the user and the 'Remaining taxa' shows the taxa that correspond to the attributes chosen by the user.

Figure 3

Examples of illustrations that can be added in IntKey to illustrate each character state, e.g. a) spiked body versus b) smooth body.

a) spiked body



b) smooth body

A few steps are necessary to create an interactive key. First, the user creates a database of characters and states of characters (as in Table 1). Next, the IntKey function of DELTA is used to create the interactive key (Figure 2). Illustrations can be added for each character state, e.g. spiked body versus smooth body (Figure 3), so that the user can understand the characters, including even relatively difficult “technical” ones.

This article provides the first synthesis on identification of all Seychelles stick insects based on an interactive key which will be available online once completed. The National Herbarium Team at the Seychelles Natural History Museum has also been using DELTA to produce descriptions of species and interactive identification keys for the palms and ferns of Seychelles. More interactive keys should be developed for other groups, especially those that remain difficult to identify by most non-specialists (e.g. caecilians, frogs, freshwater crabs and other crustaceans). DELTA and its programme IntKey are versatile, user-friendly tools that can be used for taxonomic studies, and the information can be made available to other users. As such, well described and well catalogued taxa are important for decision making, research, education and the conservation of biodiversity.

References

- Bolivar, I. and Ferriere, C. (1912). “Orthoptera, Phasmidae of the Seychelles.” *Transactions of the Linnean Society London* **15**: 293-300.
- Coleman, C. O., Lowry, J. K. and Macfarlane, T. (2010). *DELTA for Beginners: An introduction into the taxonomy software package DELTA*, PenSoft Publishers LTD.
- Dallwitz, M. J., Paine, T. A. and Zurcher, E. J. (2013). “Principles of interactive keys.” Web-based document <http://biodiversity.uno.edu/delta> 3.
- Friedmann, F. (1994). *Flore des Seychelles*.
- Matyot, P. (1992). “Phasmids on Praslin and La Digue islands in the Seychelles.” *Phasmid Studies* **1**(1): 17-20.
- Senterre, B., Henriette, E., Chong Seng, L., Gerlach, J., Mougil, J. and Rocamora, G. (2013). *Seychelles Key Biodiversity Areas - Output 6: Patterns of conservation value in the inner islands*. Consultancy Report, Ministry of Environment-UNDP-GEF project, Victoria, Seychelles.
- Spooner, A. and Chapman, A. (2013). “DELTA InyKey tutorial. User’s Guide, Version 1.0.1.”

Answers to ‘Spot the difference’ (see page 12)

<i>A. madagascariensis</i>	<i>A. chongsengiana</i>	<i>P. laboudalloniana</i>
Fronde with alternate pinnae (alternating up the stem)	Fronde with alternate pinnae (alternating up the stem)	Fronde with opposite pinnae (opposite each other on the stem)
Last pinnule(s) similar size to the rest	Last pinnule much longer than the rest	Last pinnule(s) similar size to the rest
Pinna rachis is not winged	Pinna rachis is winged	Pinna rachis is winged
Sporangia distinct but not fused	Sporangia distinct but not fused	Sporangia fused together

Of course there are more differences than this between the species, but this gives you an idea of the small differences that you need to look for. If you got 3 correct, then you are well on your way to being a good taxonomist!

Northia, an isolated monotypic genus of Sapotaceae lost in the middle of the Ocean: can we find its parents?

Laurent Gautier, Yamama Naciri

Conservatoire et Jardin botaniques de la Ville de Genève, Switzerland

laurent.gautier@ville-ge.ch

Northia seychellana Hook.f. ('Kapisen' in Creole; the name of this journal) is the only known species in the genus, which is endemic to the Seychelles¹. It has so far been considered to be allied to the species-rich pantropical genus *Manilkara*² (Pennington 1991). However, a combination of floral and fruiting characters indicates that this relationship might not be that close³. Indeed, recent molecular phylogenies (information about the evolutionary relationship

- 1 When J.D. Hooker described the genus, he dedicated it to Marianne North (1830-1890), but wrongly used the spelling "*Northea*". It had then to be corrected to "*Northia*" following the International Code of Botanical Nomenclature. The correct scientific name of the only species is therefore *Northia seychellana* Hook.f. (*N. hornei* Pierre being illegitimate).
- 2 due to its biseriolate calyx of 3 + 3 sepals, its hexamerous corolla with 6 stamens, and its 6-locular ovary
- 3 These traits include the obsolescence of the pair of appendages to the corolla lobes and of the staminodes, the broad adaxial seed scar covering up to half the seed surface, and the absence of endosperm.



Leaves of *Northia* showing the typical brownish underside (C Morel).

based on the analysis of genes) have considerably improved our understanding of the evolution of the Sapotaceae (Anderberg & Swenson, 2003; Swenson & Anderberg, 2005; and Smedmark et al., 2006). A recent study that focused on the subfamily Sapotoideae (Gautier et al., 2013; see Figure 1) has confirmed four different taxonomic tribes⁴: Sideroxyleae (pantropical), Tseboneae

4 monophyletic clades

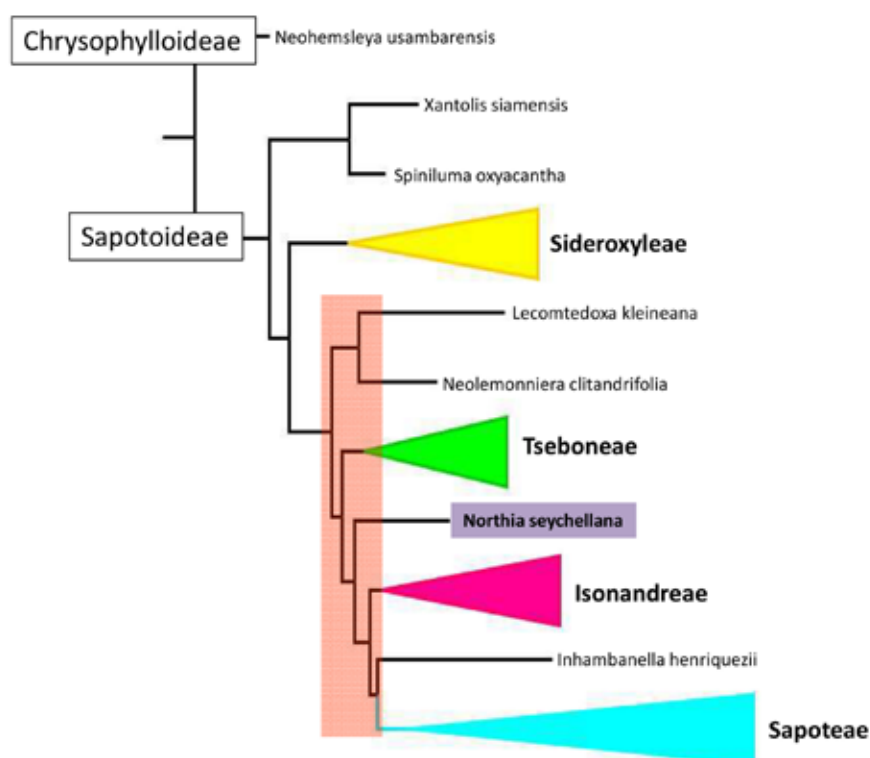


Figure 1

Bayesian majority-rule consensus tree of Sapotoideae (Sapotaceae) based on DNA molecular sequence data (ITS, trnH-psbA). Simplified from Gautier et al. (2013).

(Madagascar), Isonandreae (Indo-Pacific) and Sapoteae (pantropical, but clearly of African origin, and to which the second endemic Sapotaceae of the Seychelles – *Mimusops sechellarum* – belongs). However, a few orphan genera remain isolated from these main groups, including the basal *Spiniluma* and *Xantolis* (Asia), a few African genera (*Inhambanella*, plus *Lecomtedoxa* and *Neolemonniera*, sister to each other), and finally *Northia*. Identifying *Northia*'s closest relatives remains puzzling due to its isolated position both genetically and geographically, and the geological history of the Seychelles archipelago makes it particularly interesting.

While it is clear that the Sideroxyleae tribe and the *Xantolis* and *Spiniluma* genera evolved early in the history of the Sapotoideae subfamily, the evolution of the three other tribes – Tseboneae, Sapoteae, Isonandreae – and the remaining orphan genera (including *Northia*) is not well understood (orange rectangle in Figure 1). They form a large group now distributed widely in the Old World tropics (including the genus *Manilkara* which later colonized the Neotropics, Armstrong et al., submitted). Improving our understanding of the evolutionary history of this group on the basis of molecules will require further sampling of *Northia* and the analysis of other loci in the genome. However, on the basis of morphology, *Northia* appears more closely related to the Asian Isonandreae than to the Malagasy Tseboneae, or to the Sapoteae where it was previously grouped. Compared with what seems to be the ancestral morphology of the subfamily, both *Northia* and Isonandreae have evolved distinct new characters⁵

5 obsolescence of staminodes, and, like most Sapoteae, biseriate calyx.



Northia is often the dominant tree on higher mountain ridges (K Beaver).



Flowers of *Northia* (petals have fallen) (H Elzein).

whereas other members of the group have evolved other new traits⁶.

The estimated age of divergence between these groups (50-60 million years; Armstrong et al., submitted) is not incompatible with a biogeographical speculation involving the ancestors of Tseboneae and Sapoteae evolving between Madagascar and Africa, while the ancestors of *Northia* and Isonandreae rafted away on the Indian subcontinent, *Northia* being left behind on the Seychelles plateau while the ancestors of Isonandreae stayed on India for further radiation and colonization of Eastern Asia and Indonesia.

6 corolla lobes divided in 3 segments in Sapoteae, *Lecomtedoxa* and *Neolemonniera*, or dehiscent fruits in the two latter genera

References

- Anderberg AA & Swenson U (2003) Evolutionary lineages in Sapotaceae (Ericales): a cladistic analysis based on *ndhF* sequence data. *Int. J. Pl. Sci.* 164: 763–773.
- Armstrong K, Stone G, Nicholls J, Valderrama-Escallon E, Anderberg AA, Smedmark JEE, Gautier L, Naciri Y, Milne R & Richardson JE (submitted to *Frontiers in Genetics*) Patterns of diversification amongst tropical regions compared: a case study in Sapotaceae.
- Gautier L, Naciri Y, Anderberg AA, Smedmark JEE, Randrianaivo R & Swenson U (2013) A new species, genus and tribe of Sapotaceae, endemic to Madagascar. *Taxon* 62: 972-983.
- Pennington, T D (1991) The genera of Sapotaceae. Kew: Royal Botanic Gardens.
- Smedmark JEE, Swenson U & Anderberg AA (2006) Accounting for variation of substitution rates through time in Bayesian phylogeny reconstruction of Sapotoideae (Sapotaceae). *Mol. Phylog. Evol.* 39: 706–721.
- Swenson U & Anderberg AA (2005) Phylogeny, character evolution, and classification of Sapotaceae (Ericales). *Cladistics* 21: 101–130.

Special among a special flora - the carnivore *Nepenthes pervillei*

Mathias Scharmann

Plant Ecological Genetics, ETH Zurich, Switzerland
mathias.scharmann@env.ethz.ch

The granitic inselbergs (glacis) of the Seychelles are a hostile environment to most plants: there is little soil, strong sun, the rocks dry out so that desert-like conditions prevail, and in-between are heavy tropical downpours that leach most nutrients. One of the few plants dealing with these harsh conditions is *Nepenthes pervillei* (Lalyann potao). Its world distribution is restricted to inselbergs on Mahé and Silhouette. But unlike most other inselberg plants, its growth is sustained by something other than the little nutrients available in soils: instead, it has the ability to attract, kill and digest animals.

But it is not very easy to catch this living “fertiliser”. The traps of *Nepenthes* are called pitchers, because they are basically jug-shaped leaves containing a fluid. The traps are hardly recognisable as leaves anymore and frequently mistaken for flowers. A common belief is that the pitcher closes by moving the lid downwards to trap insects, but in fact the lid is stiff and cannot move - unlike the very active Venus Flytrap, *Nepenthes* pitchers are passive, inflexible organs and kill insects by drowning. However, young traps do have closed lids, which might compound this belief.

Studies have revealed many of the intricate details of the trapping mechanism: First, prey are lured to



The pitcher is a modified leaf, attracting insect prey (L ChongSeng).



Here pitcher plants creep over rocks rather than climbing up other plants (K Beaver).

the plant by sugary nectar on glands found all over leaves, stems and pitchers. Some species of pitcher plant even emit heavy odour, mimicking fruits and flowers. An insect foraging for nectar will be guided towards the pitcher’s opening or mouth. Around the mouth of the pitcher is a finely ridged collar with very productive nectar glands on its inner edge. When the insect tries to reach the perilously situated nectar, two different things can happen: If the collar is wet (e.g. from rain or dew), the insect will slip instantly and fall into the liquid at the bottom of the pitcher, then drown quickly. Stopping the “aquaplaning” is impossible, since its feet are blocked from touching the collar by the water film. This film is held in place by the special microscopic structure, which has recently inspired engineers to create incredibly slippery artificial surfaces (bio-mimicry). However, in dry conditions, the collar is far less dangerous. Now the pitcher relies on another mechanism that works independently of the weather: the vertical inner pitcher wall is covered in thick layers of slippery wax crystals. Insects may try to reach the nectar glands from another angle and step onto the crystals, causing them to lose their foothold and drop down into the liquid.

The pitcher fluid can be sticky, and since the pitcher walls are very smooth, there is almost no chance to escape now. Most insects drown within just a few minutes. Then digestive enzymes released from special glands in the pitcher will dissolve the prey within several days, and the nutrients are absorbed, much like in a stomach. Proteins and chemicals in *Nepenthes* pitcher fluid are another very active field of biotechnological research. But the “stomach” of *Nepenthes* is not deadly for all: for example, there are usually many thousands of bacteria and several mites and mosquito larvae living inside each pitcher. All these organisms can tolerate the fluid, and form miniature ecosystems based on the drowned insects.



Climbing *Nepenthes* plants often have slightly different pitchers at ground level to attract crawling insects (K Beaver)

The trapping mechanisms described above and the associated pitcher morphology occur all over the range of the genus *Nepenthes* in many species. Yet in some species they have been strongly modified or lost, leading to new functions such as trapping vertebrate faeces (“toilet pitcher plants”), or leaf litter. The Seychellois *N. pervillei* is conventional in trapping mostly insects, yet it is an extremely important branch on the evolutionary tree of *Nepenthes*, since it has several unusual features: the creeping as well as climbing growth habit, and the structure of inflorescence, flower, and seed. Whether such deviations represent characters ancient for the genus or derived adaptations to its inselberg / oceanic island habitat remains unclear. Molecular genetics have put *N. pervillei* as a sister lineage to all other living *Nepenthes* - over 140 named species! It appears to

be a lonely survivor, in strong contrast to the high recent diversity of other branches of its genus. Most of these occur in Southeast Asia, spanning from Hong Kong to Queensland, and throughout the Malay Archipelago. Here, every year new species are discovered as old herbarium collections and remote places are explored. The biogeographic history of *Nepenthes* remains somewhat puzzling, as outlier species live in New Caledonia (1 species), Madagascar (2 species), Sri Lanka (1 species) and Meghalaya (India, 1 species). Although *N. pervillei* lies geographically in-between Madagascar and Asia, Malagasy and Asian species appear genetically closer to each other than to *N. pervillei*. Thus, it is clear that *Nepenthes* was capable of trans-oceanic dispersal between the islands derived from the former southern super-continent Gondwana, but when and from where it spread remains unknown. Unfortunately, the ecology, physiology and genetics of *N. pervillei* have received relatively little attention. A comparison to the supposedly more derived and much better studied *Nepenthes* of Asia is a promising target of future research.

Further Reading

- McPherson, S. (2009). Pitcher plants of the Old World. Poole: Redfern Natural History.
- Moran, J. A. and Clarke, C. M. (2010). The carnivorous syndrome in *Nepenthes* pitcher plants. *Plant Signal. Behav.* 5, 644–648.
- Schmid-Hollinger, R. (1979). *Nepenthes*-Studien V Die Kannenformen der westlichen *Nepenthes*-Arten. *Bot. Jahrb. für Syst. Pflanzengesch. Pflanzengeogr.* 100, 379–405.

Not on a wing or a prayer!

Chris J Kettle
Ecosystem Management, ETH, Zurich
chris.kettle@env.ethz.ch

Trees have an enormous cultural importance; they define our landscapes, provide numerous products and services and consequently are the basis for many of our traditional practices. The Bwadfer tree or *Vateriopsis seychellarum* is no exception. Historically an abundant co-dominant canopy tree in forests at low and intermediate elevation over much of the Seychelles island of Mahé, this tree is now confined to only a few isolated and remnant forests



Figure 1 Fruits of Bornean dipterocarps showing the range of size and the wings (J Ellens).

or isolated trees standing sentinel over degraded lands.

Already rare by the mid-18th century due to the exploitation of its strong timber, Bwadfer is one of



Figure 2 Fruits of *Vateriopsis seychellarum*, showing the distinct lack of wings (A Finger).

the Seychelles many critically endangered species (Ismail et al. 2011). The populations of this species, once with many 1000s of large impressive trees, today have been reduced to some 132 trees. Only a proportion of these are large mature individuals. The largest single stand is at Rivière Caiman (L'Abondance), where 26 mature trees stand as a relic of those past forests. Other locations have as few as three or less individuals, and we know little of the active regeneration of these trees, which are likely vulnerable to habitat degradation and alien invasive plants, and depend on obligate ectomycorrhizal fungal symbionts (see Kapsen 5, p. 5-7). What we do know about the reproductive ecology of this tree is that the single lonely old grandmother tree known to many as the Tea Plantation tree, has produced many seeds over the years not by receiving pollen from other trees but by self-fertilisation. Despite this extreme level of inbreeding, these seeds have been planted in several places to produce small plantations, which are now reproductive trees.

So, in addition to its conservation status, what else makes Bwadfer special? Firstly, from an evolutionary perspective this is a truly unique species. *Vateriopsis seychellarum* is the only species in the genus *Vateriopsis* in the world, and thus an endemic genus to the Seychelles. Second, it is the only species of the large tropical tree family Dipterocarpaceae in the Seychelles. The dipterocarps are an ecologically and economically important group of timber trees, which are dominant canopy trees in lowland rainforests. The family has not only been central in the international trade in tropical hardwoods from Asia, but also supports a vast proportion of the World's forest biodiversity. The Asian subfamily,

Dipterocarpoideae, includes 15 genera and some 470 species of which *V. seychellarum* is the only species outside the distribution from Sri Lanka and India to Southeast Asia and across to New Guinea. This makes *V. seychellarum* a very special tree with a huge significance in the evolutionary history of the family Dipterocarpaceae.

As some will probably know, the name dipterocarp is derived from Greek (di = two, pteron = wing and karpos = fruit) referring to the two-winged fruit characteristic of the vast majority of species in the family today (see Figure 1). Those of you familiar with Bwadfer will of course know that the fruit has no wings at all and is a rather ordinary looking fruit (see Figure 2). This highlights yet another important aspect of this species – it may play a vital role in understanding the evolution of the winged fruit within this globally important family of tropical trees.

The family Dipterocarpaceae is made up of three subfamilies: Dipterocarpoideae, which has hundreds of species in Asia and Bwadfer in Seychelles; Monotoideae, which apart from one species in South America, is found in the rainforests of Africa and Madagascar; and Pakaraimoideae, which has only one species found in South America. The Asian dipterocarps including *V. seychellarum* are thought to share a common ancestry with a family of plants – the Sarcolaenaceae – endemic to Madagascar, and are mostly evergreen trees and shrubs. Hanging outside the current distribution of the Asian subfamily, is a strong indicator of the importance of *Vateriopsis seychellarum* as an ancestral species in the dipterocarps and perhaps the precursor to the 470 species across Asia. The limited evidence from genetic data and the fossil record support the idea that the dipterocarps first evolved on the southern supercontinent of Gondwana. Subsequently ancient species rafted off across what is now the Indian Ocean where the species went through a major radiation to form the modern distributions on the African, South American and Asian continents.

So one thing is for certain, *V. seychellarum* is a very special tree, that deserves every bit of our help to ensure that it survives in its remaining habitat.

References

Ismail, S., Huber, M.J. & Mougil, J. 2011. *Vateriopsis seychellarum*. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org. Downloaded on 05 August 2014.

PCA News

All photos by PCA

Swiss Master student joins PCA for 4 ½ months as a volunteer



Tabea Kropf is a Swiss Master student at ETH, Zurich. She is in Seychelles for work experience with PCA. As her main project she is creating interactive displays for a new natural history museum at Jardin du Roi, as part of our joint project with this tourist attraction in South Mahé (see Kapisen 16, p17). Besides designing and building displays, she is helping with other activities, such as a forest tree survey, herbarium work and our outreach programme (see below). Hopefully in the next issue of Kapisen she will write about her experiences.

PCA volunteer Tabea at the Wildlife Clubs Anniversary festival.

Education and Awareness

2014 seems to be a year for outreach and awareness-raising. We have so far taken part in five events, each with a slightly different perspective on the Seychelles environment, so PCA's displays and activities have reflected these various aims.

22 May is International Biodiversity Day and this year the theme was Island Biodiversity, recognising the fact that 2014 is also the year of Small Island States. In its displays, PCA chose to emphasise the importance of the geological history of the main granitic islands as the source of the amazing uniqueness of Seychelles' flora and fauna. These islands were originally a part of the super-continent Gondwana, with granite rock dating back 750 million years. The mini-continent that eventually broke away from Australia, Africa, Madagascar and India took with it many kinds of plants and animals that evolved into new species. Thus in Seychelles, we have species with very ancient origins: plant species such as Bwadfer (*Vateriopsis*), Bwa mediz (*Medusagyne*), Lalyann potao (*Nepenthes*), Bwa rouz (*Dillenia*) and animal species such as the small Sooglossid frogs, Caecilians and Stick insects.



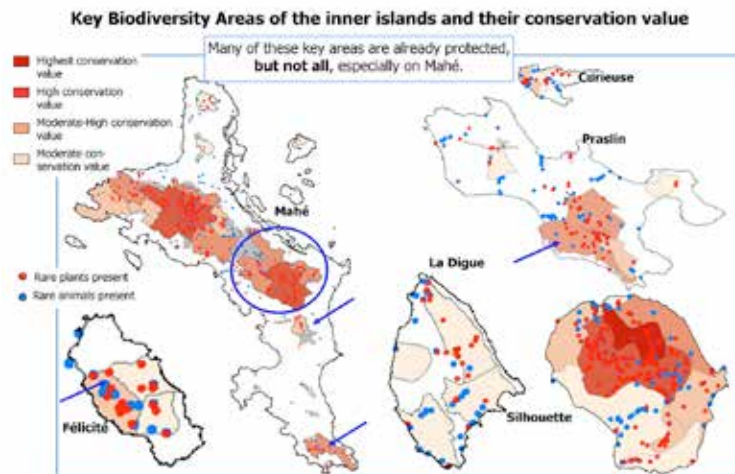
International Biodiversity Day



Opening of the Family Fun Park in Victoria

The opening of the new Family Fun Park in Victoria was quite different. It was a family event and the focus was on fun activities for children and their parents. There were plants to feel and smell (fruits, vegetables and spices), jigsaws and plant games, stickers, and tiny plants to look at using magnifying glasses. As the NGO stalls were right at the end of the playground and beyond an amazing range of roundabouts, slides, swings and a skating rink, we attracted less attention than other activities but at least PCA had a presence and received some very enthusiastic members of the youth wildlife club.

In June, PCA took part in a celebration organised by Seychelles National Parks Authority (SNPA) for the 35th anniversary of the declaration of the first National Parks in Seychelles. Our displays highlighted the importance of these protected areas for native plant species, but also noted that some key biodiversity areas are still not under any form of protection. We also included in the display a seedling of a threatened endemic tree found in the Morne Seychellois and Silhouette National Parks. Even a few SNPA forestry staff took a while to identify it because the seedling leaves are so different from the adult leaves.



Do you know this Seychelles endemic plant? Seedling leaves (left) are different from adult leaves (right)!

Another celebratory event was the 20th Anniversary of Wildlife Clubs of Seychelles (WCS) which held an environment festival at the University of Seychelles campus in July. PCA, amongst other local environmental partners of WCS, set up interactive displays and fun activities. The atmosphere was electric and it was wonderful to interact with young people (and club leaders and a few parents) full of enthusiasm, asking questions and getting fully involved. Long live WCS and our partnership with them!



Wildlife Clubs 20th Anniversary



Civil Society Organisations Fair

A fifth event in which PCA participated was a Civil Society Organisations Fair, with a sustainable development theme, which took place shortly before the UN Conference of Small Island Developing States, held in Western Samoa in early September. The PCA stall had activities for children and adults to enjoy; and we also showed off our new PCA banner and distributed redesigned PCA leaflets.

For all of these events, we rely on our members to volunteer their time, but it can also be very rewarding to interact with the people who come to see what we have to offer.

Latest News Update

A new PCA project is to be funded by the GEF Small Grant Programme. It involves restoration of an area of endangered glaciais vegetation, with the help of the local community and the Seychelles National Parks Authority.

New Seychelles fern species named after local environmentalists

Imagine being invited to what you presumed would be another boring meeting and then being told that a newly discovered endemic species of fern had been named after you! In March 2014 this was the experience of two local environmentalists - Lindsay ChongSeng (PCA's Chairperson) and Victorin Laboudallon (based on Praslin). PCA members were aware that new fern species had been discovered on Mahé and that the herbarium staff were 'working on them', but a great deal of secrecy surrounded the naming of these new species. So it was a wonderful surprise when the 'meeting' turned out to be the announcement of the new Latin names and the two honoured gentlemen were each presented with pictures of their special fern.

So now Seychelles has two new large fern species: *Angiopteris chongsengiana* and *Ptisana laboudalloniana* (see Senterre, Rouhan et al. 2014, page 27). And most of the rest of us wonder how we missed these species in the forest – which just goes to show how important good observation is in field work! See also Kapisen 13, p23 and check out the photo quiz on page 12.



Victorin Laboudallon and Lindsay ChongSeng with their respective new species (C Morel).

Interesting finds at Gorilla Rock

Gorilla Rock is a glacis in north Mahé (so called because of its shape), which became famous some years back when there was a rock fall endangering houses below and work was done to prevent further falls. We followed a track upwards through what turned out to be an 'alien heaven' - almost entirely invasive alien species such as Cinnamon, Bwa zonn, Albizya, Bwa zozo, *Ardisia elliptica*, as well as invasive creepers and alien herbs – all the way up until we reached the glacis, where the number of natives increased. In fact the glacis proved to have a few unusual 'finds' such as 2 rare orchids and the less common (but not rare) native cactus (*Rhipsalis*), which has prickles only in the very young stages. Also present were flowering Tangen and plenty of 'old man's beard' lichens (Labarb senzoze), which are typical on ridges with a good updraft of air bringing moisture. The rising air currents also bring small insects, so it is common to see dragonflies zipping around, waiting for opportunities to catch and eat them.



Flowers of Tangen



Hanging lichens festoon the trees



Native cactus

Field work and training at Jardin du Roi

January is the rainy season, but setting up the forest restoration monitoring plots at Jardin du Roi was an important task to complete for our joint project. So, despite grey skies and some heavy rain, twelve PCA members got together with 4 second year environment degree students from University of Seychelles to carry out the baseline forest monitoring. All of us learnt more about the forest and the tree species found there. For some of us the methods were new and so was the experience of carrying out scientific field work in pouring rain! So it was lovely to be able to change into dry clothes and then enjoy a delicious meal prepared by the Jardin du Roi restaurant staff.

A survey of all larger trees present in the forest was carried out in June and July with the help of another set of students from UniSey. This was to help decide which trees would be removed. Most of the mature trees are alien species, with a few native trees and an understorey containing many young native palms. The Jardin du Roi nature trail enables visitors to see this example of tropical wet forest and one of the main reasons for restoring the area is to give visitors a more authentic experience of native forest, without the invasive species which have taken over.



January field work in the rain for PCA members and UniSey students (left). June was drier and easier! (right).



Measuring the size of alien trees: UniSey student (left); PCA member and Swiss student volunteer (right).

Plant Conservation Action group – who we are and what we do

When we started: November 2002

Who we are: We are a voluntary membership organisation (NGO), with an executive committee elected every two years. We have monthly meetings and regular field trips.

Our mission: PCA mobilises action for the scientific research and conservation of plant species, and promotes community awareness of the fundamental importance of plants in Seychelles.

What we do:

- Plant species identifications
- Advice on vegetation rehabilitation
- Vegetation surveys and management plans
- Collaborative research and monitoring
- Hands-on training in practical plant conservation
- Promote awareness about plants and conservation
- Field trips for members and plant enthusiasts
- Advocate for plant conservation



Our current project: “Improving forest native biodiversity and visitor experience at Jardin du Roi.”

Website: www.pcaseychelles.org

See also: www.seychellesplantgallery.com

Contacts: pca.seychelles@gmail.com; Telephone +248 4241104 or +248 2574619



Advice and monitoring



Education and awareness



Conservation action



Field trips and research

New Literature

- Bolotov, I. N., A. A. Frolov, Y. S. Kolosova, and A. V. Kondakov. 2014. The male of *Sauris moulinieii* (Legrand, 1971) comb. n. (Lepidoptera: Geometridae: Larentiinae: Trichopterygini), an endemic Inner Seychelles moth. *Zootaxa* **3765**:397-400.
- Bristol, R. M., I. Fraser, J. J. Groombridge, and D. Verissimo. 2014. An economic analysis of species conservation and translocation for island communities: the Seychelles paradise flycatchers as a case study. *Journal of Environmental Economics and Policy*:1-16.
- Bunbury, N. 2014. Distribution, seasonality and habitat preferences of the endangered Madagascar pond-heron *Ardeola idae* on Aldabra Atoll: 2009–2012. *Ibis* **156**: 233–235.
- Canning, G., B. K. Reilly, and A. S. Dippenaar-Schoeman. 2014. The distribution and population status of *Nesiergus insulanus* (Araneae: Theraphosidae: Ischnocolinae) on Fregate Island, Seychelles. *Arachnology* **16**:116-121.
- Carvalho L., Biesmeijer J., Benadi G., Freund J., Stang M., Kaiser-Bunbury C.N. 2015. The potential for indirect effects between co-flowering plants via shared pollinators depends on resource abundance, accessibility and relatedness. *Ecology Letters*, in press.
- Cheke, A. S. and G. Rocamora. 2014. Duchemin's 'Linnet': Was there a second species of native fody *Foudia* sp. in the Granitic Seychelles? With additional evidence for the mid-19th century introduction of *F. madagascariensis*. *Malagasy Nature* **8**:73-79. http://www.vahatra.mg/volume78/mn08_chapter07.pdf.
- Chong-Seng, K. M., N. A. J. Graham, and M. S. Pratchett. 2014. Bottlenecks to coral recovery in the Seychelles. *Coral Reefs* **33**:449-461.
- Chong-Seng, K. M., K. L. Nash, D. R. Bellwood, and N. A. J. Graham. 2014. Macroalgal herbivory on recovering versus degrading coral reefs. *Coral Reefs* **33**:409-419.
- Cumberlidge, N. and S. R. Daniels. 2014. Recognition of two new species of freshwater crabs from the Seychelles based on molecular evidence (Potamoidea: Potamonautidae). *Invertebrate Systematics* **28**:17-31.
- Hansen, S.G. and Laboudallon V.F. 2014. The Flora of the Seychelles - a guide to selected plants. Printed in Denmark. 726 pp.
- Harris, D. J., I. Damas-Moreira, J. o. P. Maia, and A. Perera. 2014. First Report of Hepatozoon (Apicomplexa: Adeleorina) in Caecilians, with Description of a New Species. *Journal of Parasitology* **100**:117-120.
- Hay, C., J. X. Mitrovica, N. Gomez, J. R. Creveling, J. Austermann, and R. E. Kopp. 2014. The sea-level fingerprints of ice-sheet collapse during interglacial periods. *Quaternary Science Reviews* **87**:60-69.
- Hill, L. L. 2014. Revision of *Silhouettanus* with description of nine new species (Hemiptera: Heteroptera: Schizopteridae). *Zootaxa* **3815**:353-385.
- Ismail, S. A., J. Ghazoul, G. Ravikanth, C. G. Kushalappa, R. U. Shaanker, and C. J. Kettle. 2014. Fragmentation Genetics of *Vateria indica*: implications for management of forest genetic resources of an endemic dipterocarp. *Conservation Genetics* **15**:533-545.
- Jaloszynski, P. 2014. The enigmatic genus *Stenichnoteras* Scott from the Seychelles (Coleoptera: Staphylinidae: Scydmaeninae). *Zootaxa* **3811**:280-288.
- Kaiser-Bunbury, C., H. Cuthbert, R. Fox, D. Birch, and N. Bunbury. 2014. Invasion of yellow crazy ant *Anoplolepis gracilipes* in a Seychelles UNESCO palm forest. *NeoBiota* **22**:43-57.
- Kaiser-Bunbury, C.N., F. Fleischer-Dogley, D. Dogley and N. Bunbury. 2015. Scientists' responsibilities towards evidence-based conservation in a Small Island Developing State. *Journal of Applied Ecology*.
- Kaiser-Bunbury C.N. and B. Senterre. 2014. Manual on the Key Biodiversity Area CyberTracker application. Report, Government of Seychelles, United Nations Development Programme, Victoria, Seychelles, 30 pp.
- Kaiser-Bunbury, C. N., D. P. Vázquez, M. Stang and J. Ghazoul. 2015. Determinants of the microstructure of plant-pollinator networks. *Ecology*, in press.
- Kueffer, C. and C. Kaiser-Bunbury. 2014. Reconciling conflicting perspectives for biodiversity conservation in the Anthropocene. *Frontiers in Ecology and Environment* **12**:131-137.
- LaPolla, J. S. and B. L. Fisher. 2014. Two new Paraparatrechina (Hymenoptera, Formicidae) species from the Seychelles, with notes on the hypogaecic weissii species-group. *Zookeys*:139-155.
- Lewis, C. J., S. T. Maddock, J. J. Day, R. A. Nussbaum, C. Morel, M. Wilkinson, P. G. Foster, and D. J. Gower. 2014. Development of anonymous nuclear markers from Illumina paired-end data for Seychelles caecilian amphibians (Gymnophiona: Indotyphlidae). *Conservation Genetics Resources* **6**:289-291.

- Macbeth, F. 2014. Republic of Seychelles General Emergency Response Plan for Pests, Diseases and Alien Invasive Species. Government of Seychelles-UNDP-GEF Biosecurity Project, 38pp.
- Maddock, S. T., J. J. Day, R. A. Nussbaum, M. Wilkinson, and D. J. Gower. 2014. Evolutionary origins and genetic variation of the Seychelles treefrog, *Tachycnemis seychellensis* (Dumeril and Bibron, 1841) (Amphibia: Anura: Hyperoliidae). *Molecular Phylogenetics and Evolution* **75**:194-201.
- Matute, D. R. and J. F. Ayroles. 2014. Hybridization occurs between *Drosophila simulans* and *D. sechellia* in the Seychelles archipelago. *Journal of Evolutionary Biology* **27**:1057-1068.
- McClanahan, T. R., M. Ateweberhan, E. S. Darling, N. A. J. Graham, and N. A. Muthiga. 2014. Biogeography and Change among Regional Coral Communities across the Western Indian Ocean. *Plos One* **9**. DOI: 10.1371/journal.pone.0093385
- Phillips, K. P., J. A. Mortimer, K. G. Jolliffe, T. H. Jorgensen, and D. S. Richardson. 2014. Molecular techniques reveal cryptic life history and demographic processes of a critically endangered marine turtle. *Journal of Experimental Marine Biology and Ecology* **455**:29-37.
- Rakotonirina, J. C. and B. L. Fisher. 2014. Revision of the Malagasy ponerine ants of the genus *Leptogenys* Roger (Hymenoptera: Formicidae). *Zootaxa* **3836**:1-163.
- Reeves, C. 2014. The position of Madagascar within Gondwana and its movements during Gondwana dispersal. *Journal of African Earth Sciences* **94**:45-57.
- Reuleaux, A., H. Richards, T. Payet, P. Villard, M. Waltert & N. Bunbury. 2015. Insights into the feeding ecology of the Seychelles Black Parrot *Coracopsis (nigra) barklyi* using two monitoring approaches. *Ostrich*, In press.
- San Mauro, D., D. J. Gower, H. Mueller, S. P. Loader, R. Zardoya, R. A. Nussbaum, and M. Wilkinson. 2014. Life-history evolution and mitogenomic phylogeny of caecilian amphibians. *Molecular Phylogenetics and Evolution* **73**:177-189.
- Senterre, B. and C.N. Kaiser-Bunbury. 2014. Conception of an integrated database on the flora, fauna and vegetation of the Seychelles. Report, Government of Seychelles, United Nations Development Programme, Victoria, Seychelles, 111 pp.
- Senterre, B., G. Rouhan, I. Fabre, C. Morel, and M. J. M. Christenhusz. 2014. Revision of the fern family Marattiaceae in the Seychelles with two new species and a discussion of the African *Ptisana fraxinea* complex. *Phytotaxa* **158**:57-75.
- Senterre, B. and M. Wagner, 2014. Mapping Seychelles habitat-types on Mahé, Praslin, Silhouette, La Digue and Curieuse. Report. Government of Seychelles-UNDP-GEF Mainstreaming Biodiversity Project, Seychelles, 124 pp.
- Spurgin, L. G., D. J. Wright, M. Velde, N. J. Collar, J. Komdeur, T. Burke, and D. S. Richardson. 2014. Museum DNA reveals the demographic history of the endangered Seychelles warbler. *Evolutionary Applications*, in press.
- Stone, R. D. 2014. The species-rich, paleotropical genus *Memecylon* (Melastomataceae): Molecular phylogenetics and revised infrageneric classification of the African species. *Taxon* **63**:539-561.
- Ulitzka, M. R. and L. A. Mound. 2014. New generic synonyms in the Palaeotropical genus *Urothrips* (Thysanoptera: Phlaeothripinae) with one new species from Seychelles. *Zootaxa* **3755**:595-600.
- Valente, J., S. Rocha, and D. J. Harris. 2014. Differentiation within the endemic burrowing skink *Pamelaescincus gardineri*, across the Seychelles islands, assessed by mitochondrial and nuclear markers. *African Journal of Herpetology* **63**:25-33.
- Voelker, G., J. V. Penalba, J. W. Huntley, and R. C. K. Bowie. 2014. Diversification in an Afro-Asian songbird clade (*Erythroptgia-Copsychus*) reveals founder-event speciation via trans-oceanic dispersals and a southern to northern colonization pattern in Africa. *Molecular Phylogenetics and Evolution* **73**:97-105.
- Watling, R. and M. R. D. Seaward. 2014. Additions to the mycota of the Seychelles. *Edinburgh Journal of Botany* **71**:15-21.
- Wetterer, J. K. 2014. Worldwide spread of the lesser sneaking ant, *Cardiocondyla minutior* (Hymenoptera: Formicidae). *Florida Entomologist* **97**:567-574.
- Wright, D. J., L. G. Spurgin, N. J. Collar, J. Komdeur, T. Burke, and D. S. Richardson. 2014. The impact of translocations on neutral and functional genetic diversity within and among populations of the Seychelles warbler. *Molecular Ecology* **23**:2165-2177.
- Zhang, L., X.-M. Zhou, X.-F. Gao, and L.-B. Zhang. 2014. *Pteris barklyae* (Pteridaceae): A new combination and neotypification of *Adiantum pallens* for the fern flora of the Indian Ocean Islands. *Phytotaxa* **174**:116-118.
- Zinke, J., M. Pfeiffer, W. Park, B. Schneider, L. Reuning, W. C. Dullo, G. F. Camoin, A. Mangini, A. Schroeder-Ritzrau, D. Garbe-Schoenberg, and G. R. Davies. 2014. Seychelles coral record of changes in sea surface temperature bimodality in the western Indian Ocean from the Mid-Holocene to the present. *Climate Dynamics* **43**:689-708.