Cactus and Succulent Plants Specialist Group Newsletter

August 2023

Content

A few words from the Co-Chairs

Dear Members of the IUCN SSC Cactus and Succulent Plants Specialist Group,

It has been an exciting year and a half for work in the family Cactaceae for systematics, conservation and educational outreach. In this issue of the CSSG Newsletter, we are excited to share with you news, progress on meeting our targets and other important updates, including current research recently published and activities related to the repatriated *Copiapoa*. We also include several interesting articles in the newsletter based on work from our amazing membership. Sadly, we also acknowledge the passing of Dr. Eloy Solano Camacho and Dra. Adriana E. Hoffmann J.

We look forward to the continued hard work towards the conservation and deeper understanding of our most precious plants, with special emphasis on all of the amazing work by our group members.

We take this opportunity to thank you for your continued support, and we sincerely appreciate the time you invest as members of the CSSG.

Best regards,

Bárbara Goettsch and Lucas C. Majure (Co-Chairs of the CSSG)

Pelecyphora alversonii
(c) Michiel Pillet

CSSG News

We are saddened by the loss of Dr. Eloy Solano Camacho, expert on Mexican Asparagaceae, and Dra. Adriana E. Hoffmann J., expert on Chilean cacti, and express our condolences to their loved ones.

Obituary - Dr. Eloy Solano Camacho

October 6, 1955 - December 3, 2021

Eloy Solano Camacho was born in the beautiful state of Oaxaca, where he also passed away. He studied biology at the Facultad de Estudios Superiores Zaragoza (FES Zaragoza), Universidad Nacional Autónoma de México from 1977 to 1981. There, he became interested in botany, first as a student and later as a teacher and researcher. For more than 35 years he conducted and advised studies on the Flora of Mexico and particularly that of his native state. He also developed multiple studies on the genera *Bessera*, *Manfreda*, *Polianthes* and *Yucca*, of the latter two he described 13 species new to science.

Dr. Solano was responsible and active collector for the FEZA Herbarium, which he registered in the Index Herbariorum in 1997. He actively participated in the training of undergraduate and graduate students, taught classes, gave lectures, attended radio programs, national and international congresses, forums, symposia, among many other activities. He also founded the Plant and Soil Systematics Unit, where he assembled an exceptional work team. His professionalism and leadership in every task he performed, led him to occupy administrative positions, collegiate bodies and evaluation commissions inside and outside FES Zaragoza. He belonged to the National System of Researchers, the Botanical Society of Mexico and the International Organization for the Study of Succulent Plants.

Those of us who knew him closely will miss his joy and passion for life, his taste for sharing his Oaxacan roots, from gastronomy to music, even his bad jokes. His students called him with affection and admiration “Doc”, so wherever he is, “Doc”, we thank him for his teachings, contributions and above all what he personally gave to all of us who were part of his life.

“See you always Doctor”.

By María Magdalena Ayala Hernández

Obituary - Dra. Adriana E. Hoffmann J.

January 29, 1940 - March 20, 2022

Adriana Hoffmann, a visionary Chilean ecologist and botanist, was born on January 29, 1940, and dedicated her life to environmental preservation and research, leaving an indelible legacy in the history of conservation. Her academic journey began at the University of Chile, where she initially studied Agronomy. However, her passion for botany led her to abandon this career and delve deeper into this field. From then on, her tireless work focused on the appreciation and preservation of Chile’s flora, contributing pioneering research to the country’s botanical diversity.

The nineties were a prolific period for A. Hoffmann. In 1997, she received recognition from the UN as one of the 25 leading environmentalists of the decade. Two years later, she was awarded the National Environment Award in the Environmental Education category, given by the National Commission for the Environment (CONAMA). In 2000, in addition to representing Chile at COP 6, she took on the leadership of CONAMA, a responsibility she maintained until October 2001. In 2003, her commitment to ecological balance was honored with the Luis Oyarzún Award from the Austral University. During this decade, she also denounced the illegal logging of Chile’s native forests through her work “The Tragedy of the Chilean Forest”.

Adriana Hoffmann dedicated a significant part of her career to the study and preservation of Chilean cacti. She contributed to the nomenclature and identification of

dozens of Cactaceae species. Furthermore, her work was crucial in increasing knowledge and awareness about the conservation of cacti and other endemic species of the Atacama Desert. In 1989, she published her emblematic work “Cactaceae in the wild flora of Chile: a guide for the identification of cacti growing in the country”, which she re-edited in 2004 alongside Helmut E. Walter.

The loss of Adriana Hoffmann in 2022 left a void in the world of conservation and environmental activism, but her legacy lives on. In 2015, the Ministry of the Environment founded the “Adriana Hoffmann Environmental Training Academy”, and her influence continues in every environmental policy that is implemented and in every individual who is inspired to appreciate and protect our environment. Adriana Hoffmann, with her passion and dedication, continues to be an unforgettable iconic figure and a source of inspiration for current and future generations dedicated to the preservation of nature.

By Pablo Guerrero

New members

We welcome our new members! We continue to broaden our membership as part of our commitments in the new quadrennium (2021-2024) with a particular emphasis on increasing women and young researcher (under 35 years) representation.

- Alejandro Casas - Universidad Autónoma de México, Mexico (Cactaceae and Asparagaceae)
- María Magdalena Ayala Hernández - Universidad Autónoma de México, Mexico (Asparagaceae)
- Christian Ricardo Loaiza - Museo de Historia Natural, Ecuador (Cactaceae)
- Carol Peña - Universidad de Concepción, Chile (Cactaceae)
- Michiel Pillet - The University of Arizona, USA (Cactaceae)
- Christian Torres-Santana - TerraFormation, USA (Cactaceae)

New Program Officer on board

After looking for a Program Officer for over a year, we are pleased to announce that Michiel Pillet has now joined the CSSG team as our new Program Officer. Michiel’s passion for succulents started as a teenager in Belgium, where he had a small cactus collection. In 2016 he moved to Tucson, Arizona, USA, where he is a PhD candidate at The University of Arizona studying the impacts of climate change on cacti. Michiel also owns a conservation nursery, focusing on propagating the most threatened cacti, collaborates with botanical gardens, and serves as a member of the Cactus and Succulent Society of America Conservation Committee.

Partnerships and donations

B.Willow, our partner store located in Maryland, USA, and Summer Rayne Oakes, from the YouTube channel Plant One On Me, provided donations to the CSSG to help us advance our mission. This will be especially helpful for funding the reassessments of the Cactaceae.

Progress of the *Copiapoa* Conservation Action Plan

We are very excited to announce that the “Integral conservation planning workshop for *Copiapoa*” (Fig. 1) has been successfully completed. It was organized by Ministerio de Medio Ambiente de Chile (MMA), Chester Zoo, the IUCN Species Survival Commission (SSC) Conservation Planning Specialist Group (CPSG), and CSSG. 35 experts from over 20 institutions and five countries participated (Fig. 2). The workshop took place over the course of seven on-line sessions in August and September 2022. During the workshop, species reassessments were reviewed and main threats identified, culminating in a list of recommended conservation actions. The resulting action plan will be published as a CSSG document, and adapted as a national action plan (RECOGE) by MMA. The action plan will be published before the end of 2023, and we are confident that it will have a positive impact on the conservation of *Copiapoa*.

Figure 1. Workshop logo.

Paul Bamford, Regional Field Program Manager for Latin America at Chester Zoo, which holds the United Kingdom’s “National Collection” of *Copiapoa*, comments: “This conservation plan is something that we started discussing with CSSG back in 2019. After all the uncertainty and disruption that arrived with COVID, we feel so grateful that both organizations have been able to emerge from the pandemic to pick up the pieces and start again. With guidance and facilitation from CPSG, and the participation of our network of collaborators in Chile and beyond, the level of engagement and debate in the workshop was inspiring, and we believe that this has given us the ingredients we need for an ambitious, but robust plan. As we move toward publication internationally through CSSG, and in Chile through the national RECOGE planning framework, we are really excited to see these actions being implemented, and to discover the results that can be achieved.”

Figure 2. A subset of the workshop participants.

CSSG would like to express its gratitude to Chester Zoo for their financial and technical support. We are grateful to MMA for endorsing and supporting the action plan and for their technical input. We thank CPSG for all their hard work in preparing and facilitating the workshop.
We are also thankful to all the participants who lent their expertise. The workshop was also financially supported by the SSC Internal Grants.

Cactaceae Reassessment Task Force

A Task Force to reassess the Cactaceae family for the IUCN Red List of Threatened Species is being set up. The objective of the Task Force is to catalyze the reassessment of the Cactaceae family with the help of focal points identified by region or country. The focal points will be in charge of leading and managing the process, as well as involving experts of their respective regions/countries and seeking funding. The focal points will receive support from the CSSG Chairs and the Program Officer. If you are interested in being part of the Task Force for your country or region, please do not hesitate to let us know.

We are pleased to share that the following focal points have agreed to be part of the Task Force (from north to south):

- Jardín Botánico Regional de Cadereyta, Querétaro, Mexico - will support the reassessment of cactus species of the Queretoan-Hidalgoan region
- Duniel Barrios, Jardín Botánico de la Habana, La Habana, Cuba - will support the reassessment of Cuban cactus species
- Monica Arakaki, Museo de Historia Natural, Universidad de San Marcos, Lima, Peru - will support the reassessment of Peruvian cactus species and those species shared with Chile
- Pablo Guerrero, Universidad de Concepción, Concepción, Chile - will be in charge of the reassessment of Chilean cacti
- Yuley Encarnación Piñeyro, Department of Biology and Florida Museum, University of Florida, and Jardín Botánico Nacional "Dr. Rafael M. Moscoso", Dominican Republic - will support the reassessment of Hispaniolan cacti

Wondering what happened to the repatriated *Copiapoa*?

In November 2022, the Centro de Rescate de Cactáceas (Cactaceae Rescue Centre) in the Atacama region was opened with the purpose of housing specimens of *Copiapoa* seized during Operation Atacama in Italy. More than 800 cacti are housed in this facility, managed by the Corporación Nacional Forestal (CONAF) with technical and scientific support from the Instituto Forestal (INFOR). Also see this Twitter post.

Showcasing CSSG's work

Co-Chair Bárbara Goettsch will present on the work of CSSG at the "Cátedras del Semidesierto 2023" seminar organized by the Cadereyta Regional Botanic Garden (August 2023), as well as at the 40th Succulent Plants Symposium at The Huntington Library, Art Museum, and Botanical Gardens (September 2023). For more information on these events, please see the *Events and Opportunities* section at the end of the newsletter.

Cactaceae raising climate change awareness

The 2022 paper titled "Elevated extinction risk of cacti under climate change", resulting from a project led by CSSG Program Officer Michiel Pillet, was one of the most influential conservation papers in 2022 according to ConservationBytes.com and Altmetric. The message was loud and clear: it will be too hot even for those plants that tolerate high temperatures. This paper has been a flagship to raise awareness about climate change, and continues to receive a large amount of attention (e.g., https://www.youtube.com/watch?v=zdYEjI0InG8). We expect that climate change will become increasingly important for our assessments, and that climate resilience will be integral to successful conservation plans.

Trade in wild-collected plants in the United States

In 2023, we were informed of the operation of an international trade network supplying wild-collected plants from Latin America, Africa, and Southeast Asia to parties in the United States, particularly the state of California. We formally notified the Cactus and Succulent Society of America (CSSA) and Inter-City Cactus & Succulent Show and Sale that several individuals who are part of this network operate within their organizations, and requested their removal. While CSSA has communicated it is taking action, Inter-City Show refused to cooperate. Our statements became public, leading to us receiving additional information, as well as offers of support and encouragement by various stakeholders. We will continue efforts to dismantle this network.

Acknowledgements

On behalf of the CSSG, we would like to thank the generosity of our host institution: the Desert Botanical Garden in Phoenix, Arizona, USA. Its support is invaluable to us and thanks to them we have the assistance of our Program Officer, Michiel Pillet.

We are grateful to Liz Vayda from B.Willow and Summer Rayne Oakes from Homestead Brooklyn for their kind donations and conservation support. We express our gratitude to the CSSG members and others who contributed with articles for the newsletter.

Scientific Outreach Articles

Conservation Interventions

Community projects for the conservation of cacti in the state of Morelos, Mexico

Lluvia Ramírez Navarro[1] and Topiltzin Contreras-MacBeath[1]

[1]Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Morelos, Mexico.

Due to their distinctive shapes, their showy flowers, their attractiveness to people, as well as their ability to survive in arid and semi-arid environments, in cold latitudes such as Canada or Patagonia, and in the tropical jungle regions of Mexico, cacti are highly valued plants for international trade (Alanís and Velazco, 2008). It is known that there are some 1855 species of cacti in the world (Korotkova et al., 2021), of which 913 inhabit Mexico, with 80% of these being endemic to the country (Jiménez-Sierra, 2011). In the case of the State of Morelos, located in the central region of Mexico, 30 species and three native subspecies, such as *Mammillaria knippeliana* (Fig. 1), have been recorded as endemic (Martínez-Alvarado and Flores-Castorena, 2020).

Figure 1. *Mammillaria knippeliana*, a species endemic to Morelos (Photo: Topiltzin Contreras).

A study by Goettsch *et al.* (2015) in which 1478 species of cacti were evaluated using IUCN Red List criteria, shows that 31% of these are threatened with extinction. The same study described as the most important cause of extinction risk the unscrupulous collection of live organisms and their seeds for the ornamental plant trade, as well as for private collections, a situation that affects 47% of threatened cacti. It is worth mentioning that Mexico follows the same global pattern, as the Official Mexican Standard (NOM059-SEMARNAT-2010) lists 255 species of cacti at risk. Therefore, it is important to implement measures for their conservation and sustainable use, which means working on strategies for seed collection and preservation, growing plants in greenhouses, reintroducing plants to their natural habitats, and promoting legal trade, all accompanied by environmental education campaigns to help community members formulate strategies for sustainable use of their resources.

In Mexico for some years now, a model for the sustainable management and use of species at risk has been implemented through the so-called Environmental Management Units (UMA), which have been promoted and supervised by the federal government through the General Directorate of Wildlife of the Ministry of Environment and Natural Resources (González-Rebeles *et al.*, 2020). In this sense, starting in 2014 in the state of Morelos, as part of a strategy to promote the conservation, protection and use of cacti species, a State Government program was implemented for the establishment of "management units" for the conservation of cacti through their production in nurseries. To develop this strategy, we worked with community groups made up mainly of women who live within the state's protected natural areas. Specifically the Sierra Monte Negro and Las Estacas State Reserves, and the State Parks El Texcal and Cerro de la Tortuga and the ZSCE Los Sabinos, Santa Rosa, San Cristóbal.

Figure 2. Training process and follow-up of community projects (Photo: Topiltzin Contreras).

A total of eight community projects have been implemented (Fig. 2), which continue to operate to date, that propagate these plants. Currently, 25 species of cacti are being propagated, of which 14 species are already commercialized, among which we can mention *Astrophytum asterias* (Star Peyote), *Astrophytum capricorne* (Goat's Horn Cactus), *Astrophytum myriostigma* (Bishop's Cap Cactus), *Ariocarpus trigonus*, *Ariocarpus bravoanus*, *Kroenleinia* (*Echinocactus*) *grusonii* (Golden Barrel), and *Echinocereus rigidissimus* ssp. *rubispinus* (Rainbow Hedgehog Cactus), to name a

few. Most of them are traded locally and some community groups are working on the formation of a cooperative for national and international trade (Fig. 3).

Figure 3. Tourists visiting a production unit in Tlaltizapán (Photo: Topiltzin Contreras).

A fundamental part of the development and success of these projects was the training and follow-up provided by the government institution. This initiative generated an economic alternative for community development, especially for women in marginalized communities, as well as the conservation and protection of native cactus species. These projects work locally, but their impact is global.

References

Alanís Flores, G.J., and Velazco Macias, C.G. 2014. Importancia de las cactáceas Ciencia y Sociedad como recurso natural en el noreste de México. *Ciencia de la Universidad Nacional de Nuevo León*, 11: 6-11.

Goettsch, B., Hilton-Taylor, C., Cruz-Piñón, G., Duffy, J.P., Frances, A., Hernández, H.M., Inger, R., Pollock, C., Schipper, J., Superina, M., Taylor, N.P., et al. 2015. High proportion of cactus species threatened with extinction. *Nature Plants*, 1: 1-7.

González-Rebeles, I.C., Méndez, M.M., Anaya L., M. and Juárez Mondragón, A. 2020. Unidades de manejo para la conservación de la vida silvestre. Pp. 333-345. *In: La biodiversidad en Morelos, Estudio de Estado 2*. Vol. III. CONABIO, México.

Jiménez Sierra, C.L. 2011. Las cactáceas mexicanas y los riesgos que enfrentan. *Revista Digital Universitaria*, 12: 1-21.

Korotkova, N., Aquino, D., Arias, S., Eggli, U., Franck, A., Gómez-Hinostrosa, C., Guerrero, P.C., Hernández, H.M., Kohlbecker, A., Köhler, M., Luther, K., Majure, L.C., Müller, A., Metzing, D., Nyffeler, R., Sánchez, D., Schlumpberger, B. and Berendsohn, W.G. 2021. Cactaceae at Caryophyllales.org – a dynamic online species-level taxonomic backbone for the family. *Willdenowia*, 51: 251-271.

Martínez-Alvarado D. and Flores-Castorena, A. 2020. Cactáceas (Cactaceae). Pp. 463-470. *In: La biodiversidad en Morelos, Estudio de Estado 2*. Vol. I. CONABIO, México.

Conservation Alert

Protecting *Pygmaeocereus familiaris* F. Ritter and its associated flora in a unique succulent oasis in southern Peru

Members of Laboratorio de Sistemática y Diversidad Vegetal[1]: Mónica Arakaki[*], Renzo Villena, Susy Castillo, Soledad Rivera, Blanca León, Alejandra Huamán, Carlos Jiménez, Franco Damian, Rocio Quispe, Elmer Ramos, Pamela Aroni, Leonardo Gaspar, Piero Arana, Sebastián Riva

[1]Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru.

[*]Email: marakakim@unmsm.edu.pe.

Pygmaeocereus familiaris F. Ritter is a member of the Cactaceae, a plant family with more than 190 endemisms for Peru's flora (Arakaki *et al.*, 2006). *Pygmaeocereus familiaris* is a tiny cactus, considered here as a distinct species from *P. bylesianus* M. O. Andreae & Backeb. (Ostolaza, 2019; Villena *et al.*, in prep.). It is restricted to a few sites in desert fog oases or "lomas" in the Province of Caravelí, in Arequipa, Peru, between 120–200 m asl (Fig. 1). It was originally collected in Chala (Fig. 2a), and this type locality also harbors other endemic cacti such as *Eulychnia ritteri* Cullman (Fig. 2e), *Eriosyce islayensis* (C. F. Först.) Katt. (Fig. 2c), *Haageocereus chalaensis* F. Ritter (= *H. decumbens* (Vaupel) Backeb.) (Fig. 2f), and other, mostly succulent plants (*Cistanthe paniculata*, *Oxalis* cf. *dombeyi*, *Portulaca pilosa*) (Fig. 2g, h). *Pygmaeocereus bylesianus*, which according to Hunt et al. (2006), includes *P. familiaris*, is categorized as Critically Endangered (CR) (Cáceres, 2013) (Table 1). However, there is no detailed account of threats and conservation status of the latter considered as a distinct species.

Table 1. Contentious taxonomy of cacti in the study area, and IUCN categorizations. Taxa recognized here are in bold.

Current taxonomy	Old taxonomy	IUCN category (year)	Proposed category
Pygmaeocereus bylesianus	***Pygmaeocereus familiaris***	---	Critically Endangered (CR)
Eulychnia ritteri	***Eulychnia ritteri***	---	Critically Endangered (CR)
Eriosyce islayensis	*Islaya islayensis*	Near Threatened (2011)	Vulnerable (VU)
Haageocereus decumbens	***Haageocereus chalaensis****	---	Vulnerable (VU)

**Haageocereus chalaensis* is recognized as a good species, and not a synonym of *H. decumbens*, mainly based on chromosome numbers: *H. chalaensis* (2n = 44), *H. decumbens* (2n = 22).

The range of *Pygmaeocereus familiaris* is seriously affected by urban expansion, land trafficking, illegal ornamental trade, mining, and landfills, factors that increase habitat fragmentation and loss of individuals at a rapid pace (based on observations between 2020–2022).

Figure 1. Section of the Caravelí Province (inset map) and collection record sites of *Pygmaeocereus familiaris* in Lomas de Atiquipa (1994, green circle) and Chala (2020 and 2022, yellow circles).

Plants of *P. familiaris* grow in clumps that contain one or more individuals, branches are short, up to 2 cm, and almost at ground level; the taproot is thick and grows deep into the ground; flowers are white, funnelform, two or three times longer than the stems, and although the pollination syndrome corresponds to Sphingidae hawk moths, no observations have been recorded; fruits are globose, greenish to brown (Anderson, 2001; Ostolaza, 2019) (Fig. 2d).

What we are learning about *Pygmaeocereus*

Based on a broader research agenda to develop protocols that provide validated experiences for ex situ conservation of some highly threatened populations of cacti (funded by Peru's CONCYTEC and the World Bank), several concerns about species validity and affinities, requirements for propagation and reintroduction, and prospects for a seed bank were included. The study of *Pygmaeocereus* offered the possibility to evaluate its monophyly and determine the number of species in the genus, and to gather information on habitat quality. The ongoing phylogenetic study indicates that the genus *Pygmaeocereus* is indeed monophyletic and comprises three species: *P. familiaris*, *P. bylesianus*, and *P. bieblii* Diers (Villena *et al.*, in prep.). We are also analyzing the rhizosphere and endosphere microbial communities associated with each Pygmaeocereus species (Villena *et al.*, in prep.).

Figure 2. Critical habitat for *Pygmaeocereus familiaris*, threats and its flora: (a) view of the city of Chala from the proposed protected area, (b) solid waste entangled with *Haageocereus chalaensis* (= *H. decumbens*), and (c) *Eriosyce islayensis*, (d) *Pygmaeocereus familiaris* in habitat, (e) *Eulychnia ritteri*, (f) *Haageocereus chalaensis*, (g) *Cistanthe paniculata*, (h) *Oxalis* cf. *dombeyi*.

Impact of land use change

Satellite images from Bing Maps (Microsoft, n.d.), and time lapse images from Google Maps (Google, n.d.; Fig. 3) show the rapid expansion of urban areas since 2003, but especially increasing in 2016, invading the range of *P. familiaris* and associated flora in the lower sector of "Lomas de Chala", the type locality. Urban expansion in the area is also connected to an increase in soil and vegetation removal and garbage dumping (Fig. 2a-c, e) affecting neighboring known populations of *P. familiaris*.

The town of Chala and surrounding areas have been included in several mining claims (Fig. 4). However, no extractive activities are currently taking place in those mining concessions, which do not overlap with the critical area for the flora.

Conservation proposal

Cacti are flagship plants due to the benefits of understanding their biology and the use of this information for the common benefit of both their populations and the habitat shared with other organisms and human communities.

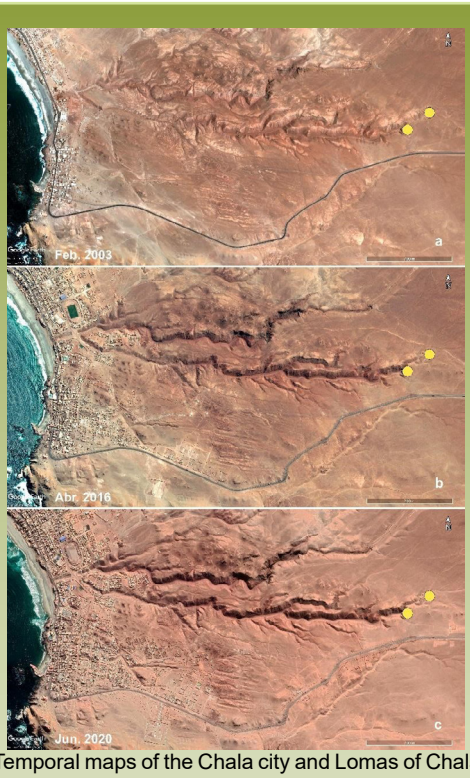

Figure 3. Temporal maps of the Chala city and Lomas of Chala, showing the rapid expansion of urban settlements: (a) 2003, (b) 2016, (c) 2020.

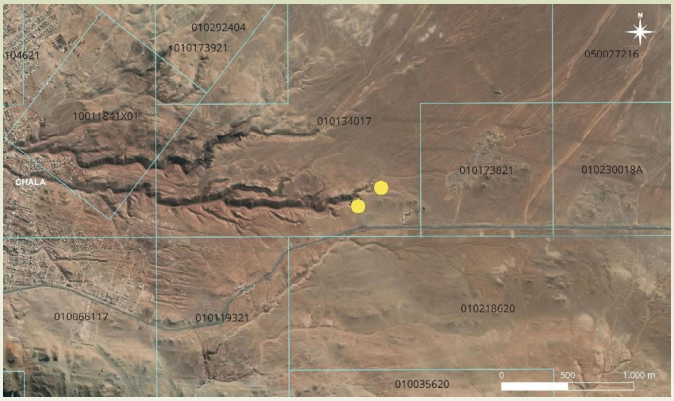

Figure 4. Mining concessions (delimited in blue) in Chala and around the critical area (Source: Hanco, 2010).

Both habitat suitability and quality are threatened by several human factors in the sites with known populations of the highly restricted *Pygmaeocereus familiaris*. The proposal of a protected area for *Pygmaeocereus familiaris* and accompanying flora responds to the need of managing and restoration actions for these species and this unique and fragile lomas ecosystem. We consider that it could be possible to propose sustainable use of the area that will include a lessening of threats affecting cactus populations and their ecosystem services in the future.

Here we propose a conservation area comprising in its landscape a bifurcated shallow canyon with reddish sand, gravel and stones (Fig. 5), and a marginal strip of about 30-40 m surrounding the canyon, considering that *P. familiaris* plants are growing on the canyon border. Because of the steepness of the area, the place has limited the expansion of urbanization, but did not stop contamination by trash, as several sectors are used as landfill deposits.

Figure 5. Proposed conservation area.

This note therefore aims to serve as a warning to all institutions involved in the area, from local authorities at the Municipal level to those in the Forestry Service of the Agricultural Ministry (SERFOR-MINAGRI), the Environmental Ministry (MINAM) and the Energy and Mining Ministry (MINEM) of the current situation endangering fragile ecosystems and restricted, endemic species. We hope that as we progress in our research, we will provide additional data needed for species recovery and population management.

References

Anderson, E. 2001. *The Cactus Family*. Timber Press, Portland, Oregon, 776 pp.

Arakaki M., Ostolaza C., Cáceres F., and Roque J. 2006. Cactacea endémicas del Perú. Pp. 193-219. *In*: León B., Roque J., Ulloa-Ulloa C., Pitman N., Jorgensen P., and Cano A. (Eds.) *El Libro Rojo de las Plantas Endémicas del Perú*. Vol. 13(2). Revista Peruana de Biología.

Cáceres, F. 2013. *Pygmaeocereus bylesianus*. *The IUCN Red List of Threatened Species* 2013: e.T152527A646914. Available from: https://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T152527A646914.en. (Accessed: 18 November 2022).

Google. n.d. Google Maps. Available from: http://google.com/maps/. (Accessed: 25 October 2022).

Hanco, W. M. 2010. Geocatmin: Sistema de Información Geológico y Catastral Minero. *XV Congreso Peruano de Geología, Cusco*. Special Issue 9.

Hunt, D., Taylor, N, Charles, G. 2006. *The New Cactus Lexicon, Volumes I and II: Descriptions and Illustrations of the Cactus Family*. dh Books, 899 pp.

Microsoft. n.d. Bing Maps. Available from: https://www.bing.com/maps/. (Accessed: 25 October 2022).

Ostolaza, C. 2019. *Todos los Cactus del Perú*. Sociedad Peruana de Cactáceas y Suculentas, Lima, Perú, 571 pp.

Renewable energy and cacti, can they coexist without collateral effects?

Carol Peña Hernández[1]

[1]Depto. de Ciencias y Tecnología Vegetal, Universidad de Concepción, Chile.

Chile is currently undergoing a process of energy transition from polluting fossil fuel sources to non-conventional renewable energies (NCRE). The Chilean state aims to be a carbon neutral country by 2050. By 2030 it is expected that 70% of electricity production will come from NCRE. Therefore, an increase in the construction of solar and wind energy projects is contemplated to achieve these goals. In 2015, when solar and wind power plants began to be integrated into the system, they accounted for less than 3% of the total energy production, while by June 2022 they represent more than 30% of the total production, being solar energy the one that has grown rapidly from 0 to 20.4% (MinEnergía, 2022).

The State of Chile is committed to ensure that the construction of new energy projects implement measures to safeguard ecosystems and biodiversity, such as the zero net biodiversity loss approach. This entails biodiversity compensation plans, where an equivalence is established between the biodiversity impacted by the implementation of the project and the biodiversity compensated (SEA, 2014). Therefore, mitigation, repair and/or compensation measures must be contemplated. To build photovoltaic plants the soil must be free of vegetation, so for the vegetation present in the project area it is only possible to implement compensation and repair measures, since the damage cannot be mitigated. One of the most commonly used compensation measures is the relocation of individuals that are in any of the threat categories established by the IUCN Red List of Threatened Species or Chilean legislation.

An example of relocation is what has happened in recent years with *Copiapoa megarhiza*, categorized as Vulnerable in 2011 (Faundez *et al.*, 2011) and more recently as Endangered (Guerrero *et al.*, in review). This is one of the *Copiapoa* species that grow furthest from the coast. This genus with 32 species is characterized by growing on rocky soils, mainly on slopes with northern exposure and under the influence of coastal fog that provides the necessary humidity to live. *Copiapoa megarhiza* grows in the Copiapó valley approximately 50 km from the coastal edge, where fog is less frequent than on the coast. It has a napiform root that allows it to store water. The root is attached to the stem by a thin neck that makes it difficult to handle, as it is usually cut in that area when it is dug up. The population with the highest density of healthy individuals is located northwest of the city of Copiapó, where two photovoltaic plants have already been installed, and a third one has been approved and is about to begin construction. Other photovoltaic plants could potentially be installed in this area because it has the infrastructure to facilitate their start-up. For the plants already built, 350 individuals of this species were relocated to nearby areas. In addition, there is an electrical transmission line that during its construction contemplated the transplanting of 260 individuals. One of the criteria established by the Chilean environmental authority to evaluate the success of these procedures is the rooting of the individuals. Of the almost 600 individuals relocated during the construction of the three projects and according to this criterion, the relocation was successful, since most of them produced new roots and showed adherence to the soil. However, after the rain that fell during June 2021, it could be observed that the individuals of the control population had a constant production of flowers and seeds between July 2021 and January 2022 (Fig. 1). In contrast, the relocated plants, which did not present flowers during the same period, also had absent the meristematic area covered by the apical woolliness characteristic of *Copiapoa*. This area is sunken and with spines concentrated on it (Fig. 2). When an individual was removed from the substrate, it was observed that the storage root characteristic of the species was absent. In its place were fibrous roots in development, so it is likely that these plants will not survive, because it is this structure that allows them to withstand long periods of drought, and they have survived for about 4-5 years. This is the period that companies commit to a constant watering regime, to help the formation of new roots.

Figure 1. *Copiapoa megarhiza* outside of the relocation site. Note the presence of flowers and the wooly apex.

On the other hand, *ex situ* conservation has been proposed as part of the reparation measures, through the safeguarding of seeds in germplasm banks of those individuals that are to be relocated. This measure also has a side that has not been evaluated, which is the lack of

knowledge about the genetic variability of the populations to be intervened. It is possible that due to the pressure to meet the minimum number of seeds required, many seeds from a few individuals could be collected, which could imply a low representation and loss of genetic diversity if future restoration plans are to be made from these seeds.

Figure 2. *Copiapoa megarhiza* at the relocation site. There are no flowers, nor is the wooly apex observed.

Therefore, it is necessary to implement changes in the evaluation criteria for these mitigation and compensation measures, such as the calculation of vegetation indices through the multitemporal analysis of satellite images or the use of multispectral cameras that allow us to know the state of the vegetation, and genetic diversity analysis, since the existing ones do not guarantee long-term survival, especially of long-lived species such as *Copiapoa*. This is of vital importance, since the construction of future projects is evaluated independently, without considering the cumulative impacts on the species present in the area caused by projects already built. This could result in the relocation of thousands of individuals of this species, which would have serious conservation consequences.

References

Faundez, L., Guerrero, P., Saldivia, P. and Walter, H.E. 2017. *Copiapoa megarhiza* (amended version of 2013 assessment). *The IUCN Red List of Threatened Species* 2017: e.T152778A121487859. Available from: https://dx.doi.org/10.2305/IUCN.UK.20173.RLTS.T152778A121487859.en. (Accessed: 10 December 2022).

Ministerio de Energía. 2022. *Transición Energética de Chile, Política Energética Nacional. Actualización 2022.* Gobierno de Chile, Santiago, Chile, 91 pp.

SEIA. 2014. *Guía Para La Compensación De Biodiversidad En El SEIA. Servicio de Evaluación Ambiental. Ministerio del Medio Ambiente.* Gobierno de Chile, Santiago, Chile, 64 pp.

Systematics, Phylogenetics, Taxonomy

The Mammilloid Clade: an example of high species richness, endemism, and rapid diversification

Peter Breslin[1]

[1]Desert Laboratory on Tumamoc Hill, The University of Arizona, Tucson, Arizona, USA.

My Ph.D. research, completed in 2020, was focused on the Mammilloid Clade, a well-supported clade currently spanning the genera *Mammillaria* Haw., *Cochemiea* (Brandegee) Walton, *Coryphantha* (Engelm.) Lem., and *Pelecyphora* C. Ehrenb. Historically, this clade has also included *Bartschella* Britton & Rose, *Chilita* Orcutt, *Dolichothele* Britton & Rose, *Ebnerella* Buxb., *Escobaria* Britton & Rose, *Escobariopsis* Doweld, *Mamillopsis* F.A.C. Weber, *Neobesseya* Britton & Rose, *Neolloydia* Britton & Rose, *Ortegocactus* Alexander, and *Phellosperma* Britton & Rose. Many of these generic circumscriptions were monotypic or consisted of very few species, and were based on unreliable, homoplastic, or uninformative characters, a problem that is characteristic of much of the cactus taxonomy of the past two centuries or so.

My particular focus within this highly diverse and fascinating clade were the Baja California and Sonoran Desert lineages, with which I remain fascinated due to their tangled taxonomic history, remarkable speciation and diversity, biogeographical patterns (cf. Breslin *et al.*, 2023), high endemism, the beauty of the flowers, and the presence of polyploidy and dioecy. There are also prior evolutionary studies that showed a unique clade position outside of traditional generic boundaries of Mammillaria for many Baja species (e.g., Butterworth and Wallace, 2005). Consider that several of the microgenera historically segregated out of *Mammillaria* (at least 5) occur in either Sonora or Baja California, and you get an idea of the intricacy of this group of beautiful species.

My original research question was whether there was support for the genus *Cochemiea* as represented by the type species *Cochemiea halei* Walton and the other original taxa: *C. maritima* H.E. Gates ex Shurly, *C. pondii* Walton, *C. setispina* Walton (all of which are narrow endemics), and the widespread *C. poselgeri* (Hildm.) Britton & Rose (Fig. 1). Near the end of my doctoral research, Garcia-Morales *et al.* (2020) described a new species, *Cochemiea thomasii* Garcia-Mor. *et al.*, the only known taxon that is

probably within the original concept of *Cochemiea* that occurs in mainland Mexico. I embarked on extensive habitat studies (that had already spanned more than 20 previous years on an amateur basis), population assessments, morphological measurements, tissue collection, whole genome DNA extraction, sequencing, alignment, and multiple analyses to investigate the most supported position for these original taxa.

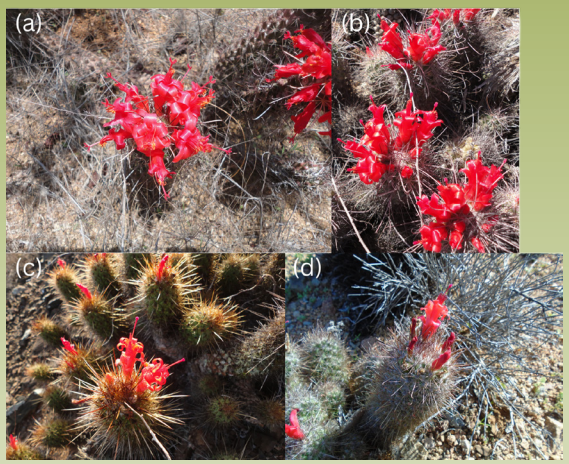

Figure 1. Various original taxa of *Cochemiea*. (a) *C. poselgeri*, the most widespread of the original species. (b) Showy flowers of *C. maritima* at the type locality, Baja California Norte. (c) *C. halei* on Isla Magdalena, Baja California Sur. (d) *C. pondii* in habitat on Isla Cedros, Baja California Norte.

Our nucleotide alignment that we used in analysis was the large single copy region of the plastome, including nearly 90,000 nucleotides. We used all three of the common algorithms available now: maximum parsimony, maximum likelihood, and Bayesian analysis. We also used strongly diagnostic morphological characters that were highly consistent at the clade level. The tree topologies across all three methods were identical, we had only one polytomy of three unresolved species in our MP and ML analyses, and there was remarkable coherence of small clades. All of our major clades and 92% of our smaller clades had 100% support (Fig. 2) (Breslin *et al.*, 2021).

My co-authors and I found that the original taxa in *Cochemiea* are indeed a well-supported clade. However, these original *Cochemiea* are nested within a group of approximately 40 taxa traditionally included in the genus *Mammillaria*. This group was recovered as a strongly supported clade sister to *Coryphantha* in the broad sense (*Coryphantha* + *Pelecyphora*), and undeniably distinct from the genus *Mammillaria*. Due to the rules of botanical nomenclature, we were required to name this clade *Cochemiea*, and we proceeded to set up the required combinations to move all the members in this clade out of *Mammillaria* and into this expanded circumscription of *Cochemiea*. The flatter, often (but not always) solitary stems, and the odd trait of producing white latex sap distinguish, for example, *Mammillaria brandegeei* Engelm. ex K. Brandegee, *Mammillaria petrophila* subsp. *arida* (Rose ex Quehl) D.R. Hunt, and *Mammillaria petrophila* K. Brandegee (Fig. 3 a-c) from *Cochemiea hutchisoniana* (H.E. Gates) P.B. Breslin & Majure, *Cochemiea angelensis* (R.T. Craig) P.B. Breslin & Majure, *Cochemiea goodridgei* (Scheer ex Salm-Dyck) P.B. Breslin & Majure, and *Cochemiea blossfeldiana* subsp. *rectispina* (E.Y. Dawson) P.B. Breslin & Majure (Fig. 3 d-g).

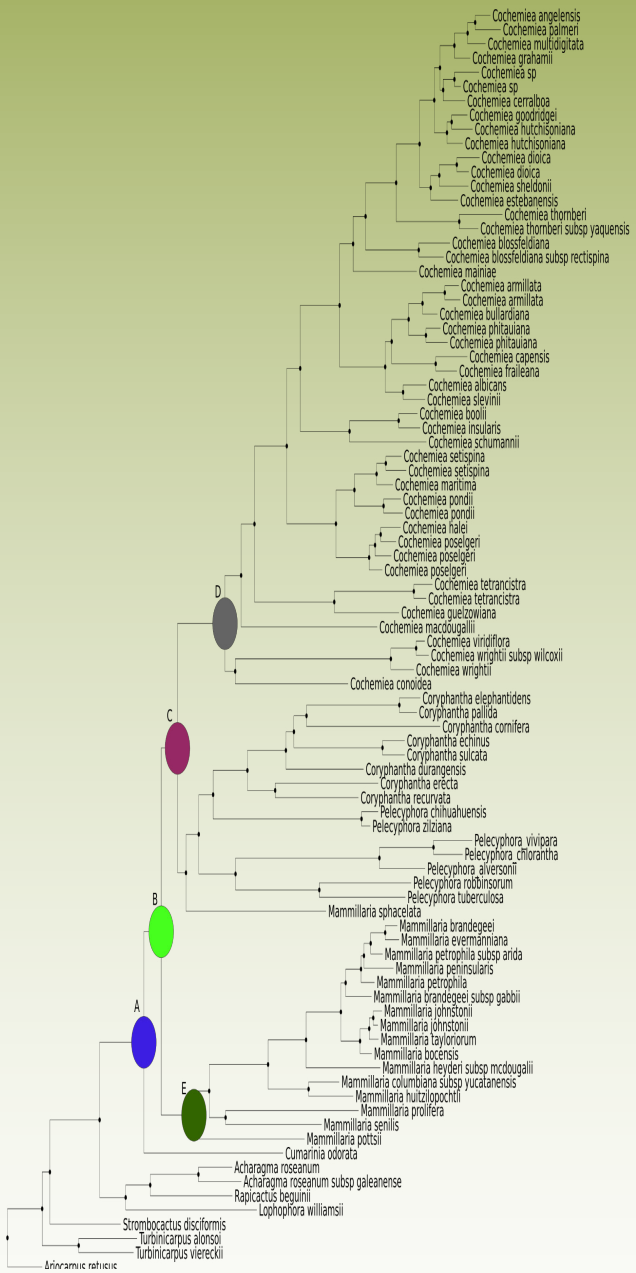

Figure 2. The molecular phylogeny of the Mammilloid Clade that resulted from our multiple analyses. (A) (deep blue circle) the most recent common ancestor of the entire Mammilloid Clade including *Cumarinia odorata* (Boed.) Buxb.; (B) (light green circle) the most recent common ancestor of the Mammilloid Clade not including *Cumarinia odorata*; (C) (magenta circle) most recent common ancestor of the *Coryphantha* + *Cochemiea* clade; (D) (grey circle) most recent common ancestor of *Cochemiea*; and E) (dark green circle) most recent common ancestor of *Mammillaria* sensu stricto. Note that *Coryphantha* (including *Pelecyphora*) is more closely related to *Cochemiea* than is *Mammillaria*.

Figure 3. (a) *Mammillaria brandegeei* near El Rosario, Baja California Norte. (b) *M. petrophila* subsp. *arida* near La Paz, Baja California Sur. (c) *M. petrophila* high in the Sierra la Laguna, Baja California Sur. (d) *Cochemiea hutchisoniana* near Puerto San Carlos, Baja California Sur. (e) *C. angelensis* in habitat on Isla Angel de la Guarda, Baja California Norte. (f) *C. goodridgei* flowering on Isla Cedros, Baja California Norte. (g) *C. blossfeldiana* subsp. *rectispina* also on Isla Cedros.

However, some of the "cactus community" has been reluctant to accept our results. This has been an interesting pattern to reflect on, and one that, as a cactus enthusiast as well as an evolutionary biologist, I have seen repeatedly over the past 20 years or so (at least). Even a recent peer-reviewed publication in a special issue *Advances in Plant Taxonomy and Systematics* of MDPI's *Biology*, which largely replicated our results (especially at the major clade level) and disregarded our biogeography, which had been published 8 months earlier (Breslin *et al.*, 2022) ignored the taxonomic changes we made, providing nearly no argument for not adopting them (Chincoya *et al.*, 2023). The authors of that paper in fact write: "We recommend detailed studies to further determine the taxonomic circumscription of" the genera they recover in their phylogeny, which match ours nearly identically. It is a strange situation, where we now have at our disposal a powerful combination of more evidence and more sophisticated analytical methods than ever before, but even trained systematists in some cases cling to phylogenetic concepts that were based on conjecture, "common sense," and an apparent resistance to "believing" the topology of well-supported phylogenetic trees. Apparently, this is even the case when their own research recovers clear, well-supported clade-level groups that can be diagnosed at the generic level, and other studies have already made the necessary changes to align those genera accordingly.

Admittedly, in Cactaceae in general, and in the Mammilloid Clade in particular, a few realities complicate the task of uncovering evolutionary relationships. One is that several apparently diagnostic and supposedly important morphological characters are in fact examples of either convergent evolution or unstable characters that come and go over time. Overemphasizing relatively minor or recently emergent characters is part of why there are so many different historical perspectives on cactus taxonomy. Another limitation is that nuclear DNA is not phylogenetically informative among some groups of cacti (the Mammilloids in particular).

However, two upsides when investigating the Mammilloid Clade are in play. One is that rapidly evolving chloroplast DNA is highly informative and gives reasonable, well-supported results where the branch tips and the internal node structures make basic sense. The other is that, apparently, even in the case of polyploids, at least in the Mammilloid Clade (very grateful I don't study *Opuntia*), reticulate evolution caused by natural hybridization seems non-existent, or at least probably has not been operating within the past 7 to 8 million years or so.

It's especially interesting to meet with resistance to our proposed changes coming from amateurs and trained scientists that arises from a sense of the "suddenness" of our changes. We simply confirmed what had long been suspected, what Lüthy and Hunt had etched out in the form of either subgenera or series (with subgenera and series having little practical use in evolutionary terms in my opinion), what Butterworth and Wallace had basically shown in 2005, what Bonnie Sue Crozier concluded in her Ph.D. thesis (2005), what Bárcenas (2011), Vázquez-Sánchez (2013), and Hernández-Hernández (2014) had shown also in the intervening decades, and what Sanchez *et al.* (2022) and Chincoya *et al.* (2023) have shown since we published.

The recent history of molecular phylogenetics producing results that regroup longstanding genera continues in our example, leaving many collectors, amateur experts, and non-scientists and scientists baffled, frustrated, or exasperated. Some have wondered whether using chloroplast DNA alone is enough to rearrange *Mammillaria*. We also used highly stable, ancient morphological characters, but this was apparently not sufficiently convincing for some. The other reality is that, as molecular phylogenies move from small, concatenated markers toward phylogenomics, the results from most angiosperm plant families get clearer and more reasonable, not less. Chloroplast data has been shown to be phylogenetically informative in thousands of completely independent studies. Our own phylogenetic tree is basically sensible, consistent with many other lines of evidence and previous studies, and informative. We did not rely only on chloroplast DNA. We incorporated ancestral traits and biogeography, and it all hangs together into a single, coherent, consistent picture (Fig. 2).

As an evolutionary biologist who first came up through the cactus collecting and growing hobby, with my first knowledge of the "hook-spined Baja California *Mammillaria*" coming from Edgar and Brian Lamb's *Exotic Collection* newsletter in the 1970's, I see the drawbacks of the last 20 years or so of clade-based taxonomy. On the one hand, the changes can at first seem quite odd, and even

strike one as the madness of lab scientists who "obviously know nothing about the plants." On the other hand, many of these changes have been decades in the making, and reflect a total evidence approach far stronger than some of the highly idiosyncratic taxonomy done in the past. It's interesting to me that many of the somewhat capricious, low-evidence-based changes that were made by both lumpers and splitters through the 1980's and 1990's, for example, were much more readily accepted than results such as ours. Detractors dismiss phylogenetic results that they do not personally approve of with the wave of a hand and a remarkably anti-scientific attitude, appealing to "common sense" when surely plant evolution often reflects anything but that.

One example of the dangers of "common sense" when making inferences about the evolutionary history of the Mammilloids is regarding *Mammillaria senilis* Lodd. ex Scheer., at one time considered special enough to have its own monotypic genus, *Mamillopsis*. Judging from the hooked spines and apparently bird-pollinated flower structures, it's easy to imagine that this taxon is "closely related or perhaps ancestral to" *Cochemiea*. Yet even with these seemingly important morphological differences, *Mammillaria senilis* is comfortably at home in every phylogeny ever done, squarely nested within *Mammillaria*. This is how powerful convergent evolution can be, especially in recently diverging, rapidly evolving groups. In fact, obviously, hooked spines have evolved several times across the Mammilloid Clade, independently. Our ancestral state analysis suggests that there's in fact about a 25% chance that the common ancestor of the entire Mammilloid Clade had hooked spines. It also seems that highly modified flowers driven by pollination syndromes often result from convergent evolution. Our best analyses suggest that the suite of seemingly significant morphological adaptations in *Mammillaria senilis* are very recent and evolved independently (and separated by about 3 million years) of the somewhat similar characters in the original concept of *Cochemiea*. If even the immediately remarkable hooked spines and exceptional flowers of *M. senilis* are deceptive, consider the more minute details that have been used to make conjectures regarding evolutionary relationships.

So, why did we move the former *Mammillaria* into an expanded concept of *Cochemiea*? Because those taxa are not *Mammillaria*. In fact, they have a closer evolutionary relationship (that is, a more recent common ancestor) with the *Coryphantha* clade (Fig. 2). Of course, you are free to continue to call them what you like. The goal of our study was not to change names. I was personally reluctant to make the move, but when it became clear we had the strongest evidence in the history of studies of these plants, there was no other choice, from an evolutionary biology standpoint.

Our results were also replicated in the somewhat surprising, expanded concept of *Pelecyphora* containing the former *Escobaria*, as communicated clearly and convincingly by Sanchez *et al.* (2022). Chincoya *et al.* (2023) also does not accept these results, again, providing no real argument why not, again in spite of replicating the clades in Sanchez *et al.* (2022). I can understand why there's some distrust of the "ivory tower of cactology" (as Michiel Pillet calls it) among enthusiasts, collectors, growers, and hobbyists. It's puzzling to encounter a somewhat anti-scientific attitude from trained systematists, however.

If you prefer a genus name that is incorrect from a clade standpoint, keeping the (mostly) hook-spined taxa (mostly) from Sonora and Baja in *Mammillaria*, then why not go with the large clade level and move every *Coryphantha* and Pelecyphora into *Mammillaria* as well? In fact, while I was doing my Ph.D. research, I showed my advisor, expert plant systematist Marty Wojciechowski, our best scoring ML tree and asked him, "how many clades do you see related to the Mammilloids?" His reply: "One." All these taxa have a single most recent common ancestor at the root (Fig. 2). Of course, the other option that aligns genera with well-supported clades is to re-segregate at the "microgeneric" level, resurrecting or recircumscribing monotypic or two-or-three species genera that are often not practically distinguishable, do not convey much of importance about evolution, and end up being not particularly useful. *Chilita dioica* (K. Brandegee) Buxb. has a nice ring to it, don't you think?

References

Bárcenas, R. T., C. Yesson, and Hawkins, J.A. 2011. Molecular systematics of the Cactaceae. *Cladistics* 27: 1–20.

Breslin, P. B., Wojciechowski, M.F., and Majure, L.C. 2021. Molecular phylogeny of the Mammilloid clade (Cactaceae) resolves the monophyly of *Mammillaria*. *Taxon* 70: 308–323.

Breslin, P.B., Wojciechowski, M.F., and Majure, L.C. 2022. Remarkably rapid, recent diversification of *Cochemiea* and Mammillaria in the Baja California, Mexico region. *American Journal of Botany* 109: 1472–1487.

Butterworth, C. A., and Wallace, R.S. 2004. Phylogenetic studies of *Mammillaria* (Cactaceae)—insights from chloroplast sequence variation and hypothesis testing using the parametric bootstrap. *American Journal of Botany* 91: 1086–1098.

Chincoya, D.A., Arias, S., Vaca-Paniagua, F., Dávila, P., and Solórzano, S. 2023. Phylogenomics and biogeography of the Mammilloid Clade revealed an intricate evolutionary history arose in the Mexican Plateau. *Biology* 12(4).

Crozier, B. S. 2005. *Systematics of Cactaceae Juss.: Phylogeny, cpDNA evolution, and classification, with emphasis on the genus* Mammillaria *Haw*. Ph.D. dissertation. University of Texas, Austin, Texas, USA.

García Morales, L.J., González González, R., Jiménez, J.G., and Iamonico, D. 2020. A new species of *Cochemiea* (Cactaceae, Cacteae) from Sinaloa, Mexico. *Acta Botánica Mexicana* 127: e1626.

Hernández-Hernández, T., Brown, J.W., Schlumpberger, B.O., Eguiarte, L.E., and Magallón, S. 2014. Beyond aridification: Multiple explanations for the elevated diversification of cacti in the New World Succulent Biome. *New Phytologist* 202: 1382–1397.

Vázquez-Sánchez, M., Terrazas, T., Arias, S., and Ochoterena, H. 2013. Molecular phylogeny, origin, and taxonomic implications of tribe Cacteae (Cactaceae). *Systematics and Biodiversity* 11: 103–116.

Synergy

iCAN, yet another association of cactophilous people?

Monica Arakaki[1], Karen Bauk[2], Fernando F. Franco[3], Bárbara Goettsch[4], Pablo Guerrero[5,6,7], Laura Las Peñas[2,8], Lucas C. Majure[9], Evandro M. Moraes[3], Eddy Mendoza[10], Matias Köhler[3], Raul Puente[11], Ulises Rosas[12], Tania Hernández-Hernández[11,*]

[1]División Botánica, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Perú.

[2]Instituto Multidisciplinario de Biología Vegetal (UNC-CONICET), Córdoba, Argentina.

[3]Departamento de Biologia, Universidade Federal de São Carlos, ¡São Carlos, São Paulo¸ Brazil.

[4]International Union for Conservation of Nature, Species Survival Commission, Cactus and Succulent Plants Specialist Group, Cuernavaca, Mexico.

[5]Departamento de Botánica, Universidad de Concepción, Concepción, Chile.

[6]Instituto de Ecología y Biodiversidad (IEB), Concepción, Chile.

[7]Millennium Institute Biodiversity of Antarctic and Sub-Antarctic Ecosystems (BASE), Santiago, Chile.

[8]Universidad Nacional de Córdoba, Facultad de Ciencias Exactas, Físicas y Naturales, Córdoba, Argentina.

[9]University of Florida Herbarium, Florida Museum of Natural History, Gainesville, Florida, USA.

[10]Evolutionary Biology Centre, Uppsala University, Uppsala, Sweden.

[11]Research, Conservation and Collections, Desert Botanical Garden, Phoenix, Arizona, USA.

[12]Jardín Botánico, Instituto de Biología, Universidad Nacional Autonoma de Mexico, Ciudad de México, Mexico.

[*]Corresponding author; personal email: thernandez@dbg.org; organizational email: ican@dbg.org.

During pre-pandemic times, scientific researchers used to physically gather at academic events such as conferences and seminars. We were not used to virtual meetings and video calls as we are today. Networking used to mean grabbing a drink during a poster session in a congress or workshop, mixing with a bunch of people sharing similar interests, introducing yourself, and talking about your work. In those in-person conferences, a particular group of researchers working on various scientific projects, all related to the cactus family, met and started sharing ideas, experiences, knowledge, and plans. In contrast to all existing groups and associations around the plant family Cactaceae, in addition to our love for cacti, this emerging group of people performed active scientific research and had very diverse academic interests; however, all used cacti as a study subject. Although many of these researchers were interested in different aspects of Cactaceae, such as evolution, systematics, taxonomy, genetics, and conservation, this was not a conservation- or taxonomy-focused group. Some others were performing innovative projects such as using transcriptomics, genomics, physiology, anatomy, or even studying developmental mechanisms. All those people felt the need to share their ideas and results with experts in the cactus family. This group of people had in common the academic interest in understanding these wonderful succulent plants from different perspectives and the wish to implement novel approaches and technologies to study cacti. Creating an international group would be a necessary way to integrate and generate knowledge and preserve cacti more efficiently. Forming an organized group would facilitate collaboration, share resources, material, and information, and help prepare the next generation of students of cacti. Bringing together future collaborative efforts was obvious, but how they would interact needed to be clarified.

In 2018 the vision of organizing a meeting and creating a group started to be discussed more seriously. Some of us concurred at the Latin American Botanical Conference in Quito, Ecuador. In one of those mixing and networking poster sessions, a small international group got together after a wonderful Cactaceae seminar organized by Dr. Teresa Terrazas and decided to pursue international collaborations. Everyone agreed to try finding the resources and ways to bring us together and start working toward our academic goals. Unfortunately, the pandemic

began, and it was impossible to organize a traditional in-person meeting for a while. So, we relocated our efforts to the virtual setting. During September 1st-3rd, 2021, the Desert Botanical Garden hosted the first-of-its-kind International Virtual Mini-Symposium, entitled "Cactaceae: phylogenetics, evolution, and conservation in the genomic era" (iCAN, 2021a). The pandemic brought some good things, and the new ease of virtual encounters allowed the complete success of the Symposium, evidenced by the number of participants and the different nations represented.

The symposium gathered nearly 50 attendees from the U.S., Mexico, Chile, Argentina, Brazil, Peru, the United Kingdom, and Germany. Many of them are part of the new generation of 'cactologists', approaching their research from different perspectives (evolution, anatomy, physiology, genetics, ecology, conservation, etc.) and using novel technologies and methods to generate data. The enthusiasm and the prolific and enriching discussions held during the symposium helped clarify future actions that this academic community wanted to take toward understanding and preserving cactus diversity, given their importance and vulnerability. It was a significant challenge to overcome: while cactus enthusiasts and researchers are widespread across the globe, particularly in Europe and the U.S., the highest diversity of Cactaceae occurs elsewhere, mostly in developing Latin American countries, where resources for conservation and research are scarce.

After the symposium online discussion sessions, we came to several agreed conclusions. First, we identified the need for a concerted effort towards scaling the studies on the family with new technologies and approaches, mainly using state-of-the-art DNA sequencing tools, in other words, bringing the cactus research towards the genomic era. Regarding conservation efforts, and having examples from living collections worldwide, we discussed the creation of an international cactus bank for ex situ conservation of seeds, plus tissues and DNA for research. A coordinated network of Cactaceae research groups and conservation associations spread around the globe could facilitate such initiatives and the gathering of information like collection inventories or morphological and physiological trait databases, that are currently scattered and isolated. We also debated the academic exchange of students and the organization of workshops or online courses to learn how to use and analyze novel genetic data and motivate young students.

Another unanimous conclusion during the meeting was that international collaboration was imperative to better understand the family's biodiversity and get genuinely effective conservation efforts. There is a need to understand better the current resources that the international scientific community has available to study and preserve species in Cactaceae locally, *in situ*, and *ex situ*, as well as prioritize needs for future actions. After discussing the status of Cactaceae living collections in each country or region, we recognized that these collections are diverse, being maintained under different conditions and circumstances. In addition to living collections hosted by botanical gardens, both private and public, there are also living collections owned and maintained by particular research groups in different academic institutions. Some collections are well managed and monitored, but others require more effort to document and preserve specimens. In many cases, these collections are 'hidden' from the global community since there are no webpages, indices, catalogs, or directories to consult and know about them. Through international collaboration and sharing, could we be able to generate the best and well documented meta-living collection of cactus biodiversity in terms of species numbers for future generations? Developing a world catalog of Cactaceae species and specimens found in both public and academic living collections worldwide was extensively discussed (Hultine *et al*., 2016).

Figure 1. iCAN logo.

Figure 2. Screenshot of iCAN attendees.

After the event, participants in the symposium started meeting regularly. As the network took shape, objectives, and goals were also discussed. Since then, we have achieved an initial webpage (iCAN, n.d.) and started organizing monthly webinars (iCAN, 2022) and social networks (iCAN, 2021b). We found a high need and demand for online accessible scientific information about the biology of Cactaceae from the general public, which is not surprising given the global popularity of this succulent plant family. Our monthly seminars have an average attendance of 50 guests from around ten different countries. It was soon apparent that what we were creating was a different 'cactophylic' association, and what was different from others was the exclusive academic nature of the work and interests of the participants. Then, we decided on a name for this group: iCAN (International Cactaceae Academic Network) (Fig. 1, Fig. 2). Amongst many other goals, iCAN promotes the exchange of

information, resources, and other physical materials for working with Cactaceae, for example tissue, seeds, or DNA. With academic and scientific backgrounds, we also promote the dissemination of the work and results that international groups worldwide are performing. We are very optimistic about this exciting new direction in the international organization of the Cactaceae scientific community. We are confident that iCAN has the potential to open previously untapped funding avenues to support the research, education, and conservation of cacti and provide resources for underfunded botanical gardens in Latin America (Hultine *et al.*, 2016).

References

Hultine, K.R., Majure, L.C., Nixon, V.S., Arias, S., Búrquez, A., Goettsch, B., Puente-Martinez, R. and Zavala-Hurtado, J.A., 2016. The role of botanical gardens in the conservation of Cactaceae. *BioScience* 66(12): 1057-1065.

iCAN, n.d. *International Cactaceae Academic Network.* iCAN. Available from: https://www.ican-cactaceae.org/. (Accessed: 2 August 2023).

iCAN. 2021a. *International Virtual Mini-Symposium "Cactaceae: Phylogenetics, Evolution and Conservation in the Genomic Era"*. Desert Botanical Garden, Phoenix, Arizona, USA. Available from: https://dbg.org/events/cactus-symposium-2021/. (Accessed: 22 February 2022).

iCAN, 2021b. *iCAN - International Cactaceae Academic Network*. Twitter. Available from: https://twitter.com/ican_cactaceae. (Accessed: 2 August 2023).

iCAN, 2022. *International Cactaceae Academic Network (iCAN)*. YouTube. Available from: https://www.youtube.com/channel/UC32FLjWxCpSurDM134OuCqg. (Accessed: 2 August 2023).

What's New in Systematics, Phylogenetics and Taxonomy

The past year was a great year for systematic and conservation work in the family Cactaceae, with many papers on phylogenetic relationships and new species published, as well as the development of promising new genetic tools for understanding relationships across the family. Acha and Majure (2022) and Romeiro-Brito *et al.* (2022) published nuclear probe sets that can be used for phylogenetic resolution at the species level and deeper into evolutionary history. Evolutionary relationships and the biogeographic history of Cactaceae across the Caribbean, Mexico (including Baja California), United States, Central and South America were further clarified in a number of recent papers (Alvarado-Sizzo and Casas, 2022; Bárcenas and Hernández, 2022; Breslin *et al.*, 2022; Chincoya *et al.*, 2023; Majure *et al.*, 2022, 2023a,b), and Köhler *et al.* (2023) analyzed chloroplast genome variation across tribe Opuntieae. Conservation and phylogenetic diversity assessments also were considered throughout parts of the range of the family (Amaral *et al.*, 2022; Cardoso *et al.*, 2022; Cavalcante *et al.*, 2023; García Morales *et al.*, 2022; Gutiérrez Rodríguez *et al.*, 2022; Hultine *et al.*, 2023), and niche modeling across the family painted a stark future for some species (Pillet *et al.*, 2022). Majure (2022) dug deeper into the reticulate evolution of lineages with the prickly pears and Granados *et al.* (2022) across Cactaceae, further clarifying our knowledge of these fascinating processes in the family. New species and information on reproductive biology of certain members of the family were also published (Cota-Sánchez, 2022; Freilij *et al.*, 2023; Hammel and Arias, 2022; Hoxey *et al.*, 2023a,b; Merino *et al.*, 2022; Ortíz-Brunel *et al.*, 2022; Paixão *et al.*, 2023), and an annotated checklist for the cacti of Cuba will be published soon (Barrios *et al.*, in press). Finally, a special issue in the Journal of the Botanical Research Institute of Texas commemorated the legacy of Dr. Donald J. Pinkava, renowned for his work in the biosystematics of Cactaceae, especially the Opuntioids (DeVore and Pigg, 2022).

References

Acha, S. and Majure, L.C. 2022. A new approach using targeted sequence capture for phylogenomic studies across Cactaceae. *Genes* 13(2): 350.

Alvarado-Sizzo, H. and Casas, A. 2023. Genetic diversity, differentiation and phylogeography of the *Stenocereus griseus* (Haw.) Buxb. species complex (Cactaceae). *Genetic Resources and Crop Evolution* 70(3): 1023-1037.

Amaral, D.T., Bonatelli, I.A., Romeiro-Brito, M., Moraes, E.M. and Franco, F.F. 2022. Spatial patterns of evolutionary diversity in Cactaceae show low ecological representation within protected areas. *Biological Conservation* 273: 109677.

Bárcenas, R.T. and Hernández, H.M. 2022. Supporting a young age for the North American deserts: Historical biogeography of *Grusonia* (Cylindropuntieae) in a Plio-Pleistocene temporal framework. *Taxon* 71(5): 981-992.

Barrios, D., Arias, S., González-Torrez, L.R., and Majure, L.C. In press. Lista anotada de cactus nativos y naturalizados de Cuba. (Annotated list of the native and naturalized cacti of Cuba). *Botanical Sciences*.

Breslin, P.B., Wojciechowski, M.F. and Majure, L.C. 2022. Remarkably rapid, recent diversification of *Cochemiea* and *Mammillaria* in the Baja California, Mexico region. *American Journal of Botany* 109(9): 1472-1487.

Cardoso, W.C., Calvente, A., Dutra, V.F. and Sakuragui, C.M. 2022. Cactaceae in a priority area for conservation in Espírito Santo state. *Rodriguésia* 73.

Cavalcante, A., Sampaio, A.C.P., Duarte, A.S. and Santos, M.A.F. 2023. Impacts of climate change on the potential distribution of epiphytic cacti in the Caatinga biome, Brazil. *Anais da Academia Brasileira de Ciências* 95: e20200904.

Chincoya, D.A., Arias, S., Vaca-Paniagua, F., Dávila, P. and Solórzano, S. 2023. Phylogenomics and biogeography of the Mammilloid clade revealed an intricate evolutionary history arose in the Mexican Plateau. *Biology* 12(4): 512.

Cota-Sánchez, J.H. 2022. A compendium of vivipary in the Cactaceae: new reports, data, and research prospects. *Brazilian Journal of Botany* 45(3): 1001-1027.

DeVore, M.L. and Pigg, K.B. 2022. Donald Pinkava's journey from Asteraceae to Cactaceae: from the Ohio State University to Arizona State University. *Journal of the Botanical Research Institute of Texas* 16(1): 273-280.

Freilij, D., Larrea-Alcazar, D., Lopez, R.P., Velarde Simonini, F., Naoki, K. and Bessega, C. 2023. Environmental gradualism explains variation in pollination systems of columnar cacti: Phylogenetic and trait evolution analyses. *Global Ecology and Biogeography* 32(6): 1015-1029.

García-Morales, L.J., García-Jiménez, J., Contreras-Medina, R., Alcántara-Ayala, O. and Luna-Vega, I. 2022. Diversity, distribution and conservation of the Cactaceae (Caryophyllales) from Tamaulipas, Mexico. *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology* 156(6): 1405-1421.

Granados-Aguilar, X., Rosas, U., González-Rodríguez, A. and Arias, S. 2022. The prickly problem of interwoven lineages: hybridization processes in Cactaceae. *Botanical Sciences* 100(4): 797-813.

Gutiérrez-Rodríguez, B.E., Guevara, R., Angulo, D.F., Ruiz-Domínguez, C. and Sosa, V. 2022. Ecological niches, endemism and conservation of the species in *Selenicereus* (Hylocereeae, Cactaceae). *Brazilian Journal of Botany* 45(3): 1149-1160.

Hammel, B. and Arias, S. 2022. A new species of *Deamia* (Cactaceae) from Nicaragua. *Phytotaxa* 576(2): 220-226.

Hoxey, P., Gdaniec, A., Hernandez, J.D., Guzmán, M., Corniel, W. and Culham, A. 2023a. A taxonomic revision of the genus *Leptocereus* (Cactaceae) in Haiti and the Dominican Republic. *Bradleya* 2023(41): 4-80.

Hoxey, P., Tanco, G.A.P., Silvestre, V.Q. and Gdaniec, A. 2023b. A new species of *Cumulopuntia* (Cactaceae) from Peru. *Bradleya* 2023(41): 139-147.

Hultine, K.R., Hernández-Hernández, T., Williams, D.G., Albeke, S.E., Tran, N., Puente, R. and Larios, E. 2023. Global change impacts on cacti (Cactaceae): current threats, challenges and conservation solutions. *Annals of Botany*: mcad040.

Köhler, M., Reginato, M., Jin, J.J. and Majure, L.C. 2023. More than a spiny morphology: Plastome variation in the prickly pear cacti (Opuntieae). *Annals of Botany*: mcad098.

Majure, L.C. 2022. On the origin of the two putative allopolyploids, *Opuntia curvispina* and *O. martiniana* (Cactaceae): A case of cryptic speciation in prickly pear cacti. *Journal of the Botanical Research Institute of Texas* 16(1): 317-333.

Majure, L.C., Barrios, D., Díaz, E., Bacci, L.F. and Piñeyro, Y.E. 2022. Phylogenomics of the Caribbean melocacti: Cryptic species and multiple invasions. *Taxon* 71(5): 993-1012.

Majure, L.C., Murphy, T.H., Köhler, M., Puente, R. and Hodgson, W.C. 2023a. Evolution of the Xerocarpa clade (Opuntia; Opuntieae): Evidence for the Role of the Grand Canyon in the Biogeographic History of the Iconic Beavertail Cactus and Relatives. *Plants* 12(14): 2677.

Majure, L.C., Achá, S., Baker, M.A., Puente-Martínez, R., Köhler, M. and Fehlberg, S. 2023b. Phylogenomics of One of the World's Most Intriguing Groups of CAM Plants, the Opuntioids (Opuntioideae: Cactaceae): Adaptation to Tropical Dry Forests Helped Drive Prominent Morphological Features in the Clade. *Diversity* 15(4): 570.

Merino, G., Sánchez, M.A.O., Meléndez, D.I.G., Collazo-Ortega, M. and Márquez-Guzmán, J. 2022. Mating systems in a natural hybrid of *Cephalocereus* (Cactaceae) and comparative seed germination. *Journal of Arid Environments* 203: 104773.

Ortiz-Brunel, J.P., Carrillo-Reyes, P., Sánchez, D., Ruiz-Sanchez, E. and Rodríguez, A. 2023. A morphological analysis of the *Mammillaria fittkaui* species complex (Cactaceae) reveals a new species from Jalisco, Mexico. *Botanical Sciences* 101(2): 619-631.

Paixão, V.H.F., Gomes, V.G.N., de Souza, C.S. and Venticinque, E.M. 2023. Cactus height increases the modularity of a plant-frugivore network in the Caatinga dry forest. *Biotropica* 55(4): 877-887.

Pillet, M., Goettsch, B., Merow, C., Maitner, B., Feng, X., Roehrdanz, P.R. and Enquist, B.J. 2022. Elevated extinction risk of cacti under climate change. *Nature Plants* 8(4): 366-372.

Romeiro-Brito, M., Telhe, M.C., Amaral, D.T., Franco, F.F. and Moraes, E.M. 2022. A target capture probe set useful for deep-and shallow-level phylogenetic studies in Cactaceae. *Genes* 13(4): 707.

Events and Opportunities

Conferences and Congresses

- The 40th Annual Succulent Plants Symposium at The Huntington Library, Art Museum, and Botanical Gardens: this annual event in San Marino, California, USA will take place on September 1st and includes two CSSG members. Registration details can be found here.
- "Cátedras del Semidesierto" is an annual seminar organized by the Cadereyta Regional Botanic Garden in Querétaro, México. The garden lies close to the semiarid zone of Querétaro and Hidalgo, the southern end of the Chihuahuan Desert. The event is a meeting place for scholars and researchers who share interests in this zone. This year's motto is: "The Botanical Garden is a space of hope for life." It refers to the hope in scientific knowledge to consolidate biodiversity conservation. The ninth edition of the event is scheduled for August 23rd to 25th 2023 in a hybrid format (in-person, limited capacity, and remotely through YouTube). For more information, email bmaruri@concyteq.edu.mx.
- The International Cactaceae Academic Network (iCAN) organizes monthly Zoom seminars on current cactus research. Please register on their website to receive seminar announcements.
- The Cactus and Succulent Society of America organizes an online seminar series featuring cactus and succulent experts from around the world. Please register on their website.

Grants and Funding

- Applications for the Mohamed bin Zayed Species Conservation Fund are open. This global fund has been established to provide targeted grants to any individual threatened species' conservation initiatives, recognize leaders in the field and elevate the importance of species in the broader conservation debate. Deadline: October 31, 2023.
- The Cactus and Succulent Society of America Research Grants Program supports research projects involving succulent plants through small grants. Deadline: February 1, 2024.
- The Cactus and Succulent Society of America supports conservation projects involving succulent plants through small grants. Deadline: rolling basis. For more information, email irwinlightstone@att.net.
- The Tucson Cactus and Succulent Society provides small grants for both research and conservation projects involving succulent plants. Deadline: rolling basis.

صندوق محمد بن زايد
للمحافظة على الكائنات الحية
The Mohamed bin Zayed SPECIES CONSERVATION FUND

ABOUT THE NEWSLETTER

The Cactus and Succulent Plants Specialist Group Newsletter is an important tool to keep members informed of SG activities and accomplishments.

CSSG ANNUAL REPORT

2021 Report