Evolution and diversity of *Copiapoa*

Short communication on the recently published paper:

Isabel Larridon, Helmut E Walter, Pablo C Guerrero, Milén Duarte, Mauricio A Cisternas, Carol Peña Hernández, Kenneth Bauters, Pieter Asselman, Paul Goetghebeur, and Marie-Stéphanie Samain (2015) **An integrative approach to understanding the evolution and diversity of *Copiapoa* (Cactaceae), a threatened endemic Chilean genus from the Atacama Desert.** *American Journal of Botany* **102**(9): 1506–1520. DOI: 10.3732/ajb.1500168

Copiapoa species are common in botanic gardens and private cactus collections around the world. The genus is endemic to the coastal area of the Chilean Atacama Desert within the northern part of one of the world's biodiversity hotspots. According to the IUCN Red List of Threatened Species (**www.iucnredlist.org**) many *Copiapoa* species are threatened with extinction. Besides having (very) restricted distribution ranges, threats to their continued survival include increasing aridity due to climate change, habitat destruction (mining, agriculture, road construction, etc), illegal collecting, herbivory and genetic erosion. Despite being icons of the Atacama Desert and well loved by cactus enthusiasts, the evolution and diversity of *Copiapoa* had not yet been studied using a molecular approach.

In the paper, DNA sequence data of 39 *Copiapoa* taxa were analysed, and the distribution range of species was modelled based on geo-referenced localities and climatic data. Furthermore, the evolution of character states of four characters (root morphology, stem branching, stem shape and stem diameter), as well as ancestral distribution areas were reconstructed.

The results revealed several clades of species, and allowed us to recognise 32 morphologically defined species. The recovered relationships are often supported by morphological and biogeographical patterns, although some relationships are only weakly supported because the genetic diversity between several species and subspecies is too low to delimit clearly their boundaries at this time. The results indicated that the origin of the genus *Copiapoa* is likely to lie between southern Peru and the extreme north of Chile, and that the Copiapó Valley, which widens to >60 km in the coastal zone, limited colonisation between two biogeographical areas. Apart from forming a geographic barrier, in this zone the precipitation regime changes from arid (to the south) to hyper-arid (to the north) and the bioclimate from desertic-oceanic to hyperdesertic.

To conclude, we defined *Copiapoa* to include 32 species and five additional subspecies. Thirty species are classified into four sections and two subsections, while two species remain unplaced. To obtain a clearer picture of the relationships between some of the closely related taxa, further study is needed using other DNA-based techniques. Currently, we have already started a microsatellite study to investigate the genetic diversity, gene flow and population structure of *Copiapoa cinerea* and *Copiapoa gigantea*. A better understanding of the evolution and diversity of *Copiapoa* will allow the allocation of conservation resources to the most threatened lineages and focusing conservation action on real biodiversity.

Fig. 1 ***Copiapoa desertorum*** **(Photo: Helmut E Walter)**

The Editor wishes to thank Dr Isabel Larridon for supplying the review of the paper and the accompanying photograph.

The origin and predominance of *Aloe vera*

Aloe vera is undoubtedly THE best known succulent because it is the basis of a multi-billion dollar global cosmetics and toiletries industry. Its use as a medicinal plant spans many centuries and is recorded, for instance, in the Greek manuscript herbal of Dioscorides dating from AD 512 (Carter et al, 2011). *Aloe vera* is now widely cultivated as a crop plant, notably in the Caribbean, the Canary Islands (Fig. 2) and East Africa. It has also escaped and become naturalised in many countries. There are, however, no known natural populations of this species and its wild origin remains a mystery.

The genus *Aloe* is incredibly diverse with over 500 species and 50+ subspecies and varieties (Carter et al, 2011), and yet remarkably few of these are exploited commercially. In addition to *A. vera* which has market dominance, only *Aloe ferox* (in South Africa) and *Aloe arborescens* (in Asia) are economically important. Why is the diversity of *Aloe* so poorly exploited?

Grace et al. (2015) set out to provide explanations for the two issues outlined above. These are based on a molecular study, the first to include more than 10% of *Aloe* species. This new evolutionary tree confirmed results from previous studies which showed that the tree aloes, now in

Fig. 2 ***Aloe vera*** **in cultivation on Tenerife (Photo: Colin Walker)**

the separate genus *Aloidendron*, are basal or ancestral to all other aloes. The consequence of this is that aloes evolved to become less woody and, more significantly, the most recently evolved species are generally more succulent, a feature that is important in their commercial exploitation. In contrast, species with less succulent leaves, such as the grass aloes, for example, do not have significant medicinal uses. The study also shows that *Aloe* originated in southern Africa about 16 million years ago and underwent two major species radiations giving rise to the great diversity known today. Large succulent-leaved species, typical of medicinally important aloes, arose around 10 million years ago.

In this latest evolutionary tree, *A. vera* is located in a well-supported branch (clade) together with eight other Arabian species, a result which led the current authors to conclude that this species has its origins on the Arabian Peninsula within the last five million years. This species is placed at the northernmost natural limit of aloes in extreme habitats in terms of aridity and diurnal temperature fluctuations. Features such as leaf succulence, small leaf teeth, short stem and ease of propagation from cuttings are shared by other similar aloes which are not commercially exploited. The authors observe that trade routes for *A. vera* were well established by the 4th century BC and if this species had a narrow distribution range similar to other currently known Arabian aloes, then over-exploitation by harvesting may account for the absence of currently known natural populations. The contemporary overwhelming economic predominance of *A. vera* relative to the other 500+ species is postulated by Grace et al (2015) to be due to its origins near trade routes, which introduced this species into commerce, and hence into cultivation, thousands of years ago. Consequently this species may now be extinct in the wild, or it may yet be located in some extremely inhospitable wadi or mountainside in a remote corner of Arabia.

References

Carter, S, Lavranos, J J, Newton, L E & Walker, C C (2011) *Aloes. The definitive guide*. Royal Botanic Gardens, Kew / British Cactus and Succulent Society.

Grace, O M, Buerki, S, Symonds, M R E, Forest, F, van Wyk, A E, Smith, G F, Klopper, R R, Bjorå, C S, Neale, S, Demissew, S, Simmonds, M S J & Rønsted, N (2015) Evolutionary history and leaf succulence as explanations for medicinal use in aloes and the global popularity of *Aloe vera*. *BMC Evolutionary Biology* **15**:29: 1–12.

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International Euphorbia Society Convention

The International Euphorbia Society (IES) held its first ever convention in May 2015 at the Botanic Garden Meise/Brussels. The convention was held in the beautiful and sumptuous castle in the garden's grounds (Fig. 3) and as well as inclusive guided tours of the garden and glasshouses, attendees were able to visit the Euphorbia Reference Collection which is not normally open to the public. The array of international speakers included Susan Carter (IES President), Norbert Rebmann, Ricarda Riina, Bob Potter, Petr Pavelka and Rikus van Veldhuisen (Fig. 4).

Fig. 3 The 12th-century Bouchout Castle

Fig. 4 Susan Carter and Rikus van Veldhuisen discuss euphorbias in the reference collection

The weekend was a great success due to both the hospitality of the Botanic Garden Meise in hosting the convention, and to the hard work and efforts of the organisers. It is hoped that this was the first of many conventions to come and should you hear about an IES convention in the future you should not hesitate to join in.

Photos: Detlef Schnabel

Operculicarya pachypus

Joyce James of Chippenham was delighted to see the flowers on her plant of *Operculicarya pachypus* earlier this year, as she has had the plant for 20 years and this is only the second time it has flowered. The flowers were tiny, just 4mm in diameter. Joyce wonders how she can persuade the flowers to produce seed and would welcome any advice in this regard which she can use when the plant flowers again.

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Fig. 5 ***Operculicarya pachypus*** **flowering (Photo: Joyce James)**

Echinopsis terscheckii flowering

John Hayward from Ipswich has sent a photo of his 50 year-old cactus which has finally flowered.

He says: "The plant was bought soon after I started growing succulents around 1959 which makes it well over 50 years old. It was labelled *Echinopsis poco* in those days but at some time I renamed it *Trichocereus validus*. However, Graham Charles has told me its correct name nowadays is *Echinopsis terscheckii*.

After being bedded out in my centre bed about 30 years ago it has reached a height of 2m and a diameter of 19cm. The flowers which opened in the evening and lasted all the following day are about 20cm long and almost the same in diameter.

Fig. 6 ***Echinopsis terscheckii*** **in bud during August 2015**

My greenhouse is 15×16ft (4.5×4.8m) with an apex 11ft (3.3m) high. I heat with both electricity and oil and aim to maintain a minimum of 40°F (4.5°C). The plant in question still has some room to grow but an *Espostoa* growing in the bed is about 2ft (0.6m) higher and I would like to flower this before it hits the roof or I get called to the big greenhouse in the sky."

Text and photos: John Hayward.
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Fig. 7 Open flower of ***E. terscheckii***

Carnegiea gigantea

Derek Bowdery from King's Lynn shows us what can be achieved with a little patience. In the early 1970s Derek purchased a seedling *Carnegiea* from a cactus nursery in the UK. The plant remained growing in a pot until 1996 when it was planted into Derek's cactus bed by the late Charlie Glass who was visiting from America (Figs. 8 & 9). From then its growth has been phenomenal (Fig. 10) and on 28 June this year, the day of Derek's Branch Show, Keith Flanagan, who was visiting at the time, noticed that it was in bud (Figs 11, 12 & 13). Initially ants fed on the sugar exuded from the developing buds (Fig. 13). The first flower to open was at night on 7 August 2015 and each bloom lasted two days (Fig. 14). In total there were eight flowers. With no bats to pollinate the flowers Derek, with the help of step ladders and a paintbrush, tried his best. To date one flower remains attached to the plant (the window cleaner didn't help!) – only time will tell if he has succeeded. Watch this space!

Fig. 8 Derek keeping a careful eye on his *Carnegiea* as Charlie Glass plants it out in the cactus bed in 1996 (Photo: Unknown)

Fig. 9 Charlie happy with the result (Photo: Fred Braun)

Fig. 10 Derek's plant measuring approximately 'one and a half Bowderies' (7 foot) (Photo: King's Lynn Branch member)

Fig. 11 The developing buds with visiting ants (4 July) (Photo: Derek Bowdery)

Figs. 12 & 13 In bud (Photo: Derek Bowdery)

Fig. 14 In flower (9 August) (Photo: Derek Bowdery)

Are your cacti stressed?

University of Adelaide research has shown for the first time that, despite not having a nervous system, plants use signals normally associated with animals when they encounter stress.

Published in the journal *Nature Communications*, the researchers at the Australian Research Council (ARC) Centre of Excellence in Plant Energy Biology reported how plants respond to their environment with a similar combination of chemical and electrical responses to animals, but through machinery that is specific to plants.

“We’ve known for a long-time that the animal neurotransmitter GABA (gamma-aminobutyric acid) is produced by plants under stress, for example when they encounter drought, salinity, viruses, acidic soils or extreme temperatures,” says senior author Associate Professor Matthew Gilliham, ARC Future Fellow in the University’s School of Agriculture, Food and Wine. “But it was not known whether GABA was a signal in plants. We’ve discovered that plants bind GABA in a similar way to animals, resulting in electrical signals that ultimately regulate plant growth when a plant is exposed to a stressful environment.”

By identifying how plants respond to GABA the researchers are optimistic that they have opened up many new possibilities for modifying how plants respond to stress. “The major stresses agricultural crops face like pathogens and poor environmental conditions account for most yield losses around the planet, and consequently food shortages,” says co-lead author Professor Stephen Tyerman. “By identifying how plants use GABA as a stress signal we have a new tool to help in the global effort to breed more stress resilient crops to fight food insecurity.”

Despite a similar function, the proteins that bind GABA and their mammalian counterparts only resemble each other in the region where they interact with the neurotransmitter; the rest of the protein looks quite different. “This raises very interesting questions about how GABA has been recruited as a messenger in both plant and animal kingdoms,” says co-lead author Dr Sunita Ramesh. “It seems likely that this has evolved in both kingdoms separately.” The researchers say these findings could also explain why particular plant-derived drugs used as sedatives and anti-epileptics work in humans. These drugs are able to interact with proteins in the GABA-signalling system in both plants and animals, suggesting that future work on other plant GABA signalling agents will also benefit the medical field.

The above is reprinted from materials provided by University of Adelaide.

Journal Reference:

Sunita A Ramesh, Stephen D Tyerman, Bo Xu, Jayakumar Bose, Satwinder Kaur, Vanessa Conn, Patricia Domingos, Sana Ullah, Stefanie Wege, Sergey Shabala, José A Feijó, Peter R Ryan, Matthew Gillham. (2015) GABA signalling modulates plant growth by directly regulating the activity of plant-specific anion transporters. *Nature Communications* 6: 7879. DOI: 10.1038/ncomms8879

The ‘Monster of Market Street’

Diana Keen from Somerset has a very tall cereoid cactus (probably *Cereus jamacaru*) which had outgrown the house. About five years ago she contacted Tony Irons for advice and he suggested growing it outside, along with other cultivation hints. Diana changed the compost and placed it against the south-facing wall of her home, so it gets the best of the weather and sunshine. During the past few years it has gone from strength to strength and has reached the bedroom window. It is now known as the ‘Monster of Market Street’. Finally it has flowered for the first time in 64 years, and she is absolutely thrilled.

Fig. 15 The ‘Monster of Market Street’ growing in the garden. Inset, detail of flower (Photos: Diana Keen)

Correction to correction

Dr Detlev Metzing has contacted me with the following information.

“We all prefer stability in nomenclature, but sometimes we have to say goodbye to old, fond names. This is so in the case of *Hildewintera*, which was not validly published by Friedrich Ritter in 1966. The correct name to be used is *Winterocereus* (*Taxon* **56**(1): 226–228, 2007). The name *Hildewintera* was used in the June 2015 issue of *CactusWorld* twice (*CactusWorld* **33**(2): 101, 122). An alternative is to lump the two species in *Cleistocactus*, but that is a matter of taxonomy, not nomenclature.”

Mammillaria Society – free seeds

The Mammillaria Society have announced that due to a number of bequests this year, all seeds in this year’s and future years’ seed offerings will be free of charge to members. See website for further details on how to join: **www.mammillaria.net**