Cactus and Succulent Plants Specialist Group Newsletter *December, 2021*

Content

A few words from the Co-Chairs

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

We hope you and your families are well. In this newsletter, we not only celebrate the end of the year, we also celebrate the completion of the 2017-2020 quadrenium, which took place in September 2021, during the IUCN World Conservation Congress. We are pleased to inform you that despite the CONVID-19 difficulties, our group accomplished the 2020 work plan goals, including the publication of 296 new assessments of succulent plants for the IUCN Red List, the expansion of the membership with a particular focus on the inclusion of women and young professionals, the new CSSG logo, participation in three outreach events and the repatriation of illegally collected Chilean cacti, among others. It is a great pleasure to inform you that we were awarded the "Citation of Excellence 2021" granted by the IUCN SSC for our outstanding performance during 2020. This was possible thanks to your valuable support and expertise, for which we are very grateful. Congratulations! We hope this is an incentive to continue our work in the new quadrennium. We are thankful to those members who have renewed their membership and remind those who are pending, it will be an honour to continue working with you.

Continuing with celebrations, we are excited to share the CSSG Newsletter in its new format and with the publication of scientific outreach articles.We are extremely grateful to our members and other experts who contributed with articles on this issue. We would also like to thank the Latin American and Caribbean Network for Bat Conservation (RELCOM) for sharing with the CSSG the design template for the new layout of the newsletter. Finally, we would like to thank our Programme Officer, Jael M. Wolf, for her hard work designing and helping to edit the bulletin to get it ready.

Our warmest greetings during this holiday season and best wishes for 2022,

Bárbara Goettsch and Lucas Majure

CSSG News

Membership renewal

As mentioned in our previous communication (membership renewal email), the membership renewal process for the 2021-2025 period started on October 2021 and will end in early January 2022. If you haven't renewed your membership yet, we invite you to do it by clicking on the following link: https://portals.iucn.org/commissions/

If you have any issues, please contact us at jwolf@dbg.org and we will be happy to assist you.

IUCN World Conservation Congress closes with a call for a post-pandemic recovery based on nature

The IUCN World Conservation Congress was held during September 3-11, 2021 in person in Marseille, France, and online. Its goal was to set a plan for nature conservation for the next decade and beyond. The congress's primary targets were the role of nature in the global recovery from the COVID-19 pandemic, biodiversity and climate crises, and indigenous peoples' place in conservation. The key messages and important commitments made during the congress were recorded in the Marseille Manifesto. Furthermore, the next IUCN programme for 2021-2030 was approved under the name of Nature 2030: Union in Action.

Reassessment of Cactaceae, Sonoran Desert and Southwest USA region

We are pleased to inform you that we are commencing the reassessment of the Cactaceae family. Teaming up with the Sonoran Desert Plant Specialist Group, we will start reassessing the approximately 246 cactus species distributed in the Southwest of the US and Northwest Mexico.

Recognition of CSSG's performance

We are proud to share with you that the CSSG received the "Citation of Excellence 2021", which is awarded to those specialist groups that met their work targets in 2020, contributing substantially to the Species Strategic Plan.

Acknowledgements

On behalf of the CSSG, we would like to thank the generosity of our host institution, the Desert Botanical Garden, its support is invaluable to us and thanks to it we have the assistance of our Programme Officer, Jael Wolf.

We are also grateful for the generosity and enthusiasm of our partner B.Willow, who in addition to donating funds to the group, has taken upon themselves to spread the word about our work.

Finally, we would like to express our gratitude to our Programme Officer, Jael M. Wolf, for the support she provides to the CSSG and its members.

Scientific Outreach Articles

Conservation Interventions

Would you drink a Jaguar to extinction? The mezcal maelstrom and alternatives from MILPA A.C.

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Drinking a glass of Jaguar... Perhaps this analogy may seem rather strange, however, we believe it is appropriate to explain one of the many problems caused today by the voracious extraction, theft and extirpation of wild agave populations for the production of distillates, be it *mezcal*, *bacanora* (a distillate from Sonora) or *raicilla* (a distillate from the southwestern Jalisco). Like *tequila*, these agaves and their products have designated Protected Denomination

of Origin (PDO) status. Protected Denomination of Origin refers to a product from a particular geographic region, in this case of Mexico, which contains qualities or characteristics unique to the geographical environment in which it exists, including natural and human factors (*Ley Federal de Protección a la Propiedad Industrial, Diario Oficial de la Federación el 1 de julio de 2020*) (the Mexican Federal Law for Protection of Industrial Property, Official Federal Register, July 1, 2020).

Hunting or any other type of threat to the conservation of the Jaguar (*Panthera onca* L.) is punishable under Mexican law (NOM-059-SEMARNAT-2010). Its skin, claws, fangs, bones and live specimens are the main targets of illegal hunters, which they trade on the black market, representing an ostentatious and exclusive trophy for those who possess them or seek miraculous cures (Nijman *et al*., 2019). This striking and powerful wild animal, despite being a top predator, possessing claws, teeth, skill and ferocity, an icon of native cultures and a symbol of biodiversity and nature conservation for Mexico, has been decimated throughout most of its natural distribution. This has seriously endangered its survival in the short and long term, both within Mexican territory and beyond its political borders. The jaguar problem is analogous to "the *mezcal* boom," which has been developing for a little over 10 years. It has increased in parallel with the expansion and creation of different PDOs in Mexico (*bacanora and raicilla*) following the path of the tequila and mezcal PDOs. Its wake has the populations of numerous wild agave species. Like the jaguar, agaves are iconic species of Mexican biodiversity and culture. About 159 species are known in Mexico and new species continue to be described. They are found in most ecosystems, where they have key ecological functions including nectar provision and soil retention (García-Mendoza *et al*., 2019; Torres-García *et al*., 2019). There is evidence for human consumption of agave stems and leaf bases and the use of fibers for textiles and rope making date from more than 10,000 years ago (Flannery, 1986; MacNeish, 1967). *Pulque*, the sacred drink of Mesoamerican peoples, is made from the sap of agave. Agave products and use continue to be an important household mainstay in many rural communities throughout Mexico, including more than 20 types of use that have been reported for this genus. However, it is its use in the production of distillates that is of greatest importance and growth at present (Colunga-GarcíaMarín *et al*., 2017).

Agave for distillates

In the first version of the Official Mexican Standard 070 (NOM-070), which defines and regulates the *mezcal* PDO, five agave species were recognized as permitted for making this distillate. However, Colunga-GarcíaMarín and collaborators (2007) recognized 43 species reported to be used for distillates. In a subsequent (2016) modification to the NOM-070, an important change allowed for the elaboration of *mezcal* with other cultivated or wild agave or *maguey* species whose biological development has occurred in the geographical area that comprises the PDO. This change was justified with the argument that in this way *Agave* species or other traditionally used botanical genera of the Asparagaceae family would not be excluded. However, this allowed a total opening to all agave species, even those that had not been used for this purpose before, and justified the cultivation of any species within the PDO area, even if it was growing outside of its natural distribution.

Through literature review, field research with distillate producers, maguey handlers and workers and discussion forums with actors in the distillate production-marketing chain, we detected a total of 59 species of *Agave* L. reported as being used for this activity (Table 1). We found that not all species are used with the same intensity, some species are used only occasionally or in isolated circumstances and others are used in low proportion mixed with other species. For many other species, the use in the preparation of distillates is recent and for some its extraction from natural populations is intensifying and worrisome.

Some species that have been recently described, such as *Agave megalodontha* García-Mend. & D. Sandoval and *A. lyobaa* García-Mend. & S. Franco (García-Mendoza *et al*. 2019), are already in use for the preparation of distillates. Other species such as *A. pintilla* S. González, M. González & L. Reséndiz (González-Elizondo *et al*., 2011) are no longer frequently used, but historically it is recognized that their populations were decimated by *mezcal* activity before the current *mezcal* boom. Further, species such as the cultivated A. *fourcroydes* Lem., that had another main use in the past, are now being explored for their potential as raw material for distillates.

The most worrisome cases are the wild species that, for the first time in history, are being incorporated as raw material for distillates. This includes *Furcraea longaeva* Karw. & Zucc. in the district of Yautepec, Oaxaca (Palma-Cruz 2019 pers. comm.), and *A. montana Villareal*.

The Mexican Official Norm, NOM-059-SEMARNAT-2010, recognizes 18 *Agave* species with some category of risk. Of these, four are within our list as used for distillates. *Agave peacookii* Croucher and *A. titanota* Gentry are subject to special protection (Pr). *Agave lurida* Aiton and *A. victoriae-reginae* T. Moore are in danger of extinction (P).

In 2018, IUCN Red List assessments were conducted for 185 species of *Agave* and *Yucca*, this work assessed only species recognized as wild. From our list of 59 species, 46 species were evaluated. A total of 27 species were listed in the Least Concern (LC) category. Although 19 of these were reported to have stable populations, the trends of distillate production include these species; hence, the pressure on these populations is increasing.

The main threat to *A. angustifolia* Haw., *A. horrida* Lem. Ex Jacobi, *A. inaequidens* K. Koch and *A. montana* is extraction for *mezcal* and for *A. maximiliana* Baker, extraction for raicilla. The remaining eight species show declining populations. For *A. marmorata* Roezl and *A. seemanniana* Jacobi, the main and most worrying threat is the growing demand for *mezcal* and for *A. palmeri* Engelm., its extraction to produce *bacanora*.

Of the 17 species classified in a threat category, only *A. bovicornuta* Gentry is recognized as having stable populations; the rest have decreasing populations due primarily to the increase in extraction to produce mezcal. This includes *A. convallis* Trel, *A. karwinskii* Zucc, *A. nussaviorum* García-Mend., *A. cupreata* Trel. & A. Berger, *A. macroacantha* Zucc. (Fig. 1.), *A. titanota* Gentry, *A. pintilla* and *A. montium-sancticaroli* García-Mend. *Agave valenciana* Cházaro & A. Vázquez populations are decreasing due to the increasing production of *raicilla*.

Figure 1. Wild population of Agave macroacantha, growing in the Tehuacán-Cuicatlán Valley. Harvesting of this species in the past was very occasional. It is currently in danger of extinction (EN). (Photo: Ignacio Torres-García)

The problems of increasing demand

Agaves cannot move, escape or defend themselves. Although they are armed with vicious lateral teeth, sharp, piercing terminal spines and produce copious secondary metabolites that sting on contact, they are no match for today's harvesting tools coupled with the relentless growing demand for distillates from wild agave species. The destination of the bulk of these distillates is the export market, where exorbitant prices are charged and only clients with high purchasing power can afford, falling (naively or not) into the trap of marketing exclusivity.

Maguey cultivation has been seen as an alternative to reduce the pressure on the populations of wild species. However, as occurs with the cultivation of domesticated *magueys* such as *A. tequilana* F.A.C. Weber, *A. angustifolia*, and some recently cultivated wild species such as *A. potatorum* and *A. cupreata*, cultivation under intensive models brings with it processes of land use change through deforestation and abandonment of basic food production, intensive use of water, fertilizers and pesticides, marginalization of small farmers and the emergence of a chain of exploitation of land and people at the base of production systems (Tetreault *et al*., 2021).

The uniqueness or exclusivity of a *mezcal* coming from a wild species, marked as unique, rare, with exotic flavors, produced in small batches, coming from some wild and recondite place, is most likely the result of an extraction system without any management to ensure the conservation of the wild populations. Each bottle of distillate that comes from wild sites without any type of management represents a threat to wild agave populations, since the extraction rate exceeds the rate of natural regeneration. Each agave that is extracted represents thousands of seeds that will not germinate and become part of the natural population. If no positive management actions are taken, these populations face extirpation. We documented this for *A. potatorum* in the *Mixteca Poblana*, where the resource was very abundant, however, populations suffered localized extinction (Torres *et al*., 2013; 2015). Such practices directly threaten the survival of species that only reproduce by seed, such as *A. potatorum*, *A. cupreata* and *A. nussaviorum*, to mention a few.

In addition to extraction from the wild, there is evidence and testimonies of the theft of wild agaves in various areas of the country, such as those recorded for *A. marmorata* in the Tehuacán-Cuicatlán Valley and the theft of *A. cupreata* seed in Michoacán. In 2020, large areas with native vegetation in the Tehuacán-Cuicatlán Valley were deforested to establish plantations of various species with some juvenile individuals such as *A. convallis*, evidently extracted from the wild (Torres-García, 2021). The justification for these drastic actions is the high demand for commercialization and the preference of these exotic distillates outside the Mexican border.

The compilation of evidence and testimonies shows us a pattern that clearly indicates that the conservation of wild populations throughout the country is being violated by the PDOs. Among these evidences and testimonies we can mention: the extirpation of wild populations, the impossibility of recruiting new seedlings and the impact on interactions and natural pollinators, the absence of management actions, the excessive ambition masked in an idea of development based on industrial production, the lack of environmental ethics, the change of land use, the increase of demand in the national and international market and the establishment of a regulatory body that allows any kind of irregularities to certify the distillate. The combination of all of the above is the perfect formula for the collapse of the ecosystems that harbor agaves and the biocultural heritage of the communities that have historically been linked to these species.

The recent evaluation by the IUCN, the patterns of socio-environmental effects observed at the national level and the growing worldwide demand for distillates

of *Agave* species and other Asparagaceae, make clear the urgent need to carry out a serious review and update the Mexican Standards. It would be necessary to activate the application of actions, restrictions and respective sanctions. In addition, it would be necessary to generate strategies that lead to informed and responsible consumption. Consumers should be provided with information on the panorama of distillates, alerts on the implications of consuming a bottle of distillate produced with certain species should be generated, the effects of its extraction and under what conditions the distillates were produced.

Alternatives for agave management

The worrying scenario just described is linked to many other problems that directly affect the biological-ecological, socioeconomic and biocultural nature of Mexico's distillates. These intensification patterns have been monitored by the Asociación Civil Manejo Integral y Local de Productos Agroforestales (MILPA A.C. Civil Association Integral and Local Management of Agroforestry Products), which is an effort that represents the Red Nacional de Manejadores de Maguey Forestal (National Network of Forest Maguey Handlers) and includes distillate producers and agave handlers, family organizations and community organizations from around eight states of the country, academics from various universities, civil society organizations, as well as activists in the *mezcal* industry.

The main objectives of this organization are 1) the identification of problems and strengths of the participating experiences; 2) to serve as a platform for the strengthening of technical and socio-environmental governance capacities; 3) the promotion of farmer-to-farmer knowledge exchanges and to foster the dialogue of knowledge; 4) scientific research guided by the real needs of the handlers and its dissemination, application and monitoring through techniques amalgamated by traditional knowledge and scientific knowledge.

In addition, we seek to generate the recognition of good agave management practices and reflect it in the bottles of distillates, and generate spaces for the visibility of these products so that they become consumption alternatives that address the problems described. We promote forestry and agroforestry management of the resources and territories where agaves are used (Torres-García *et al*., 2019), biodiversity conservation, food sovereignty of rural communities and respect for biocultural identity.

We have held four national meetings (2015, 2016, 2018 and 2019), working together with the different sectors involved to move towards achieving the objectives set. Likewise, we have involved and received funding from academic networks and governmental institutions such as the Thematic Networks of Non-Timber Forest Products, the Network of Agroforestry Systems of Mexico and Agared of CONACYT; CONABIO and CONAFOR, who supported these efforts. It is also important to mention the contributions made by managers who are more advanced in the management and recognition of their products, covering an important part of the costs of holding these events, as well as sharing their valuable experience (Fig. 2).

Figure 2. Workshop offered by members of the Red Nacional de Manejadores de Maguey Forestal (National Network of Forest Maguey Handlers) to maguey producers and handlers from other regions of the country, in the framework of the Fourth National Meeting of Forest Maguey Handlers. At the El Rosario community library in Santa Catarina Minas, 2019. (Photo: Ignacio Torres-García)

The most tangible achievements have been the progress and development of different management and distillate production experiences. These have incorporated an integral vision for the development of their activities and are a model for management experiences, with the capacity to transmit this knowledge. In addition, they continue to constantly incorporate and experiment with innovative and traditional techniques to direct their development towards ecological and socio-cultural sustainability. Although the trajectory of the Red Nacional de Manejadores de Maguey Forestal and MILPA A.C. is short, the work agenda continues to try to influence three fundamental aspects: capacity building, scientific research and the creation of a sustainable trade platform.

To influence and guide the last point of the agenda, it is necessary to disseminate knowledge to raise awareness among consumers about the impacts of our purchasing decisions, and to support conscious and comprehensive experiences that responsibly manage species, territories and that are in harmony with the carrying capacity of ecosystems. At the same time, it is necessary to discourage the consumption of distillates that come from companies or groups that carry out practices of excessive extraction of plants in the wild, the destruction of ecosystems for the establishment of intensive monocultures, the usurpation of territories and that offer little transparency in their production methods, as well as to denounce them and press for the authorities to enforce the corresponding sanctions.

If we really want to continue toasting with mezcal in the future, we need to reverse the current consumption trends that are leading agave distillates to an increasingly worrisome scenario: decline of wild populations, local extinctions, disruption and deterioration of ecosystems, loss of ecosystem benefits, disintegration of the social

Table 1. Agave species used for the production of distillates in Mexico, population trend according to the Red List of the International Union for Conservation of Nature and Natural Resources (IUCN) and risk categories according to NOM 059-SEMARNAT 2010 of the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT, Ministry of Environment and Natural Resources).

Species	IUCN Population trend	NOM 059 – SEMARNAT 2010
A. americana L.	stable	ni
A. angustiarum Trel.	decreasing	ni
A. angustifolia Haw.	stable	ni
A. aspérrima Jacobi	stable	ni
A. atrovirens Karw. ex Salm-Dyck	stable	ni
A. bovicornuta Gentry	stable	ni
A. cantala Roxb.	not evaluated	ni
A. cerulata Trel.	decreasing	ni
A. convallis Trel.	decreasing	ni
A. cupreata Trel. & A. Berger	decreasing	ni
A. desmettiana Jacobi	not evaluated	ni
A. durangensis Gentry	not evaluated	ni
A. fourcroydes Lem.	not evaluated	ni
A. funkiana K.Koch & C.D.Bouché	decreasing	ni
A. gigantensis Gentry	stable	ni
A. guadalajarana Trel.	decreasing	ni
A. hookeri Jacobi	not evaluated	ni
A. horrida Lem. ex Jacobi	stable	ni
A. inaequidens K. Koch	stable	ni
A. jaiboli Gentry	decreasing	ni
A. karwinskii Zucc.	decreasing	ni
A. kerchovei Lem.	decreasing	ni
A. lechuguilla Torr.	stable	ni
A. lophantha Schiede	stable	ni
A. lurida Aiton	not specified	P
A. lyobaa García-Mend. & S. Franco	not evaluated	ni
A. macroacantha Zucc.	decreasing	ni
A. mapisaga Trel.	not evaluated	ni
A. margaritae Brandegee	stable	ni
A. marmorata Roezl	decreasing	ni
A. maximiliana Baker	stable	ni
A. megalodonta García-Mend. & D. Sandoval	not evaluated	ni
A. montana Villareal	stable	ni
A. montium-sancticaroli García-Mend.	decreasing	ni
A. multifilifera Gentry	stable	ni
A. murpheyi F. Gibson	not evaluated	ni
A. nussaviorum García-Mend.	decreasing	ni
A. oteroi Starr & Davis	not evaluated	ni
A. palmeri Engelm.	decreasing	ni
A. parryi Engelm.	stable	ni
A. peacockii Croucher	unknown	Pr
A. pelona Gentry	decreasing	ni
A. pintilla S. González, M. González & L. Reséndiz	decreasing	ni
A. potatorum Zucc.	decreasing	ni
A. rhodacantha Trel.	decreasing	ni
A. salmiana Otto ex Salm-Dyck	stable	ni
A. seemanniana Jacobi	decreasing	ni
A. shawii Engelm.	decreasing	ni
A. shrevei Gentry	decreasing	ni
A. sisalana Perrine	not evaluated	ni
A. sobria Brandegee	stable	ni
A. tequilana F.A.C. Weber	not evaluated	ni
A. titanota Gentry	decreasing	Pr
A. univittata Haw.	stable	ni
A. valenciana Cházaro & A. Vázquez	decreasing	ni
A. victoriae-reginae T. Moore	stable	P
A. weberi Cels ex Poisson	not evaluated	ni
A. wocomahi Gentry	stable	ni
A. zebra Gentry	unknown	ni

NOM 059-SEMARNAT 2010: Pr: Subject to Special Protection, P: Endangered, ni: Not listed.

fabric, erosion of traditional knowledge and finally the impossibility of consuming the valued *mezcal*. Efforts should be focused on the conservation of agaves, a group of plants native to Mexico, which not only provides raw material for distillates, but also offer a wide range of functions and environmental benefits, a cultural symbol and an important resource for the present and future of numerous families and communities. Beyond being able to have the ostentatious luxury of a Jaguar in a bottle, what would be really valuable is to be able to buy and consume an agave distillate (whatever it is called), with production characteristics that counteract and help to solve the socio-environmental problems exposed, where the conservation of nature and the ecosystemic benefits provided by nature are the priority, and respect for the biological, ecological and cultural aspects of one of Mexico's most representative beverages are integrated

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Personal Notes on Field Trips

The extreme aridity of the Atacama Desert

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Charles Darwin wrote of the Atacama Desert as "*a barrier far worse than the most turbulent ocean*" (Darwin, 1845), describing the extreme aridity of this unique ecosystem (Fig. 1). Large portions of the Atacama Desert have less than 5 mm of precipitation per year, and there are even areas with no precipitation recorded for hundreds of years. In addition, low atmospheric relative humidity and high U.V. radiation combine to act as a further barrier to life. The extreme aridity in this area dates back at least eight million years, providing ample time for some of the biological diversity to adapt and colonize this habitat.

Figure 1. Hyperarid Atacama Desert. (Photo: Pablo Guerrero)

Figure 2. *Eriosyce rodentiophila* growing in extremely arid conditions. (Photo: Pablo Guerrero)

Aridity has been recognized as a stimulus for evolution in plants by favouring isolation due to the heterogeneous distribution of humidity, and by promoting the appearance of adaptive strategies that provide resistance or escape from drought. For example, the flowering desert is an event of overwhelming beauty where hundreds of plant species bloom simultaneously, transforming the arid landscape into a scene dominated by the colours of flowers. In the flowering desert, annual plants that take advantage of pulses of rainfall to come out of dormancy, growing explosively and reproducing rapidly, stand out. However, the occurrence between each flowering event can be several years, a time that long-lived plants (perennials), on the other hand, have to withstand extreme aridity with very little water availability. On the coast of the Atacama Desert, you can find some points with fragile cloud ecosystems that harbour rich endemic biodiversity, each of these oases of fog emerges as an island of life surrounded by that turbulent sea of hyperaridity described by Charles Darwin. Despite

this environmental adversity, some biological groups have managed to thrive under these harsh conditions, of which the cacti are perhaps the most important because of their species richness, endemism and surprising adaptive strategies.

Figure 3. Several dead individuals of *Eulychnia iquiquensis* in coastal Atacama Desert. (Photo: Pablo Guerrero)

Two genera of cacti are astonishing for their species richness, Eriosyce and Copiapoa, with about 55 and 32 recognized species, respectively, inhabit the Arid Diagonal of South America, whose point of greatest aridity is the Atacama Desert (Fig. 2). Eriosyce species are found with different growth forms, from some spherical species, others subcolumnar and others even geophytes, whose body remains underground most of the time reducing water loss by evapotranspiration. The species of the genus Copiapoa concentrate their diversity in a much more limited area, being restricted exclusively to the coastal portion of the Atacama Desert. The 'copiaopas' have very small species with bodies of a few centimetres wide, and others that form huge clusters with numerous stems reaching up to 5 m wide. The genus Eulychnia is also common in the coastal zone, some of its members are large arborescent cacti that inhabit especially the strip of exposure to the fog, which with the support of lichens and tillandsias epiphytes intercept the water acting as true fog traps, contributing to the subsidy of the fog to the annual availability of water.

It is likely that the Atacama Desert is in one of the driest moments in its history, where the arid conditions typical of the current interglacial could be intensified by the current climate change of anthropogenic origin. One of the consequences of this climatic trend could be that lethal aridity occupies a larger portion of the territory, and there is already evidence suggesting that there is a shift in the margin of lethal aridity that could even generate local extinctions. Although aridity may have helped in the generation of new species in the past, the fact is that today many populations have the vast majority of their individuals dead. In some areas, the reduction of fog in recent decades has severely affected some species, bringing entire populations to the brink of extinction (Fig. 3). Other human disturbances such as habitat destruction and illegal exploitation of endemic species put species at high risk of extinction. There is still much to discover and investigate in this hyperarid desert; however, the future of some species that have subsisted there for thousands or even millions of years may not be assured, even for the next few decades

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Commented Publications

Cacti in a more flammable world, experiences in central Argentina

Diego E. Gurvich

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The planet is not only warming-up at rates never recorded, but it is also becoming increasingly flammable. Fires in natural ecosystems are not only increasing their frequency in regions where these events are considered a natural disturbance, but are also affecting biomes in places where they were uncommon. The Sierras de Córdoba, in central Argentina, form a particularly important region in terms of cactus species richness, as they are home to about 31 species, 13 of which are endemic. Although disturbances such as fire and grazing are considered natural in this region, the frequency of fires has increased substantially in recent years. With this problem in mind, my research group has addressed as research topic how fire affects different aspects of the life cycle of cacti as well as the possible effects on this plant group.

Over the last few years, we have studied (in a combination of lab and field studies) aspects involving how seeds respond to simulated fires, how individuals survive and grow after fires, and how fires affect the reproductive capacities of the species by affecting seed production and seed quality. These studies have been useful to better understand how

species respond to this disturbance and predict what their future could be.

The Sierras de Córdoba are a mountainous region located in central Argentina (Fig. 1a). They have an altitude ranging from 500 to 2300 m above sea level. Precipitation increases with altitude, but also decreases from east to west (humidity came from east and it is subsequently trapped by mountain ranges). Temperatures range from subtropical (mean annual temperature of 20 ˚C) in the lower elevations, to temperate/cold (mean annual temperature of 10 ˚C) in the higher elevations. Due to these changes the vegetation is heterogeneous. In general, at lower altitudes there are dry forests (Chaqueño type), which are replaced by shrubby landscapes at intermediate altitudes, and grasslands at higher altitudes (Fig. 1b). Cacti are found in all these environments, but the species have different altitudinal ranges. For instance, columnar cacti are only found in lower parts whereas globose cacti are found throughout the altitudinal gradient, but there is higher number of species at intermediate altitude sites (Gurvich *et al*., 2014).

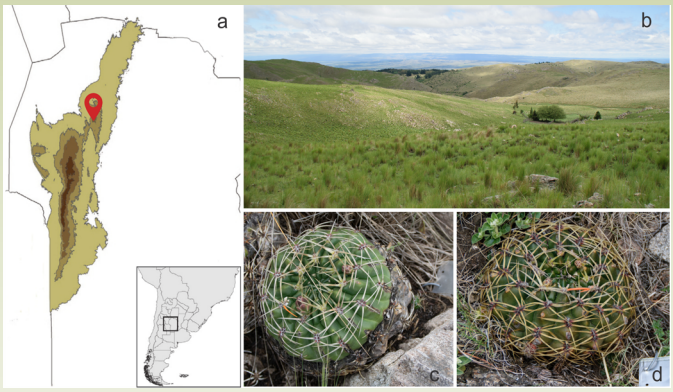

Figure 1. a) Córdoba Mountains, indicating the location of one of the sites where the response to fire in *Gymnocalycium monvillei* was studied. b) Vegetation of the study area showing temperate grasslands. c) Burned individual of *G. monvillei*. The mark left by the fire can be seen as a gray band at its base. d) Unburned individual of the same species. (Photos Diego E. Gurvich)

Because regeneration by seeds is a fundamental aspect of plant reproduction and could be of great importance to understand the ability of species to survive after fire, particularly if adult plants do not survive or suffer high mortality, an initial study (Roca *et al*., 2021) analyzed how seeds might respond to fire. This study analyzed how temperature shock treatments, i.e., seeds subjected for short time to high temperatures in order to simulate the fire effect. The authors analyzed 13 species of the subfamily Cactoideae, including globose species such as *Gymnocalycium capillense,* small columnar species such as *Trichocereus candicans*, and arboreal columnar species such as *Cereus forbesii* (Fig. 2). The main results obtained showed that the seeds of all the species studied are tolerant to fire, suggesting that once seeds are dispersed on the soil they can withstand this disturbance with possibilities of subsequent germination.

A second work analyzed post-fire survival and growth in four globose species, *Gymnocalycium mostii*, *Gymnocalycium bruchii*, *Parodia submammulosa* and *Echinopsis aurea* (Zupichiatti *et a*l., 2022). This study considered the survival of the species in the face of a natural fire in 2011 and their post-fire growth. This field study allowed to ask other questions related to the characteristics of the microenvironment in which the individuals are found and whether these have an effect on both survival and post-fire growth. The results showed that all species were tolerant to fire and had a survival rate of 80%, had good post-fire growth, but *G. bruchii*, which has a napiform root, recovered faster than the rest of the species studied. Microenvironmental variables had very little effect on both survival and post-fire growth. These results indicate that globose cacti respond relatively well to fire, and that recovery from fire may occur in short time.

Figure 2. Dead individual of *Cereus forbesii* after a fire. Forest fires seem to affect arboreal species much more negatively than globose or shrubby species. (Photo Diego E. Gurvich)

A third study analyzed the effect of fires on regenerative aspects on *G. monvillei* (Lorenzati *et al*., 2022; Fig. 1c,d). This work compared burned vs. unburned plants in terms of fruit production, seed production, seed biomass and seedling germination. Surprisingly, one year after the fire, the fire had no effect on any of the variables analyzed. In summary, even shortly after a fire, burned plants produce as many quality seeds as unburned plants.

Ongoing studies on the mortality of columnar species, particularly the tree-like cactus *C. forbessi* and the shrubby species *T. candicans*, indicate that the tree-like species has a higher mortality than the shrubby species (Fig. 2). These results, in conjunction with the studies on globose species, would indicate that species size is related to survival. This may be due to two factors: first, that during fires there is a temperature gradient from the ground, where temperatures are lower, upwards, which would differentially affect species according to their size, and second, that globose species have a lower surface/volume ratio than columnar species, so they would have a higher thermal inertia (capacity to change the temperature).

Overall, these studies indicate that, at least for globose cacti, fires would not be a harmful disturbance. It is feasible that fires have a positive effect on these cacti since they cause a decrease in the cover vegetation that competes with the cacti and, perhaps more importantly, promote soil erosion, increasing rockiness. In the study area cacti, particularly globose species, are found primarily on rocky outcrops or on sites with very little soil. Future studies are needed to understand the long-term dynamics among fire,

soil characteristics and cactus communities. In relation to columnar species and opuntias, studies are still needed to understand their resistance to fire.

Overall, these investigations increase knowledge of the effects of fire on basic aspects of the biology and ecology of cacti. However, the results presented represent a first approximation and more research is needed to understand other aspects. Although there are few studies carried out in North America, the referred studies are the first of their kind in South America, indicating that there is ample scope for future research.

Acknowledgments

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Prickly prospects for cacti under climate change

Michiel Pillet

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Cacti are one of the most endangered groups of organisms on the planet. When the Global Cactus Assessment was completed for the IUCN in 2013, the major threat processes affecting cacti were agriculture and aquaculture, biological resource use, and development. While there exists considerable interest in protecting our prickly friends, for both scientific and horticultural reasons, significant knowledge gaps remain that hamper our ability to conserve cacti.

One critical area in which understanding is lacking is the effect of climate change on cacti. In the Global Cactus Assessment, under 10% of cactus species could be considered threatened by climate change with the available information and understanding at the time. When cactus populations are negatively affected by processes such as development and poaching, there tends to be clear evidence in the form of dead or missing plants. Establishing climate change as a threat to cacti is much more difficult as the effects can take a long time to show and may change patterns of growth and reproduction, as well as directly impact mortality. A thorough accounting of the expected effects of climate change on cacti is needed to accurately assess conservation status as well as design and implement future-proof conservation strategies.

If you were to ask people who are unfamiliar with cacti how they will respond to climate change, they would likely say cacti will prosper. Given that cacti are often perceived to like hot and dry conditions, this is not a bad hypothesis. Several scientific studies support this argument. First, cacti use a special photosynthetic pathway that increases their water use efficiency and benefits from carbon dioxide, one of the building blocks for photosynthesis, under hotter and drier conditions. Second, many species are capable of acclimating to high temperatures, in some cases even higher than expected under climate change. Lastly, most cacti occur in drylands, which have been expanding rapidly across the globe in the past few decades. However, not all cacti tolerate high temperatures, and lots of species have requirements not directly related to temperature, e.g., restrictions to specific soil types. Some cacti respond poorly to even two degrees of experimental warming, while others have shown reduced germination with higher temperatures.

Given limited conservation funding, how can we rapidly assess which cactus species will do well under climate change? In our study (Pillet, M., Goettsch, B., Merow, C., Maitner, B., Feng, X., Roehrdanz, P., and Enquist, B. Will a warmer world impact global biodiversity of Cactaceae? Prickly prospects for cacti under climate change; in review), we used a method known as species distribution modelling (SDM). SDM is a type of statistical modelling that relates where species do and do not occur to aspects of the environment such as climate. These models can then be used together with climate projections to predict how suitable the environment across the landscape will be in the future. Simply put, if you were asked why saguaro does not live in the Arctic, you would likely say “too cold” – SDM is the statistical equivalent to this.

To create these models, we needed observations of where cactus species occur. In recent years, enormous repositories of biodiversity data have been developed.

One such database, BIEN (Botanical Information and Ecology Network), contains almost 200,000 cactus observations for over 1,250 species. After cleaning those data and excluding species with less than 10 occurrences (needed for SDM to perform well), 408 species were left. To account for uncertainty inherent when creating statistical models and dealing with future climate, a variety of climate scenarios and model assumptions were used, resulting in over 6,000 forecasts and maps per species.

Figure 1. (a) *Uebelmannia pectinifera* (Photo: Michiel Pillet); (b) *Backebergia militaris* (Photo: Alberto Búrquez); (c) *Ariocarpus retusus* (Photo: Michiel Pillet)

Our analyses show that the majority of cacti will experience a reduction even in a favourable climate, with about a quarter of species projected to lose over 25% of their habitat by the end of the century. Overall, 60% of species are predicted to lose habitat. Only 12% of species are projected to gain more than 25% of their current habitat. Since there are many maps per species, these numbers represent the average across all maps. These results are unlikely to be exactly right: species are able to adapt to changes in the environment, and multiple threats affect many cacti simultaneously. However, the overall trend is clear – cacti will be negatively impacted by climate change. Also important is if there are patterns explaining which cacti will do worse. We found that there is no relationship between current conservation status and climate change impacts. While *Uebelmannia pectinifera* (Fig. 1A), a Brazilian species currently considered Endangered due to overcollection, is projected to lose 65% of its habitat, the Vulnerable *Backebergia militaris* (Fig. 1B) is predicted to gain 12%. *Ariocarpus retusus* (Fig. 1C), an extremely slow-growing species listed as Least Concern, is expected to decrease by 34% - bad news for this species that is unlikely to be able to disperse quickly. The models also show no relationship between current range size and forecasts. However, many endemic species are missing from our analyses, which may skew the results. Separating species by growth form, only epiphytic species do significantly worse than other forms. Finally, species in areas of high cactus richness are predicted to lose more of their current habitat.

The negative effects of climate change are also apparent when we look at species richness instead of individual species (Fig. 2). By superimposing predictions for single species, we created maps of the number of cactus species now and in the future across the Americas. Hot spots of cactus diversity visible on expert maps by the Global Cactus Assessment, such as the American Southwest, Mexico, eastern Brazil, and northern Argentina, are reflected in our map. This indicates our models perform well. Widespread decreases in cactus diversity are apparent from averaged maps for both 2050 and 2070. Many hot spots of cactus diversity are projected to experience sharp declines relative to current richness, including the Brazilian Atlantic Forest and eastern portions of the Brazilian Caatinga. Projections for parts of Mexico exceed a loss of 50% of cactus species. Sadly, areas, where losses are predicted due to climate change, coincide with regions of intense human activity. Most of the uncertainty in our predictions is driven by how fast species can disperse or move across the landscape. Given the slow life cycle of many cacti, dispersal to keep up with favourable climate will likely be negligible.

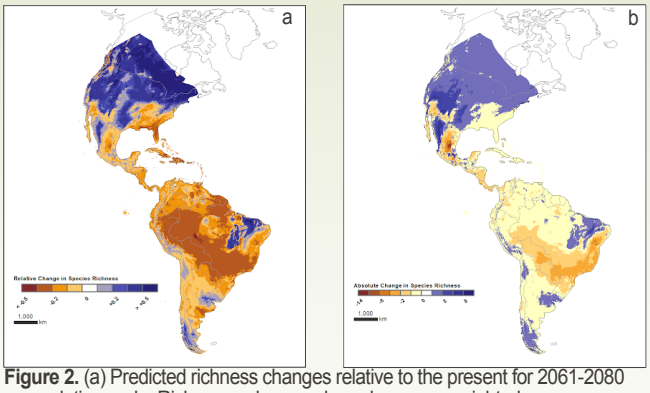

Figure 2. (a) Predicted richness changes relative to the present for 2061-2080 on a relative scale. Richness values are based on an unweighted average across all model runs. (b) Predicted richness changes relative to the present for 2061-2080 on an absolute scale (number of species). Richness values are based on an unweighted average across all model runs.

Cacti currently experience a diverse range of threats to their conservation. Our results show that climate change has the potential to become a more widespread threat to cacti than direct anthropogenic factors such as development and agriculture. All current hot spots of cactus diversity are projected to experience sharp declines relative to current richness. Improving the conservation outlook for cacti will require an understanding of the interactions of human land use and climate change, particularly whether direct anthropogenic drivers and climate change affect different species, or the same species will be impacted

by both. Depending on how strongly these threats compound, prospects will become increasingly prickly for cacti. Better forecasts of extreme events such as fire and prolonged droughts, as well as insight into the tolerances of young cacti, will also be invaluable. Assuming the species assessed here represent the family as a whole, up to 90% of all cactus species could become threatened.

Acknowledgements

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Opinion

Can COVID-19 teach us anything about the illegal trade in cactus and succulent plants?

Jared Margulies

About once per week, I receive some version of an article from a friend or colleague about how the isolation of the COVID-19 pandemic has driven surging interest in collecting plants—cactus and succulent plants among them. A number of popular press articles such as those in the New York Times, EcoWatch, and Business Insider have further speculated that the surge in popularity of growing cacti and other succulents may be exacerbating already existing problems of illegal succulent plant trade. Amidst the pandemic and concerns over the origins of the COVID-19 virus, illegal wildlife trade as a matter of general concern entered the global limelight. Perhaps it was only natural then that worries about how the pandemic might further drive illegal trade in plants would soon begin to circulate.

Although collectible cacti have nothing to do with "wet markets" or zoonotic disease transmission, there appears to be a relentless appetite amidst this global pandemic for stories about how human interference in the 'natural world' inevitably leads to disaster (see the trend of "nature is healing" memes during the early days of the pandemic as just one example). While it is unquestionably good for a wider consumer audience to be aware of the existence of illegal trade in cactus and succulent plants, caution is also warranted in suggesting that there is something inherently unethical or bad about the increasing popularity of keeping houseplants in private collections, succulents included. And yet, I am concerned that this messaging is often lost at the expense of splashy, headline-worthy stories about "the dark side" of growing succulents or the rise of a "black market" in cacti. As one commenter of a recent online video about illegal succulent trades relates, "Thanks, I needed something new to feel guilty about!"

It is unambiguous that illegal trade and wild collection of succulents is an ongoing problem, and at least in some regions, like Southern Africa, one that is only getting worse. A variety of incidents have highlighted the many cases of illegal poaching of succulents from South Africa and Namibia this year alone, while legislation was recently introduced in California to make the taking of *Dudleya farinosa* (Lindl.) Britton & Rose a felony after the sudden emergence of widespread poaching of the species in the past several years. While many will have read with great relief about the successful repatriation of over 1,000 wild-harvested Chilean cacti in April 2021 that were confiscated in Italy the year prior, the scale and impact of this enormous poaching event remains disconcerting, both for its brazenness and signal of other potential illegal shipments of wild plants that invariably go undetected. For every major cactus poaching bust that is discovered by authorities, how many are not?

There is no reason, however, to believe the COVID-19 pandemic has anything to do with these instances of illegal trades in cactus and succulent plants described above, and it is important to remember that international trade in wild-collected cactus and succulent plants is nothing new, and in fact has been a persistent issue for decades (to say nothing of the same trades occurring for centuries prior to the emergence of CITES in the 1970s). But if the COVID-19 pandemic holds any important lessons for the interdisciplinary conservation community interested in protecting cactus and succulent species, it is that people are yearning for deeper connections with plant life, and prohibition and fear-mongering are not the appropriate response. Rather than scare people away from this growing interest, leaving them to wonder if the common Echeveria plants for sale at the local grocery store are smuggled contraband (they aren't!), we should embrace this interest by (especially younger) people in developing more meaningful connections with plants.

Cactus and succulent houseplant growers are plant conservationists in the making (if they are not already). While this is not a novel concept by any means, important communication work remains to be done in helping guide this growing community of increasingly younger houseplant enthusiasts to "connect the dots" between the plants they are growing in their homes and posting about on Instagram to the wild species the CSSG community is so invested in protecting. Rather than only express concern in the growing number of succulent enthusiasts worldwide as would-be participants in illicit succulent economies, I would argue instead this is very good news. But it will still require work to make it so. It would represent a major failing if the conservation community

does not facilitate positive communication about how the growing interest in cactus and succulents can and should be a positive force for conservation good rather than representing some kind of existential threat to species.

This is not to downplay the real presence and problem of illegal succulent trades worldwide, but to be realistic about the proportionally much smaller number of bad actors within the overall succulent grower/collector community. It is a truly unfortunate reality that a relatively small number of actors can have such an outsized effect on the conservation outcomes of threatened or near-threatened cactus and succulent species. But the onus to reduce or eliminate the market for these wild collected plants should not fall only on the shoulders of consumers, many of whom unwittingly acquire these plants due to a lack of prior knowledge. It is not reasonable to expect general plant consumers to be well-versed in the intricacies of CITES appendices, international trade law, or access and benefit sharing agreements. Instead, respected conservation institutions could be leveraging their legitimacy to work with and pressure commercial sector entities to provide sourcing transparency and educational information to consumers; not only to make them aware of the problems of plant poaching and illicit trades, but to educate consumers about wild species and the threats they face.

It is not unreasonable to speculate that what might follow from such efforts of consumer education is increasing pressure by consumers on commercial entities to do more for actual species conservation. As long as there is a robust commercial market in the sale of cactus and succulent plants, it will be an entirely missed opportunity if those sales are not also directly supporting efforts to ensure the wild relatives of species in cultivation that collectors and hobbyist cherish continue to thrive.

Jared Margulies is an assistant professor of geography at the University of Alabama. He is currently writing a book about global illicit cactus and succulent trades and collecting cultures forthcoming with University of Minnesota Press. He can be reached at jdmargulies@ua.edu.

Note from Liz Vayda, owner and operator of our partner B.Willow

Liz Vayda

My name is Liz Vayda – I own and operate an indoor houseplant shop in Baltimore, Maryland, called B.Willow, specializing in succulents, cacti, tropicals, and air plants. This is a business I came into somewhat unexpectedly. As an undergraduate, I was studying Psychology at Earlham College when a semester abroad in New Zealand brought into focus my deep fascination with the natural world. Pursuing this, I completed my Master's Degree in Environmental Sciences and Policy at Johns Hopkins. When I graduated in 2013, I hadn't quite put my finger on my dream job, but knew I wanted to help foster people's connection with nature: 1) to promote its therapeutic and restorative effects on our minds and bodies, and 2) to encourage us to be better stewards of our environments, as we often take better care of things that we feel connected to.

As someone who vigorously studied environmental issues, but often feels debilitated by the magnitude of threats, I understand how challenging it is to empower people to know they can make a difference. We must generate a larger collective feeling of connection to the "more than human" world. If large numbers of people spend very little time outdoors, with little sensorial engagement with the non-human world, establishing that connection can be especially difficult. We spent thousands of years co-evolving with the world around us, but now find ourselves cut off. Our senses were shaped by sights, sounds, and sensations of a world we too often now only see through a screen. A majority of our everyday experience has become self-reflective. Species slip away into extinction at an unprecedented rate, but we're too busy scrolling through our phones to notice. My desire to do something about this led me to the creation of my business. If our reality largely entails an indoor lifestyle, it's imperative for us to bring the outdoors in.

When I opened my storefront in 2017, houseplants were just beginning to rise in popularity. Other than bigger stores, my shop was the first boutique houseplant shop in Baltimore. Over the years, I've seen the houseplant industry grow and grow, with more people asking for rarer plants to add to their collection. Almost every day we get requests for hard to find aroid varieties, alocasias, variegated string of (anything). Encountering these more frequent requests for rare plants encouraged me to reach out to a friend of mine, Dr. Jared Marguiles, who has written extensively about the illegal houseplant trade. Initially, we spoke about my interest in incorporating the academic and conservation worlds into my work, specifically through organizing guest lectures. I wanted to use my storefront to provide the experience of higher education in a non-academic setting. We spoke about his research into the illegal cacti trade- I was shocked that this was happening, but sadly not too surprised.

With a business founded on the premise of affecting positive environmental change, the last thing I wanted was to unknowingly support the exploitation of plants or the reduction of biodiversity. As most of our suppliers sell plants that are widely cultivated or grown via tissue culture, I didn't have alarm bells going off about the sourcing of their plants; however, with more and more customers requesting rare plant varieties, these alarms have been sounding. It's clear that there is no framework for me, as a business involved in the buying and selling of houseplants directly to consumers, to feel confident that I am buying plants that are grown 100% ethically.

There is no rulebook from which to work with. I have no assurance that the plants I might order off Ebay haven't been stripped from the wild. For that reason, I do not purchase them; however, the demand is very much there, and someone else will fill it.

Dr. Marguiles graciously introduced me to the CSSG, which has led to a formal partnership between my business, IUCN CSSG, and Desert Botanical Garden. I am thrilled to be partnering with these groups. Our goal is to work together to create more awareness of the illegal plant trade amongst consumers, while raising funds to be directed towards conservation efforts around the globe. I believe that the buying and selling of plants should also help conserve them in the wild. Through a series of educational efforts via social media and online lectures via Zoom, we intend to promote awareness of the illegal plant trade, and help drive better standards within the industry so consumers can purchase plants knowing they are ethically grown and traded. After all, what plant enthusiast would be content to buy and own plants, knowing they're being ripped from the wild, or at the brink of extinction? With an increased demand for rare, exotic, and unique houseplants, it's imperative that the house plant trade acknowledges its potentially negative environmental impact. We hope to affect the industry as a whole through tighter regulations, greater consumer demand for ethically-grown plants, and regular funding of conservation efforts via consumer purchases. My business can act as a bridge between researchers, conservation and the rising demand for houseplants. Follow us by clicking the social media to stay up-to-date with our future efforts!

Liz Vayda is the owner of B.Willow, an indoor houseplant shop in Baltimore, Maryland, US. B.Willow has recently established a partnership with IUCN CSSG and Desert Botanical Garden to create awareness of the illegal plant trade amongst consumers and raise funds for plant conservation. She can be reached at hello@bwillow.com.

What's New in Systematics, Phylogenetics and Taxonomy

Cactaceae at Caryophyllales.org – a dynamic online species-level taxonomic backbone for the family

by Nadja Korotkova, David Aquino, Salvador Arias, Urs Eggli, Alan Franck, Carlos Gómez-Hinostrosa, Pablo C. Guerrero, Héctor M. Hernández, Andreas Kohlkbecker, Matias Köhler, Katja Luther, Lucas C. Majure, Andreas Müller, Detlev Metzing, Reto Nyffeler, Daniel Sánches, Boris Schlumpberger, and Walter G. Berendsohn.

Abstract: This data paper presents a largely phylogeny-based online taxonomic backbone for the Cactaceae compiled from literature and online sources using the tools of the EDIT Platform for Cybertaxonomy. The data will form a contribution of the Caryophyllales Network for the World Flora Online and serve as the base for further integration of research results from the systematic research community. The final aim is to treat all effectively published scientific names in the family. The checklist includes 150 accepted genera, 1851 accepted species, 91 hybrids, 746 infraspecific taxa (458 heterotypic, 288 with autonyms), 17,932 synonyms of accepted taxa, 16 definitely excluded names, 389 names of uncertain application, 672 unresolved names and 454 names belonging to (probably artificial) named hybrids, totalling 22,275 names. The process of compiling this database is described and further editorial rules for the compilation of the taxonomic backbone for the Caryophyllales Network are proposed. A checklist depicting the current state of the taxonomic backbone is provided as supplemental material. All results are also available online on the website of the Caryophyllales Network and will be constantly updated and expanded in the future.

Read the paper here

Taxonomic implications of seed morphology in Melocactus (Cactaceae) from Cuba

by Hany Lemus-Barrios, Duniel Barrios, José Ángel García Beltrán, Salvador Arias, and Lucas C. Majure

Abstract: Although *Melocactus* is the second-most diverse cactus genus in Cuba, there is still no consensus regarding species circumscription. Seed morphology has not been used for classifying species in this group in Cuba, despite the taxonomically useful data obtained in some other genera of Cactaceae. In this study, seeds were evaluated for all *Melocactus* taxa known from Cuba, and seed morphological variability was analysed. Seed descriptions for each studied taxon (or localities) are presented here. We analysed 10 quantitative, and 19 qualitative characters in 50 seeds of 14 accessions. Seeds of the native species of *Melocactus* of Cuba are small to medium-sized, which place them among the smaller in the Cactoideae, and their shape is circular to broadly oval. Our results show that seven quantitative and six qualitative characters evaluated were suitable to distinguish among taxa. Such characters allowed establishing a general seed pattern for the *M. matanzanus* and *M. curvispinus* group, however, seeds in the *M. harlowii* group were less distinguishable using these characters. Colliculate relief characterized seeds of the *M. matanzanus* group with the testa border not expanded, while the *M. curvispinus* group seeds were identified by their ventro-apical keel. The most useful characters for species delimitation in the *M. curvispinus* group were seed length, and hilum-micropylar region characters. Significant characters that reveal differences within the *M. harlowii* group are lustre, seed relief and testa border expansion.

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Melocactus spp.

Events and Opportunities

Grants and Funding

- The call for the **Mohamed bin Zayed species conservation fund** grants is now open. This global fund has been established to provide targeted grants to any individual species conservation initiatives, recognize leaders in the field and elevate the importance of species in the broader conservation debate. Deadlines: February 28, June 30, and October 31, 2022.

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