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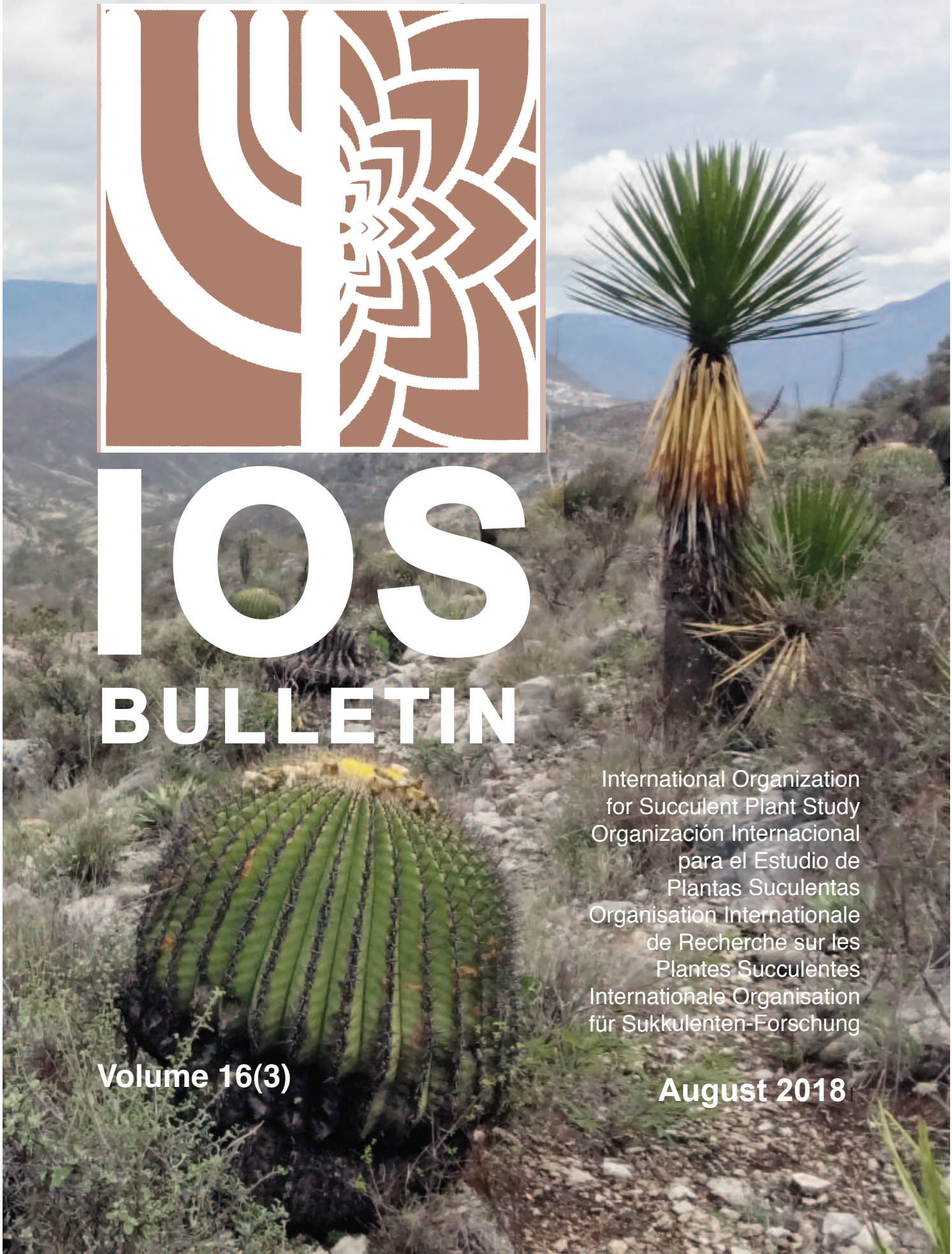

IOS BULLETIN

International Organization
for Succulent Plant Study
Organización Internacional
para el Estudio de
Plantas Suculentas
Organisation Internationale
de Recherche sur les
Plantes Succulentes
Internationale Organisation
für Sukkulenten-Forschung

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Contents

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For the composition of the Executive Board 2018-2019, see page 56

This issue of IOS Bulletin compiled and edited by the Secretary
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Message from the President

IOS Congresses were organized in Mexico on two previous occasions and I am pleased that it was held in this country for a third time last year. The 34th IOS Congress took place in the Jardín Botánico Regional de Cadereyta, in Cadereyta, Querétaro, Mexico, on October 23–28, 2017, and was co-organized by members of the IOS Executive Board and staff of the Querétaro Botanical Garden. Cadereyta was an excellent venue for our congress as it holds probably the most beautiful and well-organized botanical garden devoted to succulents in Mexico, and whose goals and approach are concurrent with those of IOS. In addition, Cadereyta is located right in the area, at the very south-eastern extreme of the Chihuahuan Desert Region, with the highest diversity of endemic Cactaceae and other succulent plant families, many of which are highly endangered. The setting at the Botanical Garden and the organization of all aspects of the congress were excellent, and especial recognition should be made to the Garden's Director, Emiliano Sánchez, and to the staff members Beatriz Maruri and Ma. Magdalena Hernández for all their time and effort that resulted in an outstanding and memorable congress.

The programme included 25 oral presentations (of which the Abstracts are printed in this Bulletin) and 46 posters comprising a wide spectrum of research approaches, such as phylogenetic analyses, ecology, biogeography, conservation biology, anatomy, morphology, ethnobotany, tissue culture, biotechnology, etc., and it covered several taxonomic groups, primarily Cactaceae, Agavaceae, Bromeliaceae, Asparagaceae and Portulacaceae, among others. Most of the 80 registered participants came from Mexican academic institutions, although a small group of participants from Brazil, Canada, Gibraltar, Peru, United Kingdom, and United States of America were also present at the event. It was encouraging to see the strong participation of graduate students presenting accounts of their research. It is important to mention that, in order to facilitate participation to the congress, the Executive Board approved small travel grants to five of the speakers from abroad and covered the registration fee of ten Mexican students. Details of the organization, the academic programme, the abstracts, and the mid-congress and post-congress excursions were included in a 113-page booklet presented to all participants, this being printed with the financial support of the Instituto de biología, UNAM.

The statutory Members' meeting was held on October 23rd with the participation of eleven IOS members, including four members of the Board. Important points of the meeting agenda included, 1) approval of the nominated Board members for 2017–2019; 2) approval of several amendments of the IOS Statutes and 3) discussion of the invitation made by the Sociedad Peruana de Cactus y Suculentas to hold the next IOS Congress in Ica, Peru, something that was very well received by the meeting participants.

When in January 2017 we were starting to plan the congress, we estimated a participation of about 50 people. However, two months before the congress itself, the number of registered

participants surpassed our expectations, and we were forced to the embarrassing decision of refusing to accept more registrations, in order to guarantee the viability of the event. The high number of abstracts included in the programme shows that interest for this kind of event still exists in Mexico and elsewhere, affirming the IOS's goals of promoting research and conservation of succulent plants, and stimulating exchange of information.

Héctor M. Hernández
President

34th IOS CONGRESS
of the International Organization for Succulent Plant Study

"Succulent plants in everyone's life"

Jardín Botánico Regional de Cadereyta 'Ing. Manuel González de Cosío'
Cadereyta, Querétaro, Mexico
October 23–28, 2017

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International Organization for Succulent Plant Study
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M. en C. Carlos Gómez-Hinostrosa

Universidad Autónoma de Querétaro
Dr Rolando T. Bárcenas

PROGRAMME

** = presenter*

Monday 23 October

08:00 Registration

09:00 Opening ceremony

09:45 Morning Coffee

10:00 ***Keynote address***

IS DEVELOPMENT, MORPHOLOGY, AND STRUCTURAL SUPPORT OF CEPHALIA AND PSEUDOCEPHALIA ADAPTIVE?
Root Gorelick

Morning Session: Ecology of Cactaceae

11:00 EFFECT OF HABITAT DISTURBANCE ON THE GENETICS OF *STENOCEREUS QUEVEDONIS* (CACTACEAE) IN INFIERNILLO, MICHOACÁN, MEXICO
José Francisco Paz Guerrero, Alejandro Casas & Hernán Alvarado-Sizzo*

11:30 DEMOGRAPHY AND REPRODUCTIVE PHENOLOGY OF *ECHINOCACTUS PLATYACANTHUS* IN TECALI DE HERRERA, PUEBLA
José H. Quiroz Soberanes & Navarro Carbajal, M. C.*

12:00 Lunch

Afternoon Session: Conservation of Cactaceae

13:00 CONSERVATION STATUS OF PERUVIAN CACTACEAE
Carlos Ostolaza Nano

13:30 NATIONAL CONTRIBUTIONS OF THE PERUVIAN CACTUS AND SUCCULENT SOCIETY – SPECS – TO THE KNOWLEDGE OF PERUVIAN CACTI
Sidney Novoa

14:00 IDENTIFICATION OF PRIORITY AREAS FOR THE CONSERVATION OF ENDEMIC CACTI IN THE SONORAN DESERT REGION
Bárbara Larraín-Barrios & Héctor M. Hernández*

14:30 Afternoon Coffee

15:00 Poster Session

16:00 General Meeting (IOS Members only)

Evening free

Tuesday 24 October

Keynote address

09:00 BRAZILIAN CACTI TODAY
Daniela Zappi

10:00 Morning Coffee

Morning Session: Special Topics of Cactaceae

10:30 ERUMPENT BUD DEVELOPMENT IN *ECHINOCEREUS* (CACTACEAE)
Daniel Sánchez, Grego-Valencia, D., Teresa Terrazas & Salvador Arias*

11:00 CHEMICAL ANALYSIS OF SECONDARY XYLEM BY FTIR IN CACTACEAE
Agustín Maceda-Rodríguez, Teresa Terrazas, Soto-Hernández, R.M., Reyes-Rivera, J., Salvador Arias, Trejo, C., Peña-Valdivia, C.B. & Martínez-Vázquez, M.*

11:30 DETERMINATE GROWTH OF CACTOIDEAE PRIMARY ROOT, AND BEYOND
Svetlana Shishkova, Gustavo Rodríguez-Alonso, Mayra López-Valle, Selene Napsucialy-Mendivil, Marcela Ramírez-Yarza, Marta Matvienko & Joseph G. Dubrovsky*

12:00 Lunch

Keynote address

13:00 A 37-YEAR BALANCE OF THE ACTIVITIES IN CACTUS SYSTEMATICS: THE ATTRACTIVE CONSERVATION AND THE OSTRACISED NOMENCLATURE
Rolando Tenoch Bárcenas Luna

Afternoon Session: Systematics of Cactaceae

14:00 PHYLOGENY OF *CEPHALOCEREUS* (CACTACEAE) BASED ON MOLECULAR AND STRUCTURAL DATA
Héctor Tapia & Salvador Arias*

14:30 PHYLOGENETIC RELATIONSHIPS OF *ECHINOCACTUS* LINK & OTTO (CACTOIDEAE, CACTACEAE) INFERRED FROM NUCLEAR DNA SEQUENCES OF *DODA* AND *5GT* GENES
Mario Vargas-Luna, Patricia Hernández-Ledesma, Raúl Puente, Lucas C. Majure, Héctor M. Hernández & Rolando T. Bárcenas*

15:00 SYSTEMATICS OF THE ENIGMATIC GENUS *APOROCACTUS* (CACTACEAE)
Isaura Rosas-Reinhold & Salvador Arias*

15:30 A PHYLOGENOMICS APPROACH TO TACKLING RELATIONSHIPS IN SUBFAMILY OPUNTIOIDEAE (CACTACEAE)
Lucas C. Majure, Raul Puente, Andrew Salywon, Shannon Fehlberg & Marc A. Baker*

16:00 INTEGRATIVE TAXONOMY BASED ON GENETIC DELIMITATION: THE STUDY CASE OF *STENOCEREUS GRISEUS* SPECIES COMPLEX (CACTACEAE)
Hernán Alvarado-Sizzo, Alejandro Casas & Teresa Terrazas*

A view in the Jardín Botánico Regional de Cadereyta, Querétaro, Mexico

16:30 Afternoon Coffee
Congress photo

Special address

17:00 FERNANDO ALTAMIRANO CARBAJAL: ANAMNESIS OF OUR REMARKABLE ORIGINS
Emiliano Sánchez Martínez, Beatriz Maruri, Yasmín Hailen Ugalde & Ma. Magdalena Hernández*

18:00 Cocktail reception at the Botanical Garden
Concert of the Orquesta típica Makochi-Dulcemelos

Wednesday 25 October

Mid-congress Tour
(Lunch provided)

09:30 Meeting point at Quinta "Fernando Schmoll" nursery

Visit to "Quinta Fernando Schmoll" nursery, Cadereyta
Visit to "Granja GG" nursery, Tequisquiapan
Visit to "La Biznaga Vagabunda" nursery, Ezequiel Montes
Visit to "Casa de Cactus San Martín" nursery, Bernal

16:30 Congress dinner at "El Cuartel", Bernal

9:00 Return to Cadereyta

Thursday 26 October

09:00 ***Keynote addres***s

A CENTURY OF SUCCULENT PLANT TAXONOMY
Len Newton

10:00 Guided tour through the Cadereyta Regional Botanical Garden

Morning Session: Conservation of other succulents

11:00 *IN-SITU* CONSERVATION OF FIVE SPECIES OF CRASSULACEAE AT THE ÁREA DE PROTECCIÓN DE FLORA Y FAUNA LA PRIMAVERA, JALISCO
Aarón Rodríguez, Ortiz-Brunel, J.P., Pablo Carrillo-Reyes, & Ramírez-García, E.*

11:30 DISTRIBUTION AND CONSERVATION OF THE GENUS *PINGUICULA* (LENTIBULARIACEAE) IN MEXICO AND CENTRAL AMERICA
Sergio Zamudio & Julián Hernández Rendón

12:00 Lunch

Afternoon Session: Systematics of other Succulents

13:00 DIVERSITY OF THE GENUS *SEDUM* (CRASSULACEAE) IN THE SIERRA MADRE DEL SUR, MEXICO
Juvenal Aragón-Parada, Pablo Carrillo-Reyes & Guadalupe Munguía-Lino*

13:30 DIVERSITY AND ENDEMISM OF STONECROPS (CRASSULACEAE) IN WESTERN MEXICO
Pablo Carrillo Reyes, Guadalupe Munguía Lino & Juvenal Aragón Parada*

14:00 SYSTEMATICS OF *PORTULACA* (PORTULACACEAE)
Gilberto Ocampo

14:30 INFLORESCENCE ARCHITECTURE, FLOWER DEVELOPMENT AND EVOLUTION IN PORTULACACEAE
Thaíla Vieira Santos, Gladys F. A. Melo-de-Pinna, Gilberto Ocampo & Reyjane Patricia de Oliveira*

15:00 Afternoon Coffee Break

15:30 ***Keynote address***

HECHTIOIDEAE (BROMELIACEAE) A MEGAMEXICAN GROUP
Ivón M. Ramírez-Morillo, Germán Carnevali, Juan P. Pinzón, Katya Romero-Soler, Nestor Raigoza, Claudia Hornung-Leoni, Rodrigo Duno & José Luis Tapia-Muñoz*

16:30 Closing remarks and farewell

Evening free

Congress Participants at the entrance to the Jardín Botánico, Cadereyta, Querétaro, 24 October 2017

Congress Participants

IOS Members

Name	Affiliation	Presentation: Oral [O] or Poster [P] & ref. no.
Bárcenas Luna, Rolando	Universidad Autónoma de Querétaro	[O] 11
Gdaniec, Andrew	Gibraltar Botanic Gardens, Gibraltar	
Gómez Hinostrosa, Carlos	Instituto de Biología, UNAM	
Gorelick, Root	Carleton University, Canada	[O] 01
Hernández, Héctor M.	Instituto de Biología, UNAM	[P] 15
Majure, Lucas	Desert Botanical Garden Phoenix Arizona USA	[O] 15
Newton, Leonard	IOS Past-President & Archivist, UK	[O] 18
Ostolaza Nano, Carlos	Sociedad Peruana de Cactus y Suculentas, Perú	[O] 04
Ramirez-Morillo, Ivon	Centro de Investigación Científica de Yucatán, A. C.	[O] 25
Sánchez Martínez, Emiliano	Jardín Botánico Regional de Cadereyta	[O] 17
Santos,Thaìla Vieira Alves	Universidade Estadual de Feira de Santana, Brazil	[O] 24 & [P] 39
Zappi, Daniela	Museu Paraense Emilio Goeldi, Belém, Pará, Brazil	[O] 07

IOS President Héctor Hernández with (*left to right*) Maria Magdalena Hernández, Beatriz Maruri and Yazmin Hailen Ugalde

Other participants

IOS Vice-President Daniela Zappi with Carlos Gómez Hinostrosa

Gutiérrez Cruz, Jesús Edgardo	Instituto de Biología, UNAM	
Hernández Cruz, Rocío	Universidad Nacional Autónoma de México	[P] 14
Hernández Martínez, María	Jardín Botánico Regional de Cadereyta	
Hernández Sandoval, Luis	Universidad Autónoma de Querétaro	[P] 16
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Huerta Saavedra, Valeria	Universidad Autónoma Metropolitana	[P] 17
Jiménez, Montserrat	Universidad Autónoma Metropolitana	
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Larraín-Barrios,Bárbara	Universidad Nacional Autónoma de México	[O] 06
López Ortiz, Nelly María	Universidad Nacional Autónoma de México	[P] 19
Luna Zúñiga, Judith	Universidad Autónoma de Querétaro	[P] 21
Maceda Rodríguez, Agustín	Colegio de Postgraduados	[O] 09
Martínez C., Magali	[Oaxaca]	[P] 22
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Maruri Aguilar, Beatriz	JardÌn Botánico Regional de Cadereyta	
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Matias Palafox, Ma. Loraine	Comisión Nac. para el Estudio y Uso de la Biodiversidad	[P] 25
Matvienko, Marta	Davis, California, USA	[P] 26
Nieto Sotelo, Jorge	Instituto de Biología, UNAM	
Novoa, Sidney	Sociedad Peruana de Cactus y Suculentas, Perú	[O] 05
Ocampo Acosta, Gilberto	Universidad Autónoma de Aguascalientes	[O] 23
Ortega González, Pactli	Universidad Nacional Autónoma de México	[P] 27
Ortiz Brunel, Juan Pablo	Universidad de Guadalajara	

IOS Past-President, Len Newton (*left*) with Root Gorelick

Ortiz Martínez, Luis Eder	Centro Interdisciplinario Inv. Desar. Integ. Reg. Oaxaca IPN.[P] 28
Ostolaza Nano (Sra) (Esposa)	Perú
Palomeque Carlín, Alejandra	Universidad Autónoma de Aguascalientes México .....[P] 29
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Quirino Olvera, Ricardo	Universidad Autónoma de Nuevo León
Quiroz Soberanes, José Hiram	Benemérita Universidad Autónoma de Puebla .....[O] 03
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Rojas Aréchiga, Mariana	Instituto de Ecología, UNAM.....[P] 30 & [P] 36
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Romero Soler, Katya Jeanneth	Centro de Investigación Científica de Yucatán, A.C. .....[P] 38
Rosas Reinhold, Isaura	Instituto de Biología, UNAM .....[O] 14
Sánchez Carbajal, Daniel	CONACY Laniveg (CUCBA, Universidad de Guadalajara) .[O] 08
Shishkova, Svetlana	Instituto de Biotecnología, UNAM .....[O]10
Sosa Jiménez, Eric Fernando	Instituto de Biología, UNAM .....[P] 40
Tapia Salcido, Héctor	Universidad Nacional Autónoma de México .....[O] 12
Ugalde de la Cruz, Yazmin Hailen	Jardín Botánico Regional de Cadereyta .....[P] 41
Valera Romero, Carlos	Universidad Autónoma de Querétaro .....[P] 42
Vargas Luna, Mario Daniel	Universidad Autónoma de Querétaro .....[O 13
Vásquez Luis, Patricia	Instituto Tecnológico de Oaxaca .....[P] 43
Zamudio Ruiz, Sergio	Investigador Independiente ..... [O] 20 & [P] 44

ABSTRACTS OF ORAL PRESENTATIONS

[1] Is development, morphology, and structural support of cephalia and pseudocephalia adaptive?

Root Gorelick

Carleton University, 1125 Raven Road, Ottawa, Ontario, Canada.

Cactus cephalia and pseudocephalia are peculiar structures, with odd development, anatomy, morphology, and structural support. *Discocactus* cephalia are deeply sunken, with a quixotic "W" shaped border between photosynthetic and reproductive parts. Unlike *Melocactus*, *Discocactus* continue growing new photosynthetic tissue after cephalium formation, resulting in the eponymous disk-shape of their photosynthetic parts. *Espostoa* and *Coleocephalocereus* can have precariously leaning lateral cephalia, but their shoots somehow manage to straighten out as they grow, often with disheveled phyllotaxy. Many species with lateral pseudocephalia also have this peculiar temporary leaning of shoot tips, despite lacking cork formation under flowering areoles, but having orderly phyllotaxy. In some species, branches almost never arise from cephalia; whereas in other species, branches almost always arise from cephalia. *Lophocereus* shoots grow slowly before pseudocephalium development, but rapidly once a pseudocephalium is formed. How do their massive shoots not break in the wind, but often bend or break once pseudocephalia form? Is this due to development of woody subdermal thorns? By examining parts of shoots not usually visible because of being covered by epidermal and other tissues, I show how peculiar cactus architectures of cephalia and pseudocephalia sometimes seem adaptive and sometimes do not.

Key words: cephalium, pseudocephalium, anatomy, morphology, ontogeny, non-adaptive, maladaptive

[2] Effect of habitat disturbance on the genetics of *Stenocereus quevedonis* (Cactaceae) in Infiernillo, Michoacán, Mexico

José Francisco Paz Guerrero[1*], *Alejandro Casas*[2] *& Hernán Alvarado-Sizzo*[2]

[1] Universidad Michoacana de San Nicolás de Hidalgo, Gral. Francisco J. Múgica S/N, Ciudad Universitaria, 58030 Morelia, Michoacán, Mexico. [2] Instituto de Investigaciones ene Ecosistemas y Sustentabilidad, Universidad Nacional Autónoma de México, Antigua Carretera a Pátzcuaro 8701, Ex-Hacienda de San José de La Huerta, 58190 Morelia, Michoacán, Mexico.

Stenocereus quevedonis (Ortega) Buxb. "pitire" is endemic to the Balsas river Basin, where the vegetation is tropical dry forest and xerophytic scrub. The study area is located in Arteaga, Michoacán, in the village of Infiernillo, which is part of the Zicuirán-Infiernillo Biosphere Reserve.Our aims were to compare the genetic diversity, gene flow, and genetic structure of *S. quevedonis* populations in conserved and disturbed sites, and thus determining if habitat disturbance has negative effects on these cacti populations. Information on population genetics may be useful to designing and establishing proper landscape managing strategies. We sampled tissue from 20 adult plants per site in three conserved and three disturbed sites, accomplishing 120 samples. DNA was extracted from tissue samples and we genotyped them through six nuclear microsatellite markers, which, allowed estimating allelic frequencies, genetic diversity,

flow and structure through Bayesian cluster analysis. Univariate analyses were performed with all parameters calculated to determine differences according to disturbance. Expected heterozygosity (He) varied 0.437-0.526, similarly to other columnar cacti, with no significant differences among disturbed and undisturbed sites; gene flow (Nm) was 0.163-2.067 (□=1.0974), indicating overall gene flow and genetic drift equilibrium, with some populations tending to drift. Fst values varied between 0.048-0.020, which means low genetic differentiation among populations. However, Bayesian cluster analysis indicates that one out of four genetic groups is lost in disturbed sites. .Our results indicate that disturbance effect in *Stenocereus quevedonis* genetics is still incipient, apparently because the fragmentation event is relatively recent (nearly 40 years). It may also be buffered by ecological factors previously described (high pollen movement among populations) that may ensure reproductive success, although genetic effects of disturbance might be evident after plants recruited in both site types reach reproductive stage.

Key words: microsatellites, genetic drift, gene flow, genetic diversity, heterozigosity

[3] Demography and reproductive phenology of *Echinocactus platyacanthus* in Tecali de Herrera, Puebla

José H. Quiroz Soberanes & Ma. del Carmen Navarro Carbajal*

Plant Ecology Laboratory, Biological Science Faculty, Benemérita Universidad Autónoma de Puebla, Boulevard Valsequillo y Av. San Claudio, Edificio 112-A, Ciudad, Universitaria, Col. Jardines de San Manuel, C. P. 72570, Puebla, Mexico.

Echinocactus platyacanthus is a Mexican endemic cactus catalogued under special protection by the NOM-059-2010 due to population decline caused by land use change, illegal commerce and acitron (cactus candy) production. Few demographic and phenology studies exist for this species, and there isn't information about the actual state of the populations. The present study describes some demographic and reproductive aspects of *Echinocactus platyacanthus* in the Huexotitlanapa ravine in Tecali de Herrera, Puebla. The results of this study can be used in designing management plans for the species and as a strategy for the *in-situ* conservation of *E. platyacanthus* The main density of this population was 390.51 plants/ha; the adult category was the most abundant (53.84 adult 1/ha, 142.93 adult 2/ha, 87.65 adult 3/ha and 50.35 adult 4/ha); whereas seedlings and juvenile plants were more scarce (14.84 seedlings/ha and 40.87 juveniles/ha). Of the total plants registered in the area 84.19% (1838 individuals) were solitary and only 15.8% (345 individuals) were colonies. The individuals in this population had a continuous production of reproductive structures from November 2015 to September 2016, with a maximum production of buds and flowers in July and of fruit in August. Fruit volume and weight of *E. platyacanthus* are positively correlated with the number of seeds produced (F = 179.67, $P < 0.00$, $r = 0.804$; $F = 103.37$, $P < 0.00$, $r = 0.716$ respectively).

Key words: *Echinocactus platyacanthus*, census, size-category, life-form

[4] Conservation status of Peruvian Cactaceae

Carlos Ostolaza Nano

Sociedad Peruana de Cactus y Suculentas –SPECS, Ca. Rosa Pérez Liendo 196, Distrito San Miguel, Lima, Peru.

This contribution deals with the conservation status and IUCN categories of Peruvian cacti taxa (81% of them are endemic) and the measures adopted to minimize the conservation threats with habitat destruction of most of the cacti populations in the valleys surrounding Lima and other coastal valleys because of the inflow of peasants from the countryside to the outskirts of the cities. We are reporting one example of Peruvian cacti species in each of the main IUCN Redlist categories: Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR), and a proposal to include 14 of them in the CITES Appendix I list, following the example of other countries like Mexico, Brazil and the United States. This year the Peruvian Agriculture Ministry approved a list with 91 cacti species categorized, which is an increase, but they represent only 35 % of the whole number. American cacti are exotic and ornamental plants for the rest of the world and that produces a great demand. We must know them well as the only way of preserving the species because of depredation since the discovery of America. We must categorize them to know which species should be protected as a priority. CITES should cover the categorized species even if the commercial demand is not very high, if the country involved asks for it.

Key words: conservation, Redlist categories, CITES, Peruvian Cactaceae

[5] National contributions of the Peruvian Cactus and Succulent Society – SPECS – to the knowledge of Peruvian cacti

Sidney Novoa

Sociedad Peruana de Cactus y Suculentas-SPECS, Ca. Rosa Pérez Liendo 196, Distrito San Miguel, Lima, Peru.

The Peruvian Cactus and Succulent Society-SPECS is a non-profit civil society with 30 years of existence, which was formed with the aim of disseminating scientific knowledge, cultivation and conservation of Peruvian cacti and other succulents. The goal of this resume is to present the SPECS contributions to the knowledge of cacti in Peru. For the analysis, we considered the review and classification of bibliographic sources produced by SPECS, or in which it had direct collaboration, since 1987. During this time, the members of SPECS have contributed with more than 350 articles by approximately 100 different authors, covering different topics, including taxonomy, description of new species, travel, ecology, uses, conservation, as well as notes on art, literature, philately, history, referring to this group of plants. During this period of time, we supported the organization of three national congresses (2013, 2015 and 2017), where more than 100 unedited researches on cacti and other Peruvian succulents were presented. Currently, SPECS members are recognized as CITES scientific authorities, to issue binding technical opinions concerning the commercialization of national species, as well as to update the list of threatened species at the national level. In addition, SPECS has collaborated with undergraduate and postgraduate theses, especially between 2002-2006, where various dissertation, scientific articles, and presentations in other national and international events. At

the same time, the founder of SPECS, Carlos Ostolaza, has published three books of scientific dissemination with the support from the Ministries of Agriculture and Environment. These results show the valuable contribution of SPECS, for 30 years, to the development of research on cacti and other succulents in Peru.

Key words: SPECS, contributions, research publication, congress

[6] Identification of priority areas for the conservation of endemic cacti in the Sonoran Desert Region

Bárbara Larraín-Barrios[1*] *& Héctor M. Hernández*[2]

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We explored the spatial pattern of endemic cacti in the Sonoran Desert Region (SDR) in order to define priority areas for its conservation and evaluate the effectiveness of the protected area network in Mexico. To pursue this: 1) we defined the endemic species of the SDR using a database and field information, which were analysed in a geographic information system. This allowed us to select endemic species using at least 75% of its records inside SDR as criteria, 2) we evaluated the spatial patterns of the endemic species using 30 minutes latitude by 30 minutes longitude grids, and we obtained maps of richness, rarity and conservation value. A complementarity analysis was performed to optimize the protection of species in a minimum area, 3) we established a consensus map in order to obtain the potential conservation areas by selecting the highest values of the each individual map, and 4) we evaluated the effective protection through: (a) comparison of the consensus map with current protected area network, selecting those potential areas outside the network, and also (b) performing a spatial complementarity index to the species not protected by the current network. Finally, we combined both (a,b) in order to obtain the priority conservation areas.

Seventy-two endemic species were identified and we selected eight potential conservation areas, four in the Baja California Peninsula and four in Sonora. We found that 23 species were not under any official protection, and that eleven complementary cells protect all of endemic species. With this information, we select five priority areas; three located in Baja California and two in Sonora. These areas, considering the priority areas and the current conservation network, guarantee the protection of 70 species, representing 97.2% of all endemic cactus species in the region.

Key words: biodiversity conservation, Cactaceae, endemism, richness, rarity, complementarity

[7] Brazilian cacti today

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The taxonomy and systematics of Brazilian cacti has changed dramatically in the last 20 years. We provide a review of these developments and present several of the most iconic and enigmatic species that share a diversity centre in Eastern Brazil. These studies continue through the Brazilian Flora Online 2020 project, which provides a dynamic platform to record the distribution of the family throughout the country, which is considered today home to the highest plant diversity. On the other hand, the provision of a detailed alpha taxonomy for the family in the country has fostered recent genetic studies that show interesting (and intriguing) patterns regarding the distribution, diversification and speciation of key genera (*Pilosocereus, Cereus*). Brazilian cactus species may thus be used as a model group to study wider questions regarding arid lands biodiversity and speciation. Allied to those, in-depth studies of pollination biology are providing subsidies to the conservation of this knowingly highly endangered group of plants in Brazil and in the Americas.

Key words: Brazil, cacti, Brazilian Flora Online, taxonomy

[8] Erumpent bud development in *Echinocereus* (Cactaceae)

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In Cactaceae, the areole is the organ that forms the leaves, spines and buds. Peculiarly, species in *Echinocereus* develop erumpent buds, which break through the epidermis of the stem above the areole. However, there is no clarity about how this trait is acquired, nor if the entire genus has it. Therefore, the development of the areole was investigated here in order to understand the anatomical modifications that lead to internal bud development and to supplement anatomical knowledge of plants that do not behave according to classical shoot theory. The external morphology of the areole was documented and the anatomy was studied using tissue clearing, scanning electron microscopy and light microscopy for 50 species including *Morangaya pensilis* (*Echinocereus pensilis*). Results showed that in *Echinocereus*, including those species cited as having non-erumpent buds, the areole is sealed by periderm, and the areole meristem is moved and enclosed by the differential growth of the epidermis and surrounding cortex. The enclosed areole meristem is differentiated in a vegetative or floral bud, which develops internally and breaks through the epidermis of the stem. In *Morangaya pensilis*, the areole is not sealed by the periderm and the areole meristem is not enclosed. The anatomical evidence supports the hypothesis that the enclosed bud represents one synapomorphy for *Echinocereus* and also supports the exclusion of *Morangaya* from *Echinocereus*. The enclosed areole meristem and internal bud development are understood to be an adaptation to protect the meristem and the bud from low temperatures.

Key words: areole meristem, enclosed meristem, enclosed bud, erumpent bud, sealed areole, periderm

[9] Chemical analysis of secondary xylem by FTIR in Cactaceae

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One characteristic of the Cactaceae is its wood diversity and its relation to vascular tissue lignification. The three main types of wood are: non-fibrous (wide band tracheids and vessel elements, wbt-ve), fibrous (ve and fibers, ve-fi) and dimorphic (a transition from wbt-ve to ve-fi). Recent research shows that species with fibrous wood have similar patterns in lignin composition (syringyl or guaiacyl type), whereas in species with non-fibrous and dimorphic woods no pattern in lignin composition is distinguished. Therefore, the aims of this study were to analyse the chemical composition of lignin mainly in species with non-fibrous and dimorphic woods of the Cactoideae and determining their relation to vascular tissue anatomy. We used 26 species of Cactaceae, Pereskioideae (1), Opuntioideae (5) and Cactoideae (20), to remove the vascular cylinder at the base of the stem. Part of this cylinder was dried and milled to make successive extractions and measurements according to TAPPI Standard T207 om-93. Lignin was analysed and characterized by Fourier transform infrared spectroscopy. A slide of the same fresh vascular cylinder (0.5-1.0 cm thick) was fixed, sectioned and stained to characterize the species wood. The results show that lignin percentage in Cactaceae is similar to other families; however, the percentage is higher in species with fibrous wood than those with non-fibrous and dimorphic wood, due lignification differences. The spectrum shows that species with fibrous wood have a stable pattern of lignin similar to reports in the literature as for other Eudicotyledons; non-fibrous and dimorphic species show a relationship within each genus, but have little differences due abundance of wbt-ve. *Echinocereus* (Echinocereeae, tribe with fibrous wood) has a similar lignin composition to other species with dimorphic wood of the Cacteae as for *Echinocactus*. Variation in vascular tissue anatomy has a strong relation to differences in lignin types in the secondary wall.

Key words: spectroscopy, syringyl, guaiacyl, lignin

[10] Determinate growth of Cactoideae primary root, and beyond

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Determinate root growth involves the root apical meristem (RAM) exhaustion and differentiation of root tip cells. Determinate growth of the primary root (PR) was first reported in a few desert Cactaceae species. With the objectives (i) to survey the incidence of determinate growth of the Cactaceae primary root, we analysed PR growth pattern in species from this family; and (ii) to explore the mechanisms of the RAM exhaustion, we *de novo* assembled the transcriptome of the *Pachycereus pringlei* PR tip and characterized differential expression of the transcripts and microRNAs in developmental stages with RAM present and exhausted. Methods: PR growth was analysed in seedlings cultivated *in vitro*. *De novo* transcriptome assembly; differential expression, miRNA and degradome analyses were performed using CLC-Genomics-Workbench, miRDeep and CleaveLand4 software. Results: PR exhibits determinate root growth in all analysed species from five non-epiphytic Cactoideae tribes. Moreover, our preliminary results suggest that (a) seedlings of two epiphytic Cactoideae tribes either do not develop PR or could exhibit determinate or indeterminate PR growth, and (b) the PR growth pattern of Opuntioideae is also variable. Analysis of the *P. pringlei* PR transcriptome, microtranscriptome, and gene regulatory network (GRN) based on the published *Arabidopsis* GRN, suggest that the transcriptional programs operating in the PR tip of Cactoideae and *Arabidopsis* are similar. However, many lineage specific transcripts were found using published and unpublished Cactaceae transcriptomic data. Conclusions: Determinate PR growth in Cactoideae matches their arid and semi-arid environment, while epiphytic Cactoideae that can also inhabit mesic environments, exhibit determinate or indeterminate PR growth. Cactaceae PR tip with exhausted RAM performs functions of root differentiation zone. In addition to the conserved molecular mechanisms of PR development in angiosperms, lineage specific genes might be involved in the regulation of determinate PR growth in Cactaceae.

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Key words: adaptation, Cactoideae, degradome, determinate root growth, meristem exhaustion, microtranscriptome, *Pachycereus pringlei*, transcriptome

[11] A 37-year balance of the activities in cactus systematics: the attractive conservation and the ostracised nomenclature

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Molecular phylogenetic analyses in the cactus family have substantially increased our knowledge of the relationships among these succulent plants. The last two decades of the reign of DNA in phylogenetics have accelerated the characterization and re-delimitation of several groups in the Cactaceae as monophyletic entities. This talk will concentrate on the recent historical balance and tendencies of the three main activities of the systematic enterprise as proposed by some practising systematists: phylogenetics, evolution and (α)-taxonomy in the particular case of the Cactaceae. A review of publications on the Cactaceae from 1980 to 2017 has shown that tendencies in research publications shifted from one or three research topics in the 1980's and early 1990's to up to 13 topics in 2012 and 2013. Few lines of research have survived through time as strong pillars of systematics such as morphology and taxonomy, as

taxonomy has not been as popular a line of research as morphology since 1980. Other neglected lines in the Cactaceae are deep morphology, nomenclatural activities and monographic revisions as research subjects, which have been stagnant at least since the 1980's. Conservation of cacti as a topic of research has been the most popular line of study powerfully beating any other topic mily by a wide margin. The omics era is just starting to have an impact in the family and parallel sequencing is now playing a more important role in the studies of the Cactaceae that will influence the three activities of the systematic enterprise. It is expected that as more groups of the Cactaceae are identified as monophyletic, the evolutionary and α-taxonomic studies could produce more solid and sound evolutionary biogeographic hypotheses or propose more and more synonyms in the next cactus monograph in order to reduce the excess of names in the family.

Key words: nomenclature, systematics, taxonomy, research enterprise, paradigm

[12] Phylogeny of *Cephalocereus* (Cactaceae) based on molecular and structural data

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Several authors have sustained the recognition of *Neobuxbaumia* as a genus separated from *Cephalocereus* since the past century, relying on the absence or the presence of a differentiated flowering region, respectively. Recent phylogenetic studies based on molecular and morphological evidence have recovered the monophyly of the "*Cephalocereus* group", including *Neobuxbaumia* and the monotypic *Pseudomitrocereus*, but the monophyly of each genus has not been resolved yet. The aims of this study were to evaluate the monophyly of these genera, and to re-assess the circumscription of the "*Cephalocereus* group". We explore two phylogenetic methods, maximum parsimony and Bayesian inference, to recognize the relationships among the species and genera from "*Cephalocereus* group". The data employed was gathered from seven molecular chloroplast markers (*petL-psbE*, *psbA-trnH*, *rpl16*, *rpl32-trnL*^{UAG}, *trnL-F*, *trnQ-rps16*, and *ycf1*), simple coded indels, and 46 structural characters. Two different datasets were constructed for: 1) molecular data alone, and 2) combined (molecular + structural) data. The different molecular and combined analyses were mostly congruent in topology and support values. Our results support the monophyly of the "*Cephalocereus* group", including all the species of *Neobuxbaumia* and *Pseudomitrocereus fulviceps*, and the distinction from other genera as *Carnegiea*, *Pachycereus* and *Lemaireocereus*. The genus *Cephalocereus* is resolved as polyphyletic because their species appeared nested in different clades with several species of *Neobuxbaumia*, which is recovered as paraphyletic, and *Pseudomitrocereus fulviceps* appeared in a derived position, instead of diverging early. We suggest grouping all the species in a natural taxon, which has priority over the name *Cephalocereus*. A combined set of molecular and morphological characters that support the circumscription of *Cephalocereus* as defined here, and internal clades are discussed.

Key words**:** combined analyses, morphology, *Neobuxbaumia*, *Pseudomitrocereus*, taxonomy

[13] Phylogenetic relationships of *Echinocactus* Link & Otto (Cactoideae, Cactaceae) inferred from nuclear DNA sequences of *DODA* and 5*GT* genes

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We tested the phylogenetic utility of DNA sequences of the *DODA* and 5*GT* betalain synthesis related nuclear genes to reconstruct-evolutionary relationships in *Echinocactus*. Maximum parsimony (MP), maximum likelihood (ML) and Bayesian analyses (BA) were performed to 34 generated sequences for 5*GT* and 19 for *DODA*. The analyses included 42 terminals, representing all taxa of *Echinocactus* and other outgroup taxa of the Cactoideae, Phyllocacteae and Opuntioideae. Results with *5GT* and with a concatenated matrix including *DODA* and *5GT* recovered the Cacteae as monophyletic with strong support. 5*GT* analyses recovered two internal clades within the Cacteae, one including all the *Ferocactus* species, *Echinocactus grusonii* and one accession of *E. polycephalus* var. *polycephalus*, here called the *Ferocactus* clade, the other including *A. ornatum* and the rest of the accessions of *Echinocactus* here called the *Astrophytum-Echinocactus* clade. These results suggest that *Echinocactus* as currently circumscribed is not monophyletic. Although, one accession of *E. polycephalus* var. *polycephalus* was nested in the *Ferocactus* clade, the other two accessions of this taxon were retrieved among the species of *Echinocactus*. In order to circumscribe a monophyletic genus we propose to recognise five species in *Echinocactus* and to exclude *E. grusonii*. Also, we propose to formally recognise the two internal clades in *Echinocactus*: the *Echinocactus* clade, including *E. platyacanthus* and *E. horizonthalonius* and the *Homalocephala* clade comprising *E. parryi, E. texensis* and the two varieties of *E. polycephalus* (var. *polycephalus* and var. *xeranthemoides*). Results with 5*GT* support the recognition of *E. polycephalus* var. *xeranthemoides* as a distinct species. Estimations of divergence times with 5*GT* suggest that the *Echinocactus* and the *Homalocephala* clades diverged during the Pliocene at 2.8 and 4.9 mya, respectively. We thank the International Organization for Succulent Plant Study for economic support to develop some of the molecular analyses.

Key words: *Echinocactus, Homalocephala, DODA,* 5*GT,* betalains

[14] Systematics of the enigmatic genus *Aporocactus* (Cactaceae)

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Lemaire designated the genus *Aporocactus* in the 19th century, although Linnaeus described the first species under the name *Cactus flagelliformis* in 1753. In spite of its popularity the

genus is nowadays very enigmatic because the number of species and its phylogenetic relationships are unknown. Botanists such as Britton and Rose and Bravo-Hollis recognized this genus during the 20th century; however, Barthlott synonymized it with *Disocactus* due to the great similarity in flower shape and colour. In this century, Hunt and co-authors and Bauer also argued in favour of recognizing only the genus *Disocactus*, but a first phylogenetic study by Cruz and co-authors did not confirm this classification. Britton and Rose (1920) and Bravo-Hollis (1978) recognized five species within the genus: *A. flagelliformis, A. martianus, A. conzattii, A. flagriformis* and *A. leptophis* but Bauer (2003) and Hunt *et al*. (2006) only accept the first two. Our study aims (1) to determine the relationships of *Aporocactus* within Hylocereeae and (2) to delimit the species that it includes, using a set of four molecular markers of cpDNA (rpl16, trnL-trnF, psbA-trnH and trnQ-rps16) and 51 associated INDELS. A total of 22 *Aporocactus* terminals were included to perform phylogenetic analysis using Bayesian Inference, Maximum Parsimony and Maximum Likelihood methods. Our results indicated that *Aporocactus* is a monophyletic genus and sister to the *Selenicereus* + *Hylocereus* and *Weberocereus* alliance. These results support the delimitation of only two species: *A. flagelliformis* and *A. martianus*. The first one is a species with a zygomorphic magenta flower distributed in Hidalgo, Queretaro, Puebla and Veracruz. The second is represented by an actinomorphic red flower, distributed in Veracruz and Oaxaca. Therefore, we propose that *Aporocactus* should be recognized as an independent genus with two species, and sister to the *Selenicereus* clade.

Key words: molecular phylogenetic, epiphytic cacti, molecular markers, Hylocereeae, cacti

[15] A phylogenomics approach to tackling relationships in subfamily Opuntioideae (Cactaceae)

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Subfamily Opuntioideae is one of the largest and most important radiations within Cactaceae, including ecologically, economically and medicinally important genera, such as *Cylindropuntia* (chollas) and *Opuntia* (prickly pears), among others. To date, relationships among the three major clades in subfamily Opuntioideae, i.e., Cylindropuntieae, Opuntieae and Tephrocacteae, have mostly evaded phylogenetic resolution. We used a phylogenomics approach, sequencing nearly entire plastomes for 103 taxa within Opuntioideae and 31 taxa within Cactoideae using the Illumina HiSeq X Ten platform, to build a more robust phylogenetic framework for understanding those relationships. Considering that the structure of the chloroplast genome is highly modified across Cactaceae, we built our dataset out of genic regions rather than using the entire set of sequences for the plastome. We also incorporated 8 taxa from Cactaceae and the outgroup *Portulaca oleracea* with comparable data from GenBank into our dataset. Our results resolve a well-supported Opuntioideae (bs=100), with Opuntieae sister to a Tephrocacteae+Cylindropuntieae clade. A southern South American origin for the clade Opuntioideae is the most likely according to our analyses. Our results underscore the utility of whole plastome data for phylogeny reconstruction across Cactaceae and its potential usage in other major clades within the family.

Key words: biogeography, morphological evolution, Opuntioideae, phylogenomics

[16] Integrative taxonomy based on genetic delimitation: the study case of *Stenocereus griseus* species complex (Cactaceae)

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Cactaceae species complexes are often hard to classify because of low-resolution of plastid molecular data and structural characters homoplasy, a consequence of the family's recent origin. Here, we describe a taxonomical multi-evidence taxonomic workflow applied to the *Stenocereus griseus* species complex (SGSC). This method departs from population genetics clustering and then validates the species status of the genetic groups by using ecological and morphological evidence. Nine microsatellite loci over 377 individuals (of three putative species) were used in order to implement population genetics clustering; then, the resulting entities were tested for ecological niche divergence and spination pattern differences. Four species were recovered: three of them correspond to previously recognized species, whereas *S. griseus* turned to be a homonym comprising two species; also, we found that species distribution is strongly associated to biogeographic regions and sympatric zones are unlikely to occur. In this way, we proved that population genetics clustering is a key evidence to be considered in integrative taxonomy, this approach is also a potential tool in order to define species limits in recently diverged species, a common issue in Cactaceae groups.

Key words: Bayesian clustering; ecological niche modelling; integrative taxonomy; microsatellites; species delimitation; spination; SSRs; systematics

[17] Fernando Altamirano Carbajal: anamnesis of our remarkable origins

Special Presentation: Remembrance and tribute.

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Jardín Botánico Regional de Cadereyta "Ing. Manuel González de Cosío, Consejo de Ciencia y Tecnología del Estado de Querétaro, Camino Antiguo a Tovares S/N, Ejido Las Fuentes y Pueblo Nuevo, Cadereyta de Montes, 76500 Querétaro, Mexico.

In order to pay a profound tribute to all the people who have dedicated their lives to understanding and caring for the succulent flora of our planet, we will use this special presentation to remember and praise Dr. Fernando Altamirano Carbajal (1848-1908), pioneer explorer and quintessential scholar of the flora of the state of Querétaro, Mexico. First, we will review the influence that Querétaro had on the infant Fernando through his grandfather Dr. Manuel Altamirano, who introduced him in the science of Botany: Surely long walks with his grandfather forged his liberal and investigative character. The fruits of this deep relation would be visible later when, having graduated as a Physician, Fernando founded the National Medical Institute, the most important centre of scientific research of Mexico in the transition from the XIX to the XX century. In a second part, we will discuss the influence that Fernando Altamirano had in the then emerging botany science of Querétaro and throughout Mexico. Basically, here, we will nostalgically review the 1905 journey that Dr. Altamirano and Dr. José Rose

(Joseph Nelson Rose, 1862-1928; Smithsonian Institution, USA) undertook in the semi-desert zone of our federal state. We conclude that the intellectual example of Fernando Altamirano Carbajal as an inspirational leader should serve to stimulate present-day scientists to fulfil the mission of plant conservation.

Key words: Fernando Altamirano, tribute, Querétaro, Mexico's Botany, pioneer, intellectual example, plant conservation

[18] A century of succulent plant taxonomy

Len Newton

Barking, Essex, UK

In January 1900, the editorial in Walton's *Cactus Journal* suggested that few if any new species were likely to be found. The International Organisation for Succulent Plant Study (IOS) was established in 1950, to facilitate cooperation amongst succulent plant researchers. One of the first publications, in 1951, was *Repertorium Plantarum Succulentarum*, listing new names (new taxa and name changes) published in the year 1950. This has continued as an annual publication to the present day, listing many thousands of new names in the 66 issues published so far. In 1992 the IOS set up a committee to plan the production of an IOS Manual of Succulent Plants. Succulents in families other than Cactaceae appeared in six volumes, *Illustrated Handbook of Succulent Plants*, published between 2001 and 2003. The Cactaceae appeared as a separate publication in two volumes, *The New Cactus Lexicon*, in 2006. Now work is proceeding on a second edition of the *Illustrated Handbook of Succulent Plants*. This presentation will show how our knowledge of two monocot genera has changed during the past century, from 1908 (Berger on *Aloe*) and 1915 (Brown on *Sansevieria*).

Key words: taxonomy, history, lexicon, *Aloe*, *Sansevieria*

[19] *In-situ* conservation of five species of Crassulaceae at the Área de Protección de Flora y Fauna La Primavera, Jalisco

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The Área de Protección de Flora y Fauna La Primavera (APFFLP) was created on March 6, 1980. It covers 30,500 hectares of oak and pine-oak forests, mainly. The nature preserve is located west of Guadalajara Metropolitan Area and partially includes the municipalities of Tala, Tlajomulco de Zúñiga, and Zapopan, in the state of Jalisco. 966 species grouped into 421 genera and 107 families of vascular plants have been registered at the APFFLP. Recent botanical explorations resulted in new records of Crassulaceae for the area. For the first time, we

document the presence of *Echeveria colorata* and *Villadia platystyla*. *Echeveria colorata* is endemic to Jalisco and Michoacán. At the APFFLP, it grows on vertical walls along a permanent creek together with *Mammillaria jaliscana*, *Pteridium aquilinum*, *Pitcairnia karwinskyana*, *Opuntia fuliginosa,* and *Epidendron rosilloi*. Similarly, *V. platystyla* is endemic to Jalisco and was known only from three localities. The new population was found on basalt outcrops on the Cerro San Miguel, the second highest point on the APFFLP. *Echeveria colorata* and *V. platystyla* prefer the oak and pine forest. Further, *E. novogaliciana* was described back in 2011 from two populations in Aguascalientes and Jalisco. The Jalisco population is found on the El Colli Volcano within the APFFLP. Numerous adult and young plants grow on a malpais at the top of the volcano, together with *Agave inaequidens*, *Opuntia atropes*, *Ipomoea intrapilosa*, *Bursera multijuga*, *B. fagaroides*, and *Dahlia coccinea*. Lastly, new populations of *Sedum greggii* and *S. jaliscanum* were located. Both are rupicolous within the oak and pine forest. While, *S. greggii* lives on vertical walls, *S. jaliscanum* prefers horizontal clefts. Both are found among abundant moss but never intermixed. Their presence at the APFFLP increases the probability of survival and conservation.

Key words: Angiosperms, *Echeveria, Villadia, Sedum*, nature preserves

[20] Distribution and conservation of the genus *Pinguicula* (Lentibulariaceae) in Mexico and Central America

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The genus *Pinguicula* is distributed in the temperate regions of the Northern Hemisphere, with some representatives in the West Indies and the South American Andes. It consists of ca. 90 species, of which 45 are known in Mexico and Central America; one is endemic to Central America, six are shared between Central America and Mexico and 38 are endemic to Mexico. In addition to these, we have seven new species from Mexico and one from Honduras in preparation. The occurrence in Mexico of ca. 50% of the known species in the world points to the conclusion that this country is the main centre of diversification of the genus.
In Mexico and Central America the butterworts are distributed along the mountainous regions in a discontinuous pattern. They grow in cliffs, slopes, ravines, rocky walls and along streams; preferentially in sites with north or northeast face, protected from direct sunlight, with high environmental humidity and frequently dripping wet. The extraordinary variation in the ecological conditions in the Mexican and Central American mountains has stimulated the ample radiation of these plants, which have diversified extraordinarily and occupied cloud forest, tropical deciduous forest and arid tropical scrub as well as the coniferous forest. None of the Mexican and Central American species are included in the Mexican Official List of Endangered Species, nor in the IUCN Red List. Accelerating environmental destruction in the region, increasing collection and illegal trade could, in the future, cause the extinction of some of these plants, mainly the micro-endemics known only from one locality. It is necessary to take action for the protection and conservation of these beautiful plants.

Key words: carnivorous plants, Lentibulariaceae, *Pinguicula*

[21] Diversity of the genus *Sedum* (Crassulaceae) in the Sierra Madre del Sur, Mexico

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Sedum is the largest genus of the Crassulaceae. It groups about 428 species of mostly herbaceous plants, with numerous leaves often arranged in rosettes, and pentamerous flowers with free petals. *Sedum* is distributed in the subtropical and temperate zones, predominantly in the Northern hemisphere. The mountains of southern Mexico, with ca. 130 species, have been recognized as one of the most important centres of diversity for the family. The Sierra Madre del Sur biogeographic province (SMS) runs from southern Jalisco and extends to the states of Oaxaca and part of Puebla and Veracruz. The goals of this work were to analyse the distribution and to identify areas with greater species richness of *Sedum* in the SMS. Fieldwork was done, herbarium specimens were reviewed and a database was generated with 420 records of taxa present in the SMS. With this information, the geographical distribution was analysed in the QGIS program 2.14.3, and the areas with greater richness were estimated with DIVA-GIS. In the SMS there are 46 species of *Sedum*, 12 of which are endemic to Oaxaca and two to Jalisco. Guerrero, Michoacán, Puebla and Veracruz each possess an endemic species. Four major areas were identified that concentrate the richness of species: southern Jalisco, the Miahuatlán region, the Sierra de Juárez, and the Mixteca. In addition, 18 species with restricted distribution to the SMS were registered; of these, there are 12 records at the most. SMS is the region with the greatest diversity of species and endemism of the genus *Sedum* in Mexico. The areas with high richness are in the pine-oak forest, ranging from 2000 to 2500 m altitude. However, there are large unexplored extensions of this region. Exploration of these areas might increase this diversity.

Key words: biogeography, distribution, endemic species, Oaxaca, species richness

[22] Diversity and endemism of stonecrops (Crassulaceae) in Western Mexico

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The Crassulaceae possess more than 1500 species distributed worldwide. Mexico, with ca. 380 species, is the richest country in the world. The western portion of this country (Aguascalientes, Jalisco, Colima and adjacent parts of Nayarit, Zacatecas, Guanajuato and Michoacán) is located in the confluence six biogeographic provinces. This area has been identified as a secondary centre of diversity of vascular plants in Mexico. The goal of this work was to describe patterns of distribution and diversity as well as to identify centres of endemism for Crassulaceae in Western Mexico. We compiled a database considering both native and naturalized species. Biogeographic analyses were performed using QGIS 2.14.3 and DIVA-GIS.

56 native and 2 naturalized species occur in western Mexico; 31 of them are endemic to this area. *Sedum* (19 spp.) and *Echeveria* (19) are the most diverse genera followed by *Graptopetalum* (7), *Pachyphytum* (6) and *Villadia* (3) The richest biogeographic provinces are the Trans Mexican Volcanic Belt (35 spp.), the Sierra Madre Occidental (13) and the Chihuahuan Desert (9). Southern Jalisco was identified as the main centre of diversity. We consider that the Balsas river Basin and Sierra Madre del Sur have an inadequate representation and additional exploration is required.

Key words: biogeography, Colima, endemism, *Echeveria*, *Graptopetalum,* Jalisco, Nayarit, *Sedum*, *Pachyphytum*

[23] Systematics of *Portulaca* (Portulacaceae)

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Portulaca is the only genus in the Portulacaceae after its recent disintegration into other families (Anacampserotaceae, Montiaceae, and Talinaceae). The genus has ca. 100 species distributed around the world, with important centres of diversification in South America and Africa. The most recent worldwide systematic study was provided by Geesink (Blumea 17(2): 275-301. 1969), who proposed a new, very simple infrageneric classification for *Portulaca*, which is generally employed by most taxonomists; however, Geesink's species sampling was very limited and primarily focused on the Indo-Australian taxa. In this talk, I will show results from phylogenetic analyses employing chloroplast and nuclear DNA sequences to explore the evolutionary relationships within *Portulaca*. Morphological, anatomical, and photosynthetic pathway data were also considered under a phylogenetic framework to study their diversification patterns. In addition, divergence times and historical biogeographical patterns were explored. The phylogenetic analyses recovered *Portulaca* as a monophyletic group and show the existence of two main clades, one with species found in the Old World and another one with taxa distributed around the globe. The resulting clades are in partial agreement with Geesink's classification. Traits that are very variable within the genus (e.g., seed micromorphology) were found to be homoplastic, although a few of them were useful to characterize major subclades within *Portulaca*. The age of Portulacaceae was estimated in 23 million years and the potential area of ancient distribution was found to be in the Southern Hemisphere. The results of this study will be used to propose a new infrageneric classification, which will include two subgenera and six sections.

Key words: Cactineae, classification, leaf anatomy, morphology, *Portulaca*, Portulacaceae, Portulacineae, photosynthetic pathways, phylogeny

[24] Inflorescence architecture, flower development and evolution in Portulacaceae

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Portulacineae (Caryophyllales) is a suborder recognized by grouping succulent families (Anacampserotaceae, Basellaceae, Cactaceae, Didiereaceae, Halophytaceae, Montiaceae, Portulacaceae, Talinaceae). Portulacaceae, as currently understood, is a monogeneric family that comprises ca. 100 species. Phylogenetic studies reconstructed six clades for *Portulaca* ("African-Asian", "Australian", "Oleracea", "Umbraticola", "Cryptopetala" and "Pilosa") and this circumscription is corroborated by anatomical and metabolic data. Current knowledge on inflorescence architecture in *Portulaca* classifies them as terminal, cymose but very congested, and head-like. However, this classification is limited, once it does not represent the diversity of inflorescences for this family. The floral structure is inserted into a whorl of leaves forming the head-like inflorescences, whereas solitary flowers have their occurrence limited to some representatives of the "African-Asian" clade, plus *P. pusilla*, from the "Pilosa" clade. The flower parts are formed by two sepals and (4-)5-8 petals, a varied number of stamens and a unilocular carpel. Similar studies focusing on the floral structures of *Portulaca* aren't very enlightening, most of them aiming at macromorphology analysis with taxonomic applications. Thus, the present project proposes to study morphological and anatomical characters with representatives of the *Portulaca* genus in order to understand evolutionary patterns for inflorescence and flower development within the different genus lineages. The methodologies chosen for this work were the usual techniques of optical anatomy and scanning electronic microscopy as a way to analyse inflorescences and flowers at various stages of their development. Finally, the results obtained will be analysed under the light of evolution, with the goal of understanding the diversification of inflorescences and flowers in the family.

Key words**:** *Portulaca*, flower, ontogeny, evolution

[25] *Hechtioideae* (Bromeliaceae) a Megamexican group

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Hechtioideae include sympodial to pseudomonopodial rosettes bearing succulent, spiny or serrulate leaves, terminal or lateral inflorescences, unisexual and fragrant flowers with superior or inferior ovary, a sessile stigma, and exhibiting dioecy, a unique combination of characters within Bromeliaceae. Based on DNA sequences (*ycf1*, *rpl32-trnL* intergenic spacer, and PRK), as well as morphological characters of 60% of the known taxa in the subfamily, using parsimony and Bayesian Inference, we tested the monophyly of Hechtioideae and study its internal relationships. Results support the monophyly of Hechtioideae and of five groups: (1) a basal clade (the *H. tillandsioides* complex) as the sister group of the rest of Hechtioideae; (2) a clade including the species of the *H. guatemalensis* complex. The remaining taxa of the subfamily are retained in *Hechtia*, which now consists of three well-supported clades: 3) *Hechtia glomerata* complex of species with lateral inflorescence distributed in the Mexican Gulf drainage; (4) a clade of two species that share an inferior ovary and are distributed north of the Tehuantepec Isthmus; and (5) an internally poorly resolved clade (Core *Hechtia*) with the remaining species containing several well-supported, geographically restricted clades. Evidence suggests that Hechtioideae originated in the lowlands of southern Megamexico III biogeographical region, from where it radiated into restricted geographical areas where they radiated, once more, exhibiting the repeated appearance of particular characters mostly associated with the invasion of dry, seasonal climates up to cooler areas in the Mexican Plateau. Lateral inflorescences, inferior ovary, as well as trochyphily have appeared more than once in Hechtioideae.

Key words: dioecy, endemism, *Hechtia,* Megamexico

Carlos Ostolaza and his wife

Abstracts of poster presentations

[1] Globular fight! How close in morphological space are the convergent globular succulents of the Americas and Africa?

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Convergent evolution is a central phenomenon in biology. However, many proposals of morphological convergence are based on qualitative assessments of the attributes. To test quantitatively similarity in shape, we applied a geometric morphometrics analysis to the classic example of convergence between globular succulents of Cactaceae from the Americas and the African Aizoaceae, Apocynaceae, and Euphorbiaceae. We included *Astrophytum asterias* and *A. myriostigma* (Cactaceae), *Conophytum calculus* (Aizoaceae), *Euphorbia meloformis*, *E. obesa,* and *E. valida* (Euphorbiaceae), and *Pseudolithos migiurtinus,* and *P. cubiformis* (Apocynaceae) to evaluate their shape in the apical and lateral views using the method of semi-landmarks. We also included a spherical shape to observe whether the globular succulents are close to the theoretically optimal form in terms of surface/volume ratios. The apical view analysis generated a morphospace with four main groups: 1) *A. asterias*-*C. calculus*-*E. obesa*-*P. migiurtinus*, 2) *E. meloformis*-*E. valida*, 3) *A. myriostigma*, and 4) *P. cubiformis*. The analysis of the longitudinal view generated a cloud of points describing a morphological continuum of shapes. When the circle was included, in both comparisons (apical/lateral), the globular species were distant from the sphere in axis 1, but in axis 2 some shapes had partial similarities with the sphere. This work allowed us to suggest that the convergence is far from being a question of all or nothing, instead describing a broad continuum in which similarity can be total or partial depending of the analytical tools. The use of geometric morphometrics corroborated the similarity in globular succulents, as well as a strong association between the form and the environment. We highlight the potential role of natural selection acting at different stages of development or dimensions (transversal or longitudinal) of the body plant to lead them to areas adjacent to theoretically optimal configurations of surface/volume ratio.

Key words: Apocynaceae, Cactaceae, convergence, Euphorbiaceae, morphometrics

[2] The photoprotective role of pigments on the photosynthetic performance of *Agave tequilana* under induced global warming: assess in early development phases

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Agave tequilana is a native Mexican plant associated with tequila production for several centuries. *Agave* species do not seem threatened by climatic warming projections; however, this assumption only considers adult plants; neglecting the potential impact of warming in early development phases. Climate change models in the Chihuahuan Desert indicate an increase in temperature of 1–2 °C by 2030. We assessed the photosynthetic performance [maximum quantum efficiency of photosystem II (Fv/Fm); effective quantum yield of photosystem II (PSII); electron transport rate (ETR) and non-photochemical quenching (NPQ)] and pigment content (chlorophylls *a*, *b*, total chlorophyll, carotenoids and anthocyanins) in *A. tequilana* under induced warming. Open-top chambers (OTCs) were used to simulate the effect of global warming on two-year old seedlings and five-year old individuals. OTCs had higher mean temperature (2oC) and

lower relative humidity (3.3%) than control plots. Induced warming affected the photosynthetic performance and pigment content of *A. tequilana*. Fv/Fm values changed differently among seedlings and young plants under induced warming; values dropped on Fv/Fm but were more pronounced on controls and stability observed on OTC. Low PSII values were registered in both development phases and conditions. ETR values were higher on young plants than in seedlings and changed over the time but not by warming treatment. Neither warming nor the age affected the NPQ values; Chlorophylls *a* and *b* were higher (until a 40% more) in seedlings than young individuals, but young plants presented more carotenoids and anthocyanins than seedlings. It might be a major ability for photoprotection of young plants than in seedlings. Therefore, under a global warming scenario, photosynthetic performance and pigment content are altered, but photoprotective pigments play an important role on sexual reproduction in the wild population of *A. tequilana*. This is the first experimental study focused on the potential impact of climate warming on photosynthetic performance of a succulent species with high economic value.

Key words: Asparagaceae, Chihuahuan Desert, global warming, photosynthetic performance, pigment content.

[3] Reproductive phenology and flower colour variation in *Lophophora diffusa* (Cactaceae)

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The beginning and length of reproductive phases in plants is subject to environmental variables and biotic interactions. For globose cacti, the flowering period usually lasts several weeks, and a positive association with precipitation and temperature has been proposed. In order to describe the reproductive phenology in a population of *Lophophora diffusa*, monthly censuses were carried out to record the presence of reproductive structures from September 2014 to November 2015 ($N = 420$ individuals). To know the degree of floral synchrony we performed the Marquis index. We also measured the frequency of the flowers according to their colour. The flowering period lasted from March to July, with a maximum production of open flowers in March and May. We determined that the population is asynchronous, which means that the flowering differs in duration time and it does not occur at the same time in all of the individuals. 42% of the plants were reproductive, but only 28% produced fruits. The fruiting began about two months after the first flowering peak and extended until the end of the year. Most of the flowers were white, only 4% of individuals were pink. The difference in floral traits may have implications in the activity of pollinators and florivores. The asynchrony in flowering has been explained as a strategy to minimize the risk of exposure to adverse conditions, which may be an advantage to the movement of the pollinators and seed dispersers. Our population of *Lophophora diffusa* presents a period of reproduction lasting several months, with more than one peak of flowering. These characteristics could generate different opportunities for the success of the pollination, fruiting, and seed dispersal.

Key words: flowering, asynchrony, floral traits, reproductive success

[4] Nectaries in the genus *Strombocactus* (Cactaceae)

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Floral nectaries are nectar-secreting structures, which are offered by the plant to its pollinating agents, promoting outcrossing. The objective of this study was to describe and compare the floral nectaries morphology and anatomy of the taxa in the genus *Strombocactus* (*S. disciformis* subsp. *disciformis*, *S. disciformis* subsp. *esperanzae* and *S. corregidorae*), all of which are threatened. Flowers of the three taxa were collected at anthesis; a portion of the material was processed for observation under a scanning electron

microscope or embedded in paraplast to perform histological sections and histochemical tests. The results show that the anatomical characteristics of the nectaries are similar among the three studied taxa. The nectarial tissue is located below the insertion of the innermost stamens and reach the upper part of the ovary, along the basal portion of the hypanthium, in the form of a ring. The nectaries are constituted of a simple almost flat epidermis (in *S. disciformis* subsp. *esperanzae*) to papillose (in *S. corregidorae*), a nectariferous parenchyma of small cells very active metabolically and a subnectariferous parenchyma of larger cells, associated with vascular bundles. The nectar is secreted by nectarostomes. Based on the floral characteristics of this genus (flowering time, shape, colour, rewards and nectar guide) and preliminary field observations it can be presumed that they are pollinated by bees.

Key words: floral nectaries, nectar, nectarostomes, *Strombocactus*

[5] Distribution and species richness of the Cactaceae in the State of Tabasco, Mexico

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Studies on the Cactaceae in Mexico are primarily focused on the species that inhabit arid zones, with little knowledge about the species which have epiphytic habits and that inhabit the rain forest areas of Mexico. In the State of Tabasco it has been documented the presence of Cactaceae; however, the knowledge generated about their biology, ecology, ethnobotany and systematics are very low. The development of the project "Diversity and species richness of the Cactaceae in the State of Tabasco" aims at: 1) determining the species diversity, 2) generating descriptions of each of the genera and species, 3) establishing their geographic distribution, and 4) developing dichotomous keys for the genera and species of the family in the state. By consulting the CSAT, MEXU, UJAT and XAL herbaria, and the collection of specimens throughout the state, it is established that in Tabasco there are 20 native species, grouped into 8 genera. The genera with the greatest diversity are *Epiphyllum* and *Selenicereus*, with 6 and 5 species respectively. The most diverse municipalities are: Tacotalpa and Teapa with 9 species for both of them and Centro with 8 species. The existence of the genera *Nopalea* and *Opuntia* are reported as introduced. *Selenicereus chrysocardium* (Alexander) Kimnach (*molecular evidence suggests *S. chrysocardium* is in fact a species of *Epiphyllum* as originally proposed by Alexander), a species that was considered endemic of Chiapas and is currently protected by Mexican regulations, is reported for the first time for the flora of the State of Tabasco. This work allowed us to know the richness of Cactaceae that inhabit Tabasco and is the basis for the development of studies aimed to establishing the conservation status of cacti populations to generate conservation and management strategies in the state. It will also help the development of research in the fields of reproduction, floral biology, associations, anatomy and physiology of Cactaceae species.

Key words: Cactaceae, *Epiphyllum, Selenicereus,* species richness, Tabasco

[6] Florivory in *Opuntia cantabrigiensis* Lynch in Cadereyta de Montes, Querétaro, Mexico

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Florivory is the consumption of buds, ovules, pistils, stamens or any part of the flower before seed formation. This interaction may impact plant reproductive output, reduce seed formation, change mating systems, plant fitness and floral traits that drive the evolution of sexual systems. In extreme cases florivory can decrease birth rate and deplete populations. The effects of florivory on reproductive output are indirect when florivores affect visitation rates or behaviour of pollinators modifying crossing rates, while direct effects reduce seed production in damaged flowers. We aimed to determine the effects of florivory on the reproductive output of *Opuntia cantabrigiensis* by assessing the association of florivory with floral synchrony, and experimentally simulating the effects of florivory on floral visitors and fruit set. Our hypothesis was that high floral synchrony will decrease florivory and damaged flowers would have reduced fruit set.

We counted reproductive structures on 35 plants every other day during the flowering period and measured frequency of floral buds, flowers or fruits and damage by florivores. Effects of florivory were assessed with an experimental design with 20 replicates (plants) and four treatments: intact flowers (control), damaged flowers with removal of 50% of perianth, 50% of stamens or all stamens. Floral visitors were registered every two hours for 30 min in experimental flowers. Fruit set of all treatments was evaluated and mature fruits collected, weighed and seeds counted. Floral visitors were captured and their activities described. Florivory was found in 26% of reproductive structures. Florivores consumed more buds (22%), which precluded reproduction as no fruits were formed (damaged flowers lack stigma) and the removal of stamens decreased floral visitors.

Key words: direct effect, floral synchrony, florivory, indirect effect, pollination

[7] Conservation status of *Beaucarnea inermis* (S. Watson) Rose in Mexico

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One of the ponytail palm species, *Beaucarnea inermis*, is endemic to northeastern Mexico. It is included in the Mexican species conservation list NOM-059, recognized as an endangered species. Most species of the genus are endangered or under the risk of extinction, and are illegally collected from natural populations to trade in both, domestic and international markets. The goal of this work is to evaluate the conservation status of *B. inermis* by means of the Mexican Risk Assessment for Wildlife Species Method (MER). The information for the MER criteria was obtained directly from the study sites, and from literature for: a) distribution amplitude, b) habitat status with respect to the natural development of the taxon, c) intrinsic biological vulnerability, and d) human activity impacts. This information showed that *B. inermis* has a restricted distribution in Mexico, comprising less than 5% of the country. The habitat status is considered intermediate or restricted. So, even that the species is found in both, primary and secondary tropical deciduous forest, and its humidity and temperature ranges are ample, stochastic factors such as prolonged droughts and hurricanes, threaten the natural populations recruitment. The intrinsic biological vulnerability of the taxon has significant differences in population structure, random recruitment events, and phenology, which is strongly associated with climatic variability. Large natural areas have *B. inermis* populations in good conservation status; however, human direct impact over the taxon is considerable as well as the strong biological communities alteration. The score obtained with the integration of the criteria, supports the maintenance of *B. inermis* under the endangered category in the Mexican NOM-059.

Key words: ponytail palm, MER, endangered species

[8] Responses to different concentrations of auxins and cytokinins in *Agave guiengola* and *A. potatorum*

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The genus *Agave* holds great biological, economic and cultural importance in Mexico. *Agave guiengola* is a microendemic species from the Guiengola region in the Tehuantepec Isthmus, in Oaxaca; it is greatly appreciated as an ornamental plant, but it is considered threatened. *Agave potatorum* is endemic of the Tehuacán-Cuicatlán valley located between Puebla and Oaxaca; it does not present asexual reproduction, and its natural populations have been subjected to intense exploitation, mostly for mezcal production. In consequence, its numbers are decreasing rapidly and the species is now considered threatened. In order to avoid the extinction of natural populations of these and other *Agave* species it is crucial to develop comprehensive management strategies with the purpose of recovering natural populations, and to help domesticate them for rational exploitation that could result in very much needed economic benefit for people of

impoverished communities. *In vitro* plant tissue culture is a vital tool in these management schemes, therefore the goal of this work is to assess the response of *A. guiengola* and *A. potatorum* to auxins, cytokinins and combinations of both. In general terms, in both species the use of cytokinins alone increases adventitious shoot formation, while auxins alone or combined with cytokinins induce callus formation; in some treatments the combination of auxins and cytokinins appears to induce embryogenic callus. Based on these results it will be possible to elaborate specific protocols, particularly those of micropropagation via organogenesis or somatic embryogenesis, that later could be used in the management strategies of these species.

Key words: *Agave guiengola, A. potatorum*, auxins, cytokinins, micropropagation

[9] Historic demography of *Cephalocereus columna-trajani* (Cactaceae) in the Tehuacán-Cuicatlán Valley, Mexico

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Historic demography changes of plant species adapted to New World arid environments could be consistent with either the Glacial Refugium Hypothesis (GRH), which posits that populations contracted to refuges during the cold-dry glacial and expanded in warm-humid interglacial periods, or with the Interglacial Refugium Hypothesis (IRH), which suggests that populations contracted during interglacial and expanded in glacial times. In order to determine if the historic demography of the giant columnar cactus *Cephalocereus columna-trajani* in the intertropical Mexican drylands is consistent with either hypothesis, sequences of the chloroplast regions *psbA-trnH* and *trnT-trnL* from 10 populations comprising the full distribution range of this species were analysed. The demographic dynamic was analysed using an Approximate Bayesian Computation (ABC) and the palaeodistribution of Late Quaternary was derived from ecological niche modelling to determine if, in the arid environments of south-central Mexico, glacial-interglacial cycles changed the distribution area of this species. ABC demographic analyses suggest a population expansion, which could have taken place in the Last Interglacial (123.04 kya, 95% CI 115.3±130.03). The estimated population size of the *C. columna-trajani* before the expansion was Nb = 996,000 individuals (95% CI 327,000±1,840,000), increasing up to an estimated size of N1 = 1,680,000 individuals (95% CI 702,000±2,370,000). The species palaeodistribution is consistent with the ABC analyses and indicates that the potential area of palaeodistribution and climatic suitability were larger during the Last Interglacial and Holocene than in the Last Glacial Maximum. Overall, these results suggest that *C. columna-trajani* experienced an expansion following the warm conditions of interglacials, in accordance with the GRH.

Key words: Quaternary climatic changes, historic demography, palaeodistribution

[10] Environmental preferences and niche similarity in fourteen crassulacean species of Oaxaca

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The aim of the present work was to determinate the environmental preferences and environmental similarities in 14 species of *Crassulaceae* from Concepcion Buenavista, Oaxaca, for which fundamental biological variables were registered. The point-centered quarter method was used for sampling an area of 13,740 m2. The variables were: nurse plants, soil depth, biotic/abiotic soil cover, canopy, solar radiation on May 15th, annual solar radiation, vegetation, bedrock and altitude. We estimated if the different species had environmental preferences and which one was the specific condition preferred through different indices. Principal Components Analysis (PCA) was used to obtain a visual examination of the environment distance between species; thus, we estimated their similarity in the environmental space. The results

showed that the *Crassulaceae* family was widely distributed, covering most of the conditions; nevertheless, the species exhibited well-defined preferences. The PCA showed that the species could be classified into three groups, each one being characteristic of a specific environmental condition; however, they are paraphyletic. Thereby, closely related species are considerably distant in the environment space, while others, which they are not so phylogenetically related, are often close. *Sedum* species had very distant preferences and only the *Villadia* group and part of the *Echeveria* group (*E. setosa* and *E. derenbergii*) had greater similarity (11/14 and 10/14 similar preferences, respectively). Moreover, we observed a phylogenetic structuring pattern of the communities where they are conformed by species belonging to different taxonomic groups. This could be due to their low competitive capacity resulting in the exclusion of less competitive related species.

Key words: niche similarity, abiotic niche, phylogenetic structure, life strategies

[11] Development of biotechnological methods for the propagation and conservation of *Ferocactus* species

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Species of the genus *Ferocactus* (Cactaceae) are characterized by their large size and globose or cylindrical shape. These plants are called biznagas and have many uses. Their stems, flowers and fruits are edible and the plants have great ornamental value. However, they are very often over-collected in their natural habitats, so some (*F. cylindraceus var. cylindraceus, F. pilosus and F. haematacanthus*) are subject to special protection, according to NOM-059-ECOL-2010. An alternative to propagate and conserve these species is through the use of biotechnological tools. The objective of this work was to test different treatments with plant growth regulators to propagate massively eight species of this genus (*F. flavovirens, F. cylindraceus var. cylindraceus, F. haematacanthus, F. hamatacanthus, F. glaucescens, F. histrix, F. latispinus var. latispinus and F. pilosus*). The first step was to establish the *in vitro* culture from seed or part of the plant, which were subjected to a disinfection process and placed in a culture medium. Then, for each species different treatments were tested by varying the plant growth regulator and its concentration for the purpose of generating shoots, to quantify them and to be able to establish the best treatment. The number of shoots per explant ranged from 4.4 to 7.5. Only *F. flavovirens* gave a good response with 2-isopentyladenine at a concentration of 4.0 mg/L, the other species did so with benzyladenine at concentrations of 0.5, 1.0 and 2.5 mg/L. Therefore, it can be concluded that the use of plant growth regulators allows the massive propagation of these species and is a viable methodology, since it gives better results and in a shorter time than propagation by conventional methods.

Key words: *Ferocactus*, *in vitro* culture, plant growth regulators

[12] Macro- and microstructural epidermal characters of *Turbinicarpus s.l.*

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The taxonomic history of *Turbinicarpus* is complex and its generic limits are not yet resolved. Molecular evidence suggests that the recognized species of *Turbinicarpus s.l.* are grouped into three clades, here named as *Turbinicarpus s.s.*, *Rapicactus* and *Kadenicarpus*. With the aim of supporting this phylogenetic hypothesis we studied the epidermis-hypodermis of 34 species belonging to *Turbinicarpus s.l.* of the tribe Cacteae, Cactaceae. The dermal tissue was prepared for light microscopy (paraffin embedding) and for scanning electron microscopy –MEB- (critical point) observations. The results showed that most species of *Turbinicarpus s.l.* have a smooth cuticle, except for four species with striated cuticle. Epidermal cells, view on the surface MEB, are polygonal elongated (19 spp.) or polygonal isodiametric (14 spp.) and pro-

jections of the periclinal wall occurred particularly in the clade of *Turbinicarpus s.s*. Stomata are paracytic or parallelocytic. All species, viewed in cross section, have a simple epidermis, where the outer periclinal wall thickness varies among clades: *Turbinicarpus s.s*. (1.66 ± 0.69 µm), *Rapicactus* (3.06 ± 1.39 µm) and *Kadenicarpus* (1.17 ± 0.46 µm). The hypodermis is composed of one to four strata mostly collenchymatous with two crystal types in their cell lumina: prisms in *Kadenicarpus* and *Turbinicarpus s.s*. and concentric druses in *Rapicactus*. It is concluded that there are epidermal characters that can contribute to support the recognition of three clades in *Turbinicarpus s.l*. However, some epidermal characters as the shape or the projections are shared with other members of Cacteae, as well as the number and thickness of the layers of the hypodermis and the shape of the crystals.

Key words: hypodermis, prismatic crystals, druses, *Rapicactus, Kadenicarpus*

[13] Diversity of Glomeromycota species in soils of Cactaceae plant communities of the Tehuacán Valley, Mexico

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The Tehuacán Valley has been reported as a centre of origin and diversification of Cactaceae, but studies of mycorrhizal associations are not yet available. Arbuscular mycorrhizal fungi are able to establish mutual symbiosis with the roots of about 75% of terrestrial plants. The general purpose of this research is to explore the diversity of Glomeromycota species in soils of plant communities with a high frequency of cacti in the Tehuacán Valley. Spores of Glomeromycota were extracted from soil samples obtained at three sites located in the Municipality of San Juan Joluxtla and Santiago Chazumba, Oaxaca, Mexico. The technique of wet sieving and decantation followed by centrifugation in sucrose was used. The extracted spores were mounted in fixed preparations in Polyvinyl alcohol-Lactoglycerol with and without Melzer reagent. We identified 18 species in the genera: *Acaulospora*, *Ambispora*, *Claroideoglomus*, *Entrophospora*, *Gigaspora*, *Glomus* and *Scutellospora*. Some of the genera found in this work have been reported as forming mycorrhizal associations with globose Cactaceae and *Pachycereus pecten-aboriginum* in the deciduous forest in Mexico. In this study a mycorrhizal association with *Coryphantha radians* was observed, which is in the process of identification. Mycorrhizal associations improve the production of plants of agricultural interest and have been used for purposes of restoration and species conservation. This work confirms the abundant presence of Glomeromycota spores in soils of the studied area and suggests it would be of interest to confirm the establishment of mycorrhizal associations in cacti.

Key words: arbuscular mycorrhiza, xerophytic shrub, *Coryphantha radians*

[14] Development and differentiation of unisexual flowers in functionally dioecious populations of *Echinocereus* in Northern Mexico

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In the Cactaceae, dioecy has evolved numerous times in unrelated taxa. Changes in the ontogenetic patterns determine the final floral morphology and define its breeding system. The genus *Echinocereus* includes hermaphrodite and dioecious taxa, which make it a good study model to determine how hermaphrodite to unisexual flower transition occurs. *E. coccineus, E. polyacanthus, E. pacificus* and *E. mombergerianus* are distributed in high and rocky areas of northern Mexico and southwestern United States. In this study, the sexual system in four *Echinocereus* taxa was determined through controlled pollination and field obser-

vations. Flowers and seed development were analysed through histological observations and scanning electron microscopy. TUNEL assays were used as an indicator of DNA fragmentation to corroborate programmed cell death during flower and seed development. Here we present how differentiation of unisexual flowers occurs late in development in the four species of *Echinocereus.* Their sexual system is functionally dioecious. Male flowers produce pollen grains and exhibit an atypical fully developed and functional gynoecium in which, after fertilization, the seeds are aborted at early stages of post-zygotic development. Female flowers do not form pollen grains in any of the species. Programmed cell death is shown to mediate both seed and pollen abortion. We propose that heterochrony, as an evolutive pattern, controls male sterility by accelerating the process of programmed cell death in tapetal cells during anthers development in female flowers. The four related taxa of *Echinocereus* have functionally dioecious populations. They share the differentiated ontogenetic pattern from bisexual to unisexual flowers and male and female sterility are stable.

Key words: dioecy, heterochrony, homoplasy, male sterility, programmed cell death, seed abortion

[15] Mapping *Mammillaria*: diversity and distribution patterns

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In this presentation we describe the second product of a project aimed at mapping the geographic distribution of all the Mexican species of Cactaceae (*Mapping the cacti of Mexico. II*. Mammillaria. *Succulent Plant Research* 9: 1-189. 2015). We mapped the global distribution of all the 155 species of *Mammillaria*, the largest genus in the cactus family, and one of the largest and most emblematic in the Mexican flora. A total of 4397 geographically referenced *Mammillaria* records was used. The northern limit of distribution of the genus occurs in southern California, Arizona, New Mexico and western Texas, with few, marginal records in Nevada and Utah. Southwards, *Mammillaria* species occur in almost every major Mexican region and in parts of Central America. In addition, three species occur sporadically in the West Indies and in a few localities in the northern Andean regions of Venezuela and Colombia. Species primarily inhabit areas with arid or semi-arid climates covered by desert scrub, although they may also be found in tropical deciduous or thorn forest, and even in more mesic areas, from sea level to 3250 m, although they tend to grow primarily at moderate elevations (1000– 2000 m). The great majority (98.7%) of the species occur in Mexico, 88.2% being endemic to this country. Six major areas of high species richness exist in Mexico: one in the Sonoran Desert (Baja California Sur), four in the Chihuahuan Desert (Jaumave, Guadalcázar, San Luis Potosí and Meridional subregion), and another one in the Tehuacán-Cuicatlán Valley. Twelve unique, microendemic species, which are extremely important from the conservation perspective, are located within these species-rich areas. Two thirds of the species (102 or 65.8%) are partially or totally protected inside Natural Protected Areas in Mexico. However, unfortunately 28, out of the 53 unprotected species, are threatened according to IUCN criteria.

Key words: Cactaceae, *Mammillaria*, biogeography, micro-endemics, conservation

[16] Morphological and anatomical evidence for the species circumscription of Nolinoideae (Asparagaceae) from the Bajío and adjacent regions, Mexico

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The Nolinoideae is a subfamily of Asparagaceae distributed in North and Central America, with most of its diversity in Mexico (ca. 86%). The group is composed of four genera (*s.l.*), and *ca*. 70 species: *Beaucarnea* with 13 spp., *Calibanus* probably three spp., *Dasylirion*, about 24 spp., and *Nolina* ca. 30 spp. However, species circumscription has been complicated due to character similarity. For the Flora of the Bajío and adjacent regions, Nolinoideae species have been studied using a critical approach for species morphological character definition, as well as leaf anatomical characters (fibers, vascular bundles, stomata and epidermis composition) when species separation is not clear. As a result, seven species have been

detected in the area, one for each of the genera *Beaucarnea*, *Calibanus*, *Nolina* and four for *Dasylirion*. One species was found to be new to science. The geographical distribution of the Nolinoideae in the region leaves five species for the state of Guanajuato, five for Querétaro and one for Michoacán, leaving the region as one of the richest areas in Mexico for Nolinoideae.

Key words: *Beaucarnea*, *Calibanus*, *Dasylirion*, *Nolina*

[17] Aboveground biomass and water and carbon storage in *Neobuxbaumia tetetzo* (Cactaceae) from Tehuacán inter-tropical Desert, Mexico

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In Mexico, the C stock in the aboveground biomass has been reported for plant species of tropical and temperate environments. However, in plant species of desert ecosystems the C stock has been scarcely studied, especially in those succulent plants such as the cacti that are representative of these environments. The objective of this study was to estimate the aboveground biomass of *Neobuxbaumia tetetzo* and its ability to store water and C in the Tehuacán inter-tropical Desert, Mexico, where this cactus is endemic and dominant within the scrubby vegetation. The density of *N. tetetzo* was estimated by marking 10 (10 × 10 m) squares, where three adult individuals were randomly selected (total 30 plants) during the dry season. The height, basal diameter, number of branches, length and diameter of each branch were measured for each plant. The aboveground biomass was estimated based on the volume of stems and branches. The water content and C concentration per plant were estimated in tissue samples by gravimetric method and a C auto-analyser, respectively. These data were extrapolated to the volume of each plant and per area unit. The sampled cacti had an average height of 5.54 m, average basal diameter of 27.8 m, and the number of branches per plant ranged from 1 to 10. Average aboveground biomass per plant was 337.3 kg. Water content per plant was 964.9 L, equivalent to 71% of its volume; while C content per plant was 83.5 kg, equivalent to 24.7% of C concentration in aboveground biomass. The plant density was 810 individuals ha-1, and it indicated an average of 8,851.36 ton C ha-1, and 101,634 703.3 L of water ha-1. Our study highlights the importance of this endemic cactus in the storage of water and C in its biomass, two ecosystem services critical for functioning of the scrubs in this Mexican inter-tropical Desert.

Key words: cactus, C concentration, semiarid ecosystems, tropical scrubs, water content

[18] Demographic aspects of a population of saguaros in El Pinacate and Gran Desierto de Altar Biosphere Reserve

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Carnegiea gigantea (Engelm.) Britton & Rose, is an emblematic columnar cactus of the Sonoran Desert, commonly known as saguaro. The species is considered at risk (A) by the Mexican law (Nom-059-SEMARNAT-2010), and it is included in the Appendix II of CITES and in the IUCN Red List (LC). The aim of this work was to describe the demographic characteristics of a population of saguaro found within El Pinacate and Altar Great Desert Biosphere Reserve. For this, we established a plot of 8.5 hectares and recorded the location of all individuals of saguaro, as well as the following variables per individual: total height, diameter, number of ribs, number of arms, reproductive structures and type of damage. We found 203 individuals, so the density was 29 ind/ha, in an aggregated spatial distribution. The minimum height recorded was 0.23 m and the maximum 9.15 m, with an average population height of 2.92 m and a distribution of multimodal values with individuals between 3.5 and 4 meters being more abundant. The number

of ribs per individual varied between 12 and 28. Most of the saguaros were monopodic, with only 2.8% of them presenting from 1 to 4 branches. The minimum height of the reproductive individuals was 2.5 m. The percentage of reproductive individuals increased with height and the range from 3 to 4 m in height provided the greatest number of reproductive structures (buds, flowers and fruits). Our data are similar to those reported for other populations of saguaro, although it is interesting that the mean heights of individuals are lower than those reported for other sites.

Key words: demography, saguaro, Sonoran Desert

[19] Evolutionary divergence of *Mammillaria* tested by genetic and ecologic perspectives

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In Cactaceae, *Mammillaria* is the richest genus with 163 species. In order to elucidate the evolutionary processes that have driven the evolutionary divergence in this genus, we analysed the molecular variation under, the phylogeographic and ecologic niche perspectives. *Mammillaria crucigera*, *M. huitzilopochtli*, and *M. supertexta* of the Supertextae series were sampled with a total of 10 cpSSR and 12 regions of cpDNA in five populations for each of these species. The hypotheses of divergence and conservatism of niche were tested with Ecological Niche Modelling (ENM) and PCA procedures. For doing so, we analysed a total of 19 climatic and two topographic variables, and 18 edaphic variables. The results showed that two cpSRR and seven cpDNA were polymorphic, and they recorded a molecular polymorphism < 2 % within and among the species analysed. It was not possible to identify phylogeographic structure in each of the three species. A total of three, five and one haplotypes were identified in *M. crucigera, M. huitzilopochtli*, and *M. supertexta*, respectively. The results of ENM revealed a geographic overlapping between *M. supertexta* with *M. crucigera* and *M. huitzilopochtli*, which supports niche conservatism hypothesis. The PCA results identified the niche differentiation hypothesis is supported by the temperature seasonality, and the levels of precipitation during the coldest and driest months. This analysis showed that the density, humidity and phosphor contained in soils, as well as, soil conductivity could drive the niche differentiation among the species studied. We concluded that the low molecular variation might have been caused by a recent evolutionary divergence and low mutation rates in DNA regions of these species. Later, the ecologic interactions (competition) could have promoted the niche differentiation that shaped the current geographic distribution of these species.

Key words: phylogeography, cpDNA, ENM, *Mammillaria*, Tehuacán–Cuicatlán Valley

[20] Micropropagation of *Echinocactus grandis*

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Echinocactus grandis is a Mexican endemic species growing mainly in the Tehuacán-Cuicatlán Valley. In this investigation, we established a methodology for the micropropagation of this species using different concentrations of BAP (0.5, 1, 1,5 y 2 mgL-1), activated charcoal (1 mgL-1), and three different explant types (shoot tip, longitudinal section and basal shoot) were used. Shoots were sectioned to obtain apical, lateral and basal explants and three explants of each type were inoculated in Murasigue and Skoog (1962) medium containing BAP at different concentrations. Each glass jar (3 per treatment) was incubated in photoperiod conditions (16/8 dark/light) at 25o C during 7 weeks. Differences (P0.05) were found. The apical section, when cultured on MS medium supplemented with 1.5 mgL-1 and 2 mgL-1 BAP, gave max-

imum axillary shoot proliferation (4.5 shoots), in contrast to the control (2 shoots per explant). Activated charcoal treatment showed no significant differences with respect to the control (1.58 shoots per explant). The shoots obtained from the different treatments were acclimatized to the greenhouse by placing samples in pots containing a mixture of peat moss and tezontle (1:1). Each plant was covered with a plastic bag, gradually opened weekly during the irrigation stage. After 8 weeks, the bag was removed and the percentage of survival corresponding to 100% was evaluated. Micropropagation offers a tool for multiple shoot induction and proliferation in 15 weeks.

Key words: micropropagation, *Echinocactus platyacanthus, shoot*

[21] Photosynthetic responses in young plants of *Yucca queretaroensis* Piña (Asparagaceae)

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Yucca queretaroensis is an endemic plant from the semiarid region in Querétaro, Mexico. Its leaf anatomic characters suggest the presence of crassulacean acid metabolism (CAM). However, no studies on the plant species photosynthetic capacity or day length variation have been carried out. The study goal was to test if *Yucca queretaroensis* presents CAM photosynthesis. Plant CO2 assimilation (*A*) and its day length variation in young plants leaves where recorded every 3 h up to 24 h, for three leaves per plant up to 20 individuals by using a Li-6400XT portable photosynthesis system. The photosynthetic activity observed for most of the measurements (24 h), showed a decrement tendency through the daylight, and an increase through the night-time. The highest *A* observed values were found at 7:00 am (4.27 µmol CO2 m-2 s-1) and at 01:00 am (3.47 µmol CO2 m-2 s-1), whereas the lowest values were found at 13:00, 16:00, 19:00 and 22:00 h (0.61, −0.39, −0.81 y −0.55, respectively). Results indicate that the evaluated plants have a facultative CAM system, being active throughout day and night-time as a probable response to non-stable environmental conditions. Further systematic long-term observations will help to assess the photosynthetic system of *Yucca queretaroensis*.

Key words: photosynthesis, CAM, Querétaro, Mexico

[22] Utility of succulent flora of Santo Domingo Tonalá, Oaxaca, Mexico

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An ethnobotanical study of succulent plants was carried out in Santo Domingo Tonalá, Oaxaca. The aim was to keep record of traditional knowledge and to identify the most culturally important plants. Species record was performed by monthly tours for one year on important sites where these species grew. To know about the traditional use and management, semi-structured interviews (2 events) were applied to 20 key informants. For analysis of ethnobotanical data, the ethnographic method of free listing and the value of use index were used. There were 44 useful succulent plant species, which were included in 21 anthropocentric categories; based on the quantitative ethnobotanical analysis, *Agave angustifolia*, *Mammillaria albilanata*, *Stenocereus pruinosus*, *S. griseus*, *Pachycereus weberi*, *Neobuxbaumia mezcalaensis* and *Dasylirion serratifolium*, were the species recognized, as those of greatest cultural value to the community. It was observed that in this region people had a wide traditional knowledge, of these plants, since they used them in a great variety of ways. Succulent flora represents an important plant resource, often used to cover part of the basic and cultural needs in the community. It is essential to continue the documentation of traditional knowledge and thereby contribute to its reassessment and rescue.

Key words: succulent plants, uses, traditional knowledge, cultural value

[23] How common is interspecific pollen transfer in *Opuntia tomentosa*?

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Most plant species grow and flower at the same time in a community. Co-flowering species can interact by affecting each other's visitation rate during pollination or through interspecific pollen transfer, via pollen-pistil interactions. These mechanisms alter reproductive success of the focal species through competition or facilitation, and may promote hybridization. Our aim was to assess pollen-pistil interactions of *Opuntia tomentosa* with three other *Opuntia* spp. that co-flower. Flowers are diurnal with longevity of one day, solitary bees are the main pollinators and fruit set is very high in all four species. Our hypothesis was that plants would reduce their fruit and seed set when receiving interspecific pollen. The pollen of a focal plant of *O. tomentosa* (OTPD-experiment) was marked with fluorescent dye at anthesis. The frequency and qualitative quantity of marked pollen on stigmas of *O. cantabrigiensis*, *O. robusta* and *O. streptacantha* was registered at flower closure. In addition, we measured pollen transfer from the other three species towards *O. tomentosa*. We targeted one species per day for two days each one species of *Opuntia* other than *O. tomentosa.* The presence of marked pollen from the other species (OXPD-experiment) was quantified on stigmas of *O. tomentosa*. We found in OTDP that the dye was absent or found in low quantities, 48.27% *O. cantabrigiensis*, 24.19% *O. robusta* and 26.67% *O. streptacantha* of the flowers had marked pollen. In the OXDP experiment most of the flowers of *O. tomentosa* did not have dye, and if there was, it also in low quantities. The interspecific pollen transfer was scarce. Co-flowering promotes facilitation by the increased availability of resources. Furthermore, floral constancy by pollinator foraging may reduce of the flow of heterospecific pollen.

Key words: co-flowering, facilitation, floral constancy

[24] Effect of phytohormones and light on the early development of five cactus species from the Southern Chihuahuan Desert

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Seed germination is a process regulated by environmental variables such as light, temperature and humidity. Germination can be controlled by the action of different plant growth regulators, also called phytohormones. In the early stages of plant development, the action of different phytohormones has been described, especially gibberellins (GA3), which stimulate seed germination and auxins (AAI), that promote root development, although AAI also promote seed germination in some species. For several species, GA3 promotes germination under darkness, thus this phytohormone can overcome the light stimulus. In Cactaceae species, there are very few studies that deal with the effect of phytohormones on seed germination and seedling growth. No response pattern has been found. In this research, our objective was to evaluate the effect of two phytohormones (GA3 and AAI) on seed germination and seedling growth of five species of cactus. The studied species were *Stenocereus queretaroensis, Echinocactus platyacanthus, Ferocactus latispinus, F. pilosus, and Coryphantha maiz-tablasensis*). Seeds from these species were germinated under two light conditions (12 h light : 12 h darkness and 24 h darkness), and six concentrations of each phytohormone: 0, 50, 100, 250, 500 and 1000 ppm. Our results suggest that, in general, light did promote seed germination without GA3 effect. In darkness, GA3 at 500 and 1000 ppm did promote seed germination for *S. queretaroensis*, *F. latispinus* and *E. platyacanthus*. Seedling growth was evaluated at the end of the germination experiment and, in general, not effect of the phytohormones was found.

Key words: Phytohormones, Chihuahuan Desert, *Stenocereus queretaroensis, Echinocactus platyacanthus, Ferocactus latispinus, F. pilosus, Coryphantha maiz-tablasensis*

[25] Analysis and identification of information gaps of Mexican cacti species at risk

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Currently the Official Mexican Standard NOM-059-SEMARNAT-2010 identifies the wild flora and fauna species or populations that are in danger in Mexico. In it, 30% of Mexican cactus taxa are categorized into one of the following categories of extinction risk: En riesgo de extinción (P), Amenazada (A) and Sujeta a protección especial (Pr). In this study we estimated the Index of Completeness of known information (IC), through the analysis of a matrix of completeness with the information contained in fact sheets made by CONABIO, of the cactus species listed in NOM-059. These fact sheets include information regarding their classification and description, geographical distribution, biology (habitat, reproduction and dispersion), ecology, demography, genetics, biological importance, economic, culture and their conservation status. Of the 276 cactus taxa in NOM-059, only 45% have an information sheet. The average IC is 0.63 ± 0.08. Only seven species (*Ariocarpus kotchoubeyanus, Cephalocereus senilis, Lophophora diffusa, Lophophora williamsii, Mammillaria gaumeri, Mammillaria humboldtii* and *Turbinicarpus pseudomacrochele* subsp. *minimus*) presented an IC greater than 0.79. What is best known about cacti are aspects of their geographical distribution (0.69), its importance in terms of commercialization and some aspects of its conservation status (0.67 respectively). The least known, although there are numerous relevant studies, are the aspects related to its ecology, demography and genetics. This work detects the information gaps of the Mexican cacti species at risk and reflects the urgency to increase the investigation of the aspects not studied, with the purpose of generating useful information to carry out more robust risk assessments that enable the true conservation status to be assessed, and thus to implement management plans appropriate to each species.

Key words: NOM-059-SEMARNAT-2010, cacti in danger, information gaps, Index of Completeness

[26] Results from 5 years of growing and fruiting pitahaya ('dragon fruit', Hylocereus hybr.) in Davis, California, USDA zone 9b

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Introduction and Methods: This hobby project started in early 2012. Cuttings were rooted in potting soil in 1 gal. pots, then replanted to larger pots as needed. Most plants are still growing in relatively small containers, with ~1 cubic foot of soil. Pitahaya is a tropical cactus, and our winter frosts can easily kill young plants. For the first two winters, all plants were placed in heated greenhouses. As the plants grew, moving them in and out of protected environment became impractical. For the last three winters, on frosty nights, the plants were just protected with fabric. *Results*: In the summer of 2017, nine out of twelve plants started in 2012 are still alive and well. A dozen additional plants were added to the collection between 2013-2017. The winter of 2016-2017 brought 212% of average winter precipitation, as well as many nights below freezing point. This claimed a few plants. The lowest temperature observed was -3.5C. Some varieties seem to be more tolerant to low temperatures than others. 'Sugar Dragon', 'Physical Graffiti', 'Haley's Comet', 'Thompson G2', 'Purple Haze', 'Condor', and 'Vietnamese Giant', are more wet-cold tolerant than 'Delight', 'Pink Panther', 'Seoul Kitchen', 'Valdivia Roja', 'El Grullo', 'Tricia', and 'Paisley'. These are just observations on small (1-4 plants) samples, and should be taken as a preliminary result, not a definite finding. As for fruit production, the most productive variety turned out to be 'Sugar Dragon', followed by 'Physical Graffiti'. In the summer of 2015, flowering and fruiting data were collected for all plants. A total of 124 fruits were produced from 142 flowers. *Conclusions*: For home growing purposes, *Hylocereus* can be grown and fruited in zone 9B. Adequate protection is needed for the first two years of plant development, and occasional protection may be required on frosty nights in later development.

Key words: pitahaya, dragon fruit, *Hylocereus*, fruiting Cactaceae

[27] Negative floral interactions in *Neobuxbaumia mezcalaensis* (Cactaceae)

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We studied the effect of florivores on floral and seed development in the columnar cactus *Neobuxbaumia mezcalaensis* from the Tehuacán Valley. In the 1990´s *N. mezcalaensis* was mentioned as androdioecious species, but at present it is recognized as hermaphrodite, where some unidentified parasites consume ovules, stigmas, styles and seeds. In order to know the impact of florivory in this species, field research was conducted in two locations (Zapotitlán Salinas and San Juan Raya, Puebla) during the stages of flowering and fruiting. Flowers and fruits were collected in different developmental stages to determine the amount of healthy *versus* affected flowers/fruits by florivores. We compared the averages of healthy *versus* damaged styles and the number of seeds in healthy *versus* infested fruits using the non-parametric U-Mann Whitney test. Research findings showed that carpenter ants (*Camponotus* sp.) consume the style and stigma, leaving the hermaphrodite flower to a male appearance. Thus it is confirmed that *N. mezcalaensis* is hermaphrodite and not androdioiecious, as previously was mentioned. Other florivorous ants were also detected, such as *Camponotus rubrithorax* (Forminicae), *Crematogaster opaca* (Myrmicinae) and *Atta mexicana* (Myrmicinae), which consume total or partially the flowers of *N. mezcalaensis*; as well as larvae of the families Muscidae (Diptera) and Pyralidae (Lepidoptera). These develop in different places in the flower, depending on the developmental stage, forming tunnels and galleries inside the ovary, consuming the ovules and funiculus. This causes a reduction of up to 23% in the number of *N. mezcalaensis* seeds available for dispersal.

Key words: andriodioecy, florivory, Formicidae, hermaphrodite, Muscidae, Pyralidae

[28] Reproductive aspects and ethnobotany of a wild *Opuntia* in the Mixteca region, Oaxaca, Mexico

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Biological diversity of succulent plants from arid regions has recently become of interest to ecologists and ethnobotanists. These plants have played an important role in the development of numerous ancient civilizations as they are nowadays. In Mexico there is a long tradition of use and management of succulent plants. Prickly pear cactus species, genus *Opuntia,* are among the most frequently used. In a small rural community from the Mixteca region in Oaxaca, *Opuntia decumbens* is a useful wild cactus that is currently facing a decline in its population due to habitat loss. This study aims to describe the sexual reproduction processes of the species as well as its use value for the local community. The breeding system was determined by pollination experiments (obligate self-pollination, natural self-pollination, outcrossing and control). The success of each pollination treatment was evaluated through the fruit set, seed set, and outcrossing rate. The outcrossing system was determined through floral morphometry and the Cruden Index. For the ethnobotanical research, semi-structured interviews were performed with local collaborators, by which information about the uses of this and other native cacti species was gathered. The Phillips & Gentry Index was employed to estimate the use value of the species and then used to compare with other native cacti species. Although all treatments produced fruits, outcrossing treatments were more successful (fruit set = 0.78). The outcrossing rate was 0.66, which indicated the presence of a mixed mating system in the species and the pollen-ovule ratio (226:1), which corresponded to a facultative xenogamy system. The fruit is the only part utilized, mainly as a natural source of pigment. The use value of the species is inferior to that of other native species that have a market and economic value, but its properties as a source of pigment and the amount of fruit it produces, give this succulent species a great utilitarian potential.

Key words: *Opuntia*, reproductive biology, ethnobotany

[29] Conservation of plants adapted to arid environments in an *in vitro* Germplasm Bank

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Arid and semi-arid zones cover an important part of Mexico, which makes water scarcity a common problem in a good part of the country, including the state of Aguascalientes. One of the measures we should take in order to adapt to this environmental problem has to do with the type of plants used in different realms, ranging from reforestation to gardening and agriculture. Mexico has a great variety of plants that are capable of developing and maturing under arid conditions, all of which have many uses that have been forgotten or displaced. Unfortunately, many of these plants face different levels of threat, so we cannot rely on wild populations to obtain the required specimens. Also, conventional propagation methods of these types of plants are generally not efficient, thus we need options that will allow an extensive harnessing of these species while reassuring the conservation of their natural populations. We propose the application of biotechnological methods (micropropagation), which allow the conservation and rational use of native plants adapted to low water availability through the creation of an *in vitro* Germplasm Bank. The Germplasm Bank developed in our institution comprises viable tissues of 127 species of plants adapted to limited water availability, of which 37 belong to the Agavaceae, 77 to the Cactaceae and 13 to the Nolinaceae. Of the Agavaceae, 31 of the species belong to genus *Agave*, and six to the genus *Yucca*. The 77 species of cactus in the bank include 24 different genera which represent three of the four cactus subfamilies: Opuntioideae, Pereskioideae and Cactoideae. Finally, it contains 13 Nolinaceae species representing the four genera that integrate this family. These plants are available for research and for education purposes, which focus on how they can be used in an intensive yet sustainable manner.

Key words: micropropagation, germplasm bank, Cactaceae, Agavaceae, Nolinaceae, conservation

[30] Seed invigoration by hydropriming of two cacti species

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Seed hydropriming is a pre-treatment that allows seeds to imbibe water and continue to the first stage of the germination process whilst preventing radicle protrusion through the testa. This method has shown - mainly in cultivated plants - that it can have positive effects on some germination parameters such as germination percentage, germination speed and uniformity and may also invigorate old seeds. Particularly with cactus species, some germination parameters have been tested with priming methods, but not the effect of it on old seeds. So we tested the effect of hydropriming cycles on the germination of old seeds of *Carnegiea gigantea* (10 years) and *Obregonia denegrii* (11 years). First, we determined the hydration-dehydration curves to define the hydration (HD) and dehydration (DH) cycles to test and assess initial germination capacity. After each hydropriming cycle (1, 2 and 3 cycles) of 24h HD and 12h DH, we sowed five replicates with 20 seeds for each species in petri dishes with 1% agar and incubated at 25 °C with a 12h photoperiod, plus a control. Germination was counted daily for 31 days. Initial seed germination was 15 % for *O. denegrii* and 28.7% for *C. gigantea*. Results from the one factor ANOVA showed that hydropriming significantly improved germination for *C. gigantea* ($F(3,16) = 16.774$; $p < 0.05$), with the two cycles treatment giving us the highest germination percentage (75%). For *O. denegrii* marginally significant differences among treatments were found ($F(3,16) = 2.8903$; $p = 0.06781$) but germination was increased with three cycles (29 %). Hydropriming results demonstrated that it is a suitable, easy and cheap invigoration method that can be used in conservation programs to recover seeds that have been in storage for a long time under sub-optimal conditions and have lost their viability.

Key words: *Carnegiea gigantea,* germination capacity, *Obregonia denegrii,* seed priming

[31] Transformed roots as an altenative for obtaining metabolites of interest in threatened cacti

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One of the most interesting aspects of the Cactaceae family is its biosynthetic capacity. These plants can produce various types of secondary metabolites such as alkaloids, phenolic compounds, betalains and others. Many of these compounds could be useful in fields such as pharmacology, food industry and cosmetics. However, currently, the study and exploitation of these compounds is very difficult. This is because many of the species that produce them are of very small size, slow-growing and threatened. These factors make it impossible to obtain the plant tissue necessary for the extraction of the metabolites of interest. The generation and *in vitro* culture of transformed roots can be a solution to this problem, as their biosynthetic capacity is very similar to the entire plant and can produce biomass at a higher rate than a cactus growing in natural conditions. The objective of this study was to produce and cultivate transformed roots of several cacti species by tissue infection with *Agrobacterium rhizogenes*. Up to now, 118 species of cacti native of Mexico, South America and the Caribbean have been tested. The response has been positive in 71 of the tested species (28 different genera), achieving the emergence and growth of transformed roots. Stable transformed roots cultures have already been generated in genera of great phytochemical interest like *Ariocarpus*, *Coryphantha, Epithelantha, Mammillaria* and *Turbinicarpus*. The biosynthetic capacity of transformed roots has already been analysed in many of the species included in the project. It has been found that its biosynthetic capacity in terms of the production of alkaloids, phenolic compounds and betalains is very similar to that of the whole plant. This suggests that transformed roots are a viable option to produce metabolites of the cacti without the need to collect plants from their natural habitat.

Key words: *Agrobacterium rhizogenes*, cacti, transformed roots

[32] Richness and distribution patterns of Echeverioideae (Crassulaceae) endemisms in the state of Oaxaca

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The richness of endemic species of Echeverioideae (Crassulaceae) was determined and their geographical distribution patterns were analysed in relation to the physiographic subprovinces, protected natural areas and priority terrestrial regions of the state of Oaxaca. From a state map divided into 15 x 15' grids and information from herbarium specimens, virtual collections, databases and field gathering, a presence/absence matrix was generated with 219 records. The Wealth and Corrected Index of Weighted Endemism were calculated for each cell. A total of 67 taxa were recorded: *Echeveria* was the most diverse genus, followed by *Thompsonella*. Of the 164 cells in which the state of Oaxaca was divided, at least one species was recorded in 62. The cells with the greatest richness contained between 10 and 14 species, others 6 to 9; 37% of the cells one species only. Five cells with high endemism were located. Of the 67 taxa recorded, 34 are endemic to Oaxaca and more than 90% are distributed in the physiographic subprovinces Montañas and Valles del Occidente, Sierra Madre de Oaxaca and Sierra Madre del Sur. Almost 60% of the endemic species are distributed in oak-pine forest and approximately 40% in low deciduous forest. 6.46% of these taxa are found in the Reserva de la Biósfera del Valle de Tehuacán-Cuicatlán and 54.72% in the Priority Terrestrial Regions: Sierra del Norte de Oaxaca-Mixe, Sierras Triqui-Mixteca, Sierra sur and Costa de Oaxaca. As most of the endemic taxa are distributed outside the Biosphere Reserve and indicated Priority Terrestrial Regions, it is recommended to extend the boundaries of this reserve to the southwest. In addition, these Priority Terrestrial Regions should be declared protected natural areas to help conserve the endemic species.

Key words: *Echeveria*, *Graptopetalum*, diversity, physiographic subprovinces, *Thompsonella*

[33] Prickly pears (*Opuntia* spp. Cactaceae) as hosts of carmine cochineals

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Cochineal (*Dactylopius* spp.) is an American group of Hemipteran insects thriving on *Opuntia* cactus plants. They show four remarkable attributes relevant to man: 1. Carminic acid extracted from fine cochineal (*D. coccus* Costa) serves for colouring food, cosmetics, drugs, fabrics, and many other products. 2. Some *Dactylopius* species are biological control agents against invasive *Opuntia* plants. 3. Cochineals can become invasive to *Opuntia* plants where they are non-native. 4. Carminic acid is being studied for other potential applications. Due to these and other points, several *Opuntia* species have been and still are introduced from America to different regions in the world, mainly from Mexico, where the most important cochineals and *Opuntia* plants (from the commercial point of view) are native. This paper aims to show the situation of *Opuntia* species known as hosts of cochineals. A literature review of Dactylopiidae family taxonomy as well as that of their hosts (*Opuntia* spp.) was the base for the present study. Also, from 1988 to 2017, the main cacti regions in North and South America have been surveyed to collect cochineals from wild and cultivated *Opuntia* plants, and from other regions of the world. All *Opuntia* and cochineal taxa were determined. *Opuntia ficus-indica* (L.) Miller is the most common species used as host for fine cochineal rearing in several parts of the world, including Argentina, Bolivia, Chile, Ecuador, Ethiopia, Peru, Mexico, Spain (Canary Islands) and other countries. However, recently wild cochineal (*D. opuntiae* Cockerell) has become an insidious plague in several countries of America and the Mediterranean basin. Tolerant and resistant *Opuntia* species, as well as biological control by predators are the focal points to solve this situation. However controversial issues have arisen, since in some regions introduced *Opuntia* species are considered invasive plants, which are controlled by means of cochineals; but in other regions, cochineals are considered pests.

Key words: nopal, *Dactylopius*, cactus pear, carminic acid

[34] Androcecium and gynoecium development of dioecious *Leuenbergeria zinniiflora* (DC.) Lodé (Pereskioideae)

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Leuenbergeria zinniiflora (Pereskioideae) is a dioecious species of the family Cactaceae, endemic to Cuba. The aim of this work was the study of androecium and gynoecium development in male and female flowers of this species in a comparative way. This study was carried out with flowers collected from individuals growing in the National Botanical Garden, in Havana, Cuba. Flowers were collected at different developmental stages and processed by different techniques of microscopy and histology. The results showed that male and female flowers begin their development being bisexual and later, by abortion of one of the sexual whorls, specialize in developing ovules (in the case of the female) or pollen grains (in the male ones). The female flower has a gynoecium whose ovary has numerous campylotropous, bitegmic and crassinucellate ovules, and well-developed style and stigma. In the female flowers, the stamens do not produce pollen grains, since the anthers stop their development at a young stage and there is no differentiation of tissues inside the microsporangium. In the male flowers there is a non-functional gynoecium, with a reduced ovary cavity, as well as a multistaminate androecium that produces many pollen grains and anthers with longitudinal dehiscence. The pollen grains, released at tricellular stage, are pericolpate; the sculpture exine is echinate. Two male floral morphs were observed. The first one initiates the development of ovules, but tissue differentiation is arrested; and in the second the ovary cavity is empty.

Key words: Cactaceae, dioecy, embryology, female sterility, *Leuenbergeria*, male sterility

[35] Ontogeny of the seed appendages in Cactaceae

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Seed appendages are outgrowths of the seed and come from tissues of different parts of the ovule. What they are called depends on the tissue from which they originate. In Cactaceae the presence of wings, wool, arils, caruncles, and strophioles on the seeds has been mentioned. In order to list all the species with seed appendages in the Cactaceae, a bibliographic review was made. Based on this, eight species from different clades were chosen to study the development of its appendage. In order to ascertain the ancestral character, we performed an ancestral character reconstruction. The results indicated that 31 genera of the Cactaceae have seed appendages. Of these, we selected *Ariocarpus kostchoubeyanus, Aztekium ritteri, Blossfeldia liliputana, Gymnocalycium mihanovichii, Lophophora williamsii, Parodia ottonis, Rebutia minuscula* and *Thelocactus leucacanthus* to study the ontogeny of the seed appendage. Our research showed that only seeds with an aril or arillode are present in the Cactaceae. The ancestral character reconstruction estimates that the aril is the ancestral character since it is presented in the Pereskioideae subfamily. The arillode has four different origins in the phylogeny, more frequently present in the Core Cactoideae. Moreover, the subfamily Opuntioideae does not have an aril like the others, but exhibits a modification in the funiculus that is initiated after the ovule develops. After fertilization, one part is differentiated in lignified tissue, while the other is differentiated in parenchymal tissue. This peculiar structure is termed the 'funicular envelope' (Stuppy 2002), in order to avoid the general and misleading term 'aril'. Finally, the presence of caruncles and strophioles in Cactaceae seeds is discounted.

Key words: aril, arillode, funicular envelope, seed ontogeny

[36] Photoblastic response and seed size in species belonging to tribe Pachycereeae (Cactaceae)

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Photoblastic response has been related to seed size by many authors mainly for species inhabiting tropical forests, where broadly the light requirement increases as seed size decreases. This is well understood as small seeds have less reserves to overcome the physical barrier imposed by soil. This relationship has been barely tested in plants inhabiting xeric environments, as in species of the family Cactaceae.
We collected seeds from 42 species from tribe Pachycereeae (Cactaceae) throughout Mexico and according to their phenology, to test photoblastic response under controlled conditions and to obtain seed length and mass of 50 seeds per species. We used the sequences of 41 species with *rpl*16 in GenBank to generate phylogenetic relatedness through RAxML and mapped the morphologic and physiologic seed traits to test patterns among species. We used phylogenetically independent contrasts (PIC) and tested phylogenetic signal *K* for seed length and mass and *D* for photoblastism. Also, we determined the ancestral and derived character states for seed length and for the photoblastic response to propose hypotheses of character evolution. Seeds showed two types of photoblastic response: positive photoblastic and indifference to light. Seeds of subtribe Stenocereinae consistently showed a positive photoblastic response and those of subtribe Pachycereinae were neutral photoblastic, with the exception of *Carnegiea gigantea,* which has the smallest seed size in its subtribe. We found a significant phylogenetic signal for seed length, and photoblastic response. In both subtribes, we found seeds in the mass categories from 4 to 7, and in the length categories from medium to extremely large, a trait that was not correlated with photoblastic response. We found that

neutral photoblastism is the ancestral character and it remained in subtribe Pachycereinae but may evolve to positive photoblastism as in *C. gigantea* within this subtribe or as in subtribe Stenocereinae.

Key words: germination, photoblastism, seed length, seed mass

[38] To nurse or not to nurse: *Mammillaria carnea* seems to prefer microsites with higher radiation incidence beneath nurse-plants canopy

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Mammillaria carnea is a globose cactus with a restricted distribution in the Tehuacán-Cuicatlán Valley, Mexico. Although it has been reported that this species requires nurse-plants for its establishment, it is common to find individuals in the open. We analysed the relationship between the spatial distribution pattern of *M. carnea* individuals, and the solar radiation regime under the nurse-plants canopy. Due to the heterogeneity of the architecture of the tree and shrub cover, a preference in the establishment of *M. carnea* in sectors where radiation is less was expected. All individuals under the canopy of 15 plants of five species of nurse-plants were mapped and their spatial distribution pattern was estimated. Each shrub was divided into 4 sectors (North, South, East and West), the surface of the canopy was measured and radiation (direct, indirect and total) and leaf-area indices were estimated from the analysis of hemispheric photographs. A Rayleigh Uniformity Test was performed to evaluate a possible preferential orientation of the cacti beneath the canopy. From a circular statistical analysis we found random and aggregate distribution patterns of *M. carnea* individuals, as well as a southern preferential orientation pattern. Although the larger class sizes had more individuals, we did not find significant differences in the radiation variables. Contrary to what we expected, the higher abundance of *M. carnea* was found where the opening of the canopy was greater; this coincides with a negative relation with the leaf-area index and positive with the indirect solar radiation. Our results suggest the existence of some fine-tuned threshold of radiation incidence where a successful establishment of *M. carnea* individuals is facilitated by the nurse-plant. Further research is needed to investigate if the presence of *M. carnea* individuals beneath the canopy responds to a facilitation process or if this is due simply to the seeds' dispersal process.

Key words: Tehuacán Valley, nurse-plants, facilitation, hemispheric photographs, crown architecture

[39] Systematics and phylogeny of the *Hechtia guatemalensis* Mez and *Hechtia tillandsioides* (André) L.B. Sm. complexes (Hechtioideae: Bromeliaceae)

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The Megamexican genus *Hechtia* is composed of several species complexes, two of which are remarkable for their morphological, ecological, and biogeographical characteristics, namely, the *H. guatemalensis* complex and the *H. tillandsioides* complex. Objectives: the main goals of this project are to test the following hypotheses: Due to their intrinsic morphological features and geographically coherent distribution, both species complexes are monophyletic entities; based upon its distinctive morphology, the *H. guatemalensis* complex is sister to the remaining species of the genus; and because most *Hechtia* species feature narrow ecological and geographical ranges, the few members of the genus that have been circumscribed as widely ranging and morphologically variable, will be composed of several, more narrowly dist

ributed and circumscribed (cryptic) taxa. Methods: this research was carried out using phylogenetic analyses using all possible evidence, sequence information from several regions of plastid (*matK-trnK*, *rpl32-trnL*+ indels, fragments 4 & 6 of *ycf1*) and nuclear DNA (the PRK region), and structural characters. The several data matrices were analysed under Maximum Parsimony and Bayesian Inference. Results and conclusions: The analyses recovered three strongly supported clades, one composed of all outgroup *Hechtia* spp. and one each for the *H. guatemalensis* and *H. tillandsioides* species complexes. The *H. tillandsioides* complex, is readily diagnosed by leaves with serrulate margins, central inflorescences bearing hundreds of flowers on thin pedicels, narrow, membranaceous petals and sepals, superior ovaries; this clade is composed by five species restricted to Mexico, one of which will be formally proposed. The *H. guatemalensis* complex, composed of three species ranging from Guatemala in northern Nicaragua, is defined by its soft, slightly succulent leaves, non-pungent spines, sessile, epigynous flowers, capsules loculicidal, erect to pendent capsules.

Key words: Megamexico, monophyly, cryptic species

[40] Micromorphological patterns in pollen grains of the genus Portulaca in Brazil

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The main goal of this study was to report the variation in pollen micromorphology as a potential tool for taxonomy within the Portulacaceae. Additionally, a second aim was to provide useful information for morphological studies of the family as a whole. Pollen grains from all *Portulaca* species that occur in Brazil were sampled from flower buds in dried material from various herbaria (ALCB, HUEFS and RB). Three specimens per species were sampled. Following this procedure the pollen was then treated by acetolysis and mounted in permanent slides. Optical microscopy was used for measuring the following features: pollen diameter (N=25); exine, nexine and sexine thickness (N=10); and sculptural elements' length. These measurements were taken within seven days after the preparation of the slides. Other pollen samples were analysed with Scanning Electron Microscopy - SEM (ME-CPqGM-FIOCRUZ). Pollen grains were classified as apolar, medium (only *Portulaca halimoides*) to large (other species) sized, and the exine's ornament was observed to be spiny and annulate perforations. Variations regarding organization and type of aperture of pollen grains allowed us to separate the species into three basic pollen types: a) Type 1: pantocolpate; recorded as the only *Portulaca* type; b) Type 2: pantocolpate; seen only in two endemic species, *P. hatschbachii* (Paraná state) and *P. goiasensis* (Goiás state); c) Type 3: pantoporate, exclusively found in *P. hirsutissima*, an endemic species from Minas Gerais state. New aperture patterns reported here for Portulacaceae pollen grains shed new light over micromorphology and its taxonomic implications. Portulacaceae is a family with wide morphological variation, and the absence of diagnostic characters for many species is often reported, which hinders taxonomic identification. Based on the combination of pollen data, morphology of the seeds' testa cells, plus species geographical distribution, two new Brazilian species from the *P. hirsutissima* complex were recently described, thus showing the potential for using a combination of these traits for taxonomical purposes.

Key words: Portulacaceae, palynology, taxonomy, Brazil

[41] Effects of the expression of mayehuelin, a type 1 RIP of *Agave tequilana*, on thermotolerance of *Saccharomyces cerevisiae*

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The genus *Agave* is composed of succulent plants of great cultural, scientific and commercial interest in Mexico. They present great resistance to drought and to heat stress, primarily in the unfolded leaves found in the *cogollo* (bud with leaves forming a long tapering cone), where it has been observed that different morphological and molecular adaptions allow it to resist up to 55°C in the case of *Agave tequilana*. Mayehuelin is a protein found only in the folded leaves of the tapering cone of *A. tequilana*, and is also present in other species of the genus. Its amino acid sequence identifies it as a protein of the type 1 RIP family. Because mayehuelin accumulates in the structure with highest heat resistance of the plant, we assumed that its function might be related with stress resistance. In this work, we evaluated the effect of expressing mayehuelin on the growth and heat tolerance of *Saccharomyces cerevisiae*. Using the expression vector pYES-DEST52 of the Gateway system we built two versions of the recombinant protein: 1) the mature protein only and 2) the mature protein fused to the epitope V5 and a tag of histidines. The vectors were introduced to the W303-1a strain and the expression of the recombinant protein in the transformants was induced with galactose. Thereafter, cell liquid cultures were subjected to heat shocks to evaluate their basal and induced thermotolerance. The recombinant protein did not affect significantly the growth of the yeast cultures. Moreover, we observed a statistically significant increase in basal thermotolerance, whereas induced thermotolerance levels were similar to the control. Our data demonstrates that mayehuelin function is involved in heat stress resistance, however its mechanism of action remains to be studied.

Key words: *Agave*, cogollo, RIPs, *Saccharomyces*, thermotolerance

[42] A numeric index to assess the level of protection of threatened, priority succulents in Mexico

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The main objective is to diagnose the effectiveness and coherence of a group of national and international conservation instruments, covering the succulents of the "List of species and priority populations for conservation". This list acts as a complementary strategy to reach international commitments of biodiversity conservation, and includes 123 species of plants, many of them already present in the NOM-059-SEMARNAT-2010, which is the first Mexican list regarding threatened species. A group of seven instruments was selected. Three of them are lists (Mexican NOM-059-SEMARNAT-2010, IUCN Red List, CITES Appendices) and four are practical approaches (Natural Protected Areas, Management Units for Wildlife Conservation, Botanic Gardens and Conservation of Genetic Resources). A numerical matrix was constructed and served as the basis for the development and application of two indexes of attention priority, as well as for the design of a visual indicator, traffic light-type. The analysis provides a comprehensive overview of the current status of the succulent species (Cactaceae, Agavaceae and Nolinaceae) included in the list, and identifies gaps, coherence and incoherence in conservation priority, according to the instruments analysed. On that basis, it establishes conservation priority. This work is an objective contribution for decision makers for future conservation activities. Data provided by the analysis will help to redefine the attention priorities, actions and directions of environmental policy and conservation.

Key words: priority species, conservation instruments, attention index, prospective actions

[43] Morphometric variation and floral biomass among natural populations of *Opuntia caracasana* Salm-Dyck (Cactaceae) in arid zones of Venezuela

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Multivariate statistical analyses have been increasingly used among morphological and reproductive morphometric characteristics to corroborate species characterization, analyse patterns of intra and interpopulation variation and interpret correlations of related groups. The morphometric variation, floral biomass and production of reproductive structures were evaluated in two populations of *Opuntia caracasana* located in the arid areas of Mangle Lloroso (Falcón state) and La Bocaina (Carabobo state), located in the western and central Venezuelan coast, respectively. The following variables were analysed: number of flower buds, number of open flowers, number of unripe fruits, number of ripe fruits, outer floral diameter, inner floral diameter, floral length, pericarpel length and dry biomass of floral whorls (tepals, androecium, gynoecium and pericarpel + receptacle). A multivariate analysis of principal components was conducted (CPA) to evaluate the affinities between the populations. No differences were found between the production of flowers and fruits, while the dimensions and floral biomass changed significantly between populations. The flowers of La Bocaina population were larger and heavier compared to those of Mangle Lloroso, showing segregation of the two populations, with an explained variance of data 66.96%, according CPA. The variables associated with biomass and floral length were the factors that contributed most to the interpopulational variation found in this species on the Venezuelan coast.

Key words: multivariate analysis, floral biology, reproductive biology, *Opuntia caracasana*, interpopulation variability, Venezuela

[44] Importance of the Doba in the Zapotec culture of the Ocotlán district, Oaxaca, Mexico

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The diversity of "doba or dub" present in the Zapotec territory of the district of Ocotlán manifests itself in a multiplicity of uses, emphasizing its medicinal and food use. The present study recognizes the importance of doba in the daily life of this indigenous culture of Oaxaca. The study was divided into two phases; the first consisted in locating and identifying the representative populations of the doba; while in the second phase 36 semi-structured interviews were held with key informants to recognize names in the local native language, as well as the importance and usefulness of each of the species studied. Two species of Bromeliads, locally called Doba kuelda (*Hechtia* sp.) and Doba xiidxu (*Bromelia pinguin*) were identified, along with nine species of the genus *Agave:* Doba biya' (*A. potatorum* and *A. nussaviorum*), Doba dxia (*A. convallis* and *A. angustiarum*), Doba ziiz (*A. karwinskii* f. *miahuatlan*), Doba daa'n (*A. karwinskii*), Doba naxh (*A. angustifolia*), Doba nupi (*A. americana*) and Doba beew (*A. marmorata*), as well as two species of *Yucca*: Doba baadu' (*Y. mixtecana* and *Y. guatemalensis*). They were classified into eight use categories: medicinal, food, fermented beverages, distilled beverages, construction, ornamental, agricultural and domestic use; of which the category with greater number of uses was construction, the inflorescence being the most important part of the plant. The Zapotec classification for doba is not exclusive to species of the genus *Agave* as it places more emphasis on the coarsely shaped plants.

Key words: doba, zapotec culture, use categories

[45] Some succulent novelties from Querétaro, Mexico

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During the development of the Flora of the Bajío and Adjacent Regions project, directed since 1985 by Dr Jerzy Rzedowski and Dra Graciela Calderón, 121 new taxa have been discovered and described, corresponding to 118 species, two subspecies and one genus. Among the new species there are some outstanding succulent plants of *Agave*, *Echeveria*, *Hechtia*, *Pinguicula* and *Sedum*. Additionally, we are proposing six more new species, collected recently in Querétaro and San Luis Potosí: *Agave mixii* Zamudio in prep., *Mammillaria occulta* Zamudio & U. Guzmán, *Mammillaria rzedowskiana* Zamudio & U. Guzmán, *Pinguicula robertiana* Zamudio in prep., *Pinguicula rzedowskiana* Zamudio in prep., and *Yucca pinophila* Zamudio in prep. All these are narrow endemics, from the southern part of the Sierra Madre Oriental in Querétaro and San Luis Potosí, known locally as Sierra Gorda. These discoveries reaffirm the importance of the region in the flora of the state.

Key words: new species, *Agave*, *Pinguicula*, *Mammillaria*, *Yucca*

[46] A New Species of Agave (Agavaceae) found with "Rock Piles Galore" in pre-Columbian agricultural fields along the San Pedro River, Arizona

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On terraces along the ca. 60 miles of bajada above the San Pedro River floodplain between Benson and Mammoth, Arizona, archeologists have documented tens of thousands of acres of pre-Columbian agricultural sites consisting of rock-pile fields and non-architectural linear rock-pile features. Evidence from previous archeological work in the region suggests that these types of fields were used to cultivate agaves, which were used by Native Americans for food, fiber and beverage. Fortuitously, there are a few locations in which agaves can still be found growing within these fields today. These agaves are only associated with these agricultural features and are not found in the surrounding unmodified settings. Furthermore, they produce very little seed, reproduce readily via vegetative means, and we cannot assign these plants to any described species by morphology or molecular data. Therefore, we propose that these plants represent a putative pre-Columbian domesticate that was cultivated by the Hohokam people. Evidence suggests that the peak interval of *Agave* cultivation in this area was from ca. A.D. 1000 to 1275 and that the impressive scope of the agricultural fields indicate that agaves were important in the Hohokam economy. The limited number of remnant agaves surviving in these field today raises concern for the conservation of this hidden domesticate without renewed human cultivation.

Key words: Agavaceae, **Agave**, Arizona, domesticate, pre-Columbian

Report of the General Meeting of Members, 23 October 2017, 16:00 hrs.

Members present: Héctor M. Hernández (President), Daniela Zappi (Vice-President), Len Newton (Archivist), Rolando Bárcenas, Andrew Gdaniec, Carlos Gómez, Root Gorelick, Carlos Ostolaza, Ivón Ramírez, Emiliano Sánchez

AGENDA AND RESOLUTIONS

Apologies for absence:
The following sent apologies for absence: Dr Mats Hjertson (former Vice-President of IOS), Dr David Hunt (IOS Secretary), Dr Sara Oldfield (former Treasurer), Dr Robert Webb.

Obituary

The President read the following text and participants stood for a minute of silence:

Dr Donald Pinkava was a distinguished member of IOS for many years. He passed away on July 25, 2017 in Arizona, at the age of 83. After receiving his doctorate in 1964, he became the Director of the Herbarium and Professor of Botany at where he taught from 1964–2000. During his 35 years at ASU, he contributed to and wrote numerous research publications, taxonomy books and academic journals on Arizona flora. He was also chairman of dozens of committees and major advisor of several recognized cactus taxonomists in North America. After retirement, he continued his research at the ASU herbarium and at the Desert Botanical Garden, primarily focusing on the cacti of western North America and his final contributions on the chromosome series of cacti were made this year. His is especially well known for his contributions to the Cactaceae of North America, and especially for being the foremost expert on the Opuntioideae of the American southwest and northern Mexico.

Secretary's report
Professor Newton read the report sent by the Hon. Secretary, Dr David Hunt.
First I must offer my apologies to the President and the other members present for my absence in person from what I believe will prove the most well-supported and successful IOS Congress for many years.

As usual, there is not much to report concerning IOS activities during the interval since the previous Congress. The Paris meeting of the Executive Board that followed the Congress at the Desert Botanical Garden in 2014 has been reported in the IOS Bulletin for 2015, along with the President's initial announcement of planning for the present Congress. Several significant publications, realised through the active collaboration of IOS members, were also mentioned in the Bulletin, and (his heavy workload at Zürich notwithstanding) Dr Urs Eggli has continued to compile annual issues of our other official publication *Repertorium Plantarum Succulentarum*.

Although, for logistical reasons, and thence a lack of the statutory quorum of three members, the five-member Executive Board was unable hold formal meetings in 2015 or 2016, such routine business as the approval of membership applications and provision of monetary grants has been satisfactorily managed by email correspondence, along with the arrangements for the present Congress.

The desirability of increasing the size of the Board from five to seven members was agreed at the Paris meeting (it was 15, prior to 2006, and resulted in the payment of heavy travelling expenses at the preceding Congress). Under Article 7 of the IOS Statutes, the Executive Board has the power to make bye-laws to assist the operation of the Statutes, and with this in mind the first member to be co-opted to the Board is Professor Dr Len Newton, formerly IOS President, in the role of IOS Archivist, whom I'm happy to say will be present among you.

With regret, however, I am sorry to report that Dr Mats Hjertson, who was elected our

Vice-President in 2014, has felt obliged to resign this year for pressing family reasons. The vacancy on the Board caused by his resignation has been filled by the Board, invoking Article 8 of the IOS Statutes, with the nomination of Dr Daniela Zappi who, again, I'm happy to say, is attending this Congress.

The former Treasurer, Dr Sara Oldfield, and theAssistant Secretary, Nikolaus Schröder, are not standing for re-election. Dr Rolando Bárcenas has been nominated as Assistant Secretary (Webmaster). The post of Treasurer is officially vacant, but with the suspension of the Membership Fee, formally agreed by the Board at our Paris Meeting, and supported by the members present at the 33rd Congress, the Treasurer's duties are now mainly limited to the payment of grants approved by the Board and these have been processed by the Secretary. They are enumerated in the Finanical Statement that follows.

David Hunt

Financial Statement and **Election of Auditors** *(Art. 16)*
IOS accounts 2014-2017

A summary of the IOS accounts for 2013 was presented to the 33rd Congress in April 2014 and approved by the Auditors in July of that year. It was based on a statement prepared by the Hon. Treasurer and published in IOS Bull. 16(1): 24–25 (2014). For your covenience a copy of the statement is attached (Doc. 1).

In August 2013 the balance in the IOS regional account in Sterling held by the Hon. Secretary was transferred to the main account (the 'Central Reserve Fund') with HSBC via BGCI on behalf of IOS, along with the bulk of the funds in the Euro account, making a total of GBP 49824.59 as of 31 December 2013. (HSBC statement Sheet 16).

Income and expenditure 2014

Funds in the US account as of 31 December 2013 amounted to US$ 2509.09. This amount was disbursed in 2014 in the form of grants to Dr Olwen Grace and Dr Gómez-Hinostrosa, plus payment of bank charges, and Dr Dorsch's US$ account was closed. The residue of the Euro account, GBP 445.72, was transferred to the main account by Dr Bauer in February 2014, and the main balance in the Swiss account, GBP 1464.96, by Mr Deubelbeiss in April 2014 (HSBC statement Sheet 18).

The annual IOS Membership fee was suspended by the 33rd IOS Congress in April 2014 and no income from fees has since been received, but a payment was received from the Mairie de Monaco in February 2014 ((HSBC statement Sheet 16).

The Secretary was reimbursed GBP 272.00 in February 2014 for the cost of printing copies of IOS Bulletin 15(6) and Repertorium Pl. Succ. 63; GBP 250.00 in March 2014 for an approved research grant to Mark Uleh via Professor Newton; and GBP 276.00 for the printing costs of IOS Bulletin 16(1) and Rep. Pl. Succ. 64. A total of GBP 1391.16 was disbursed by the Treasurer as contributions to the expenses of members attending the meeting of the IOSExecutive Board in Paris, September 2014. The balance in the IOS/HSBC account, including interest payments of GBP 20.18, as of 31 December 2014 stood at GBP 49590.27 (HSBC statement Sheet 20).

Income and expenditure 2015

Apart from an interest credit of GBP 9.89, no funds were received or disbursed via the IOS/HSBC account prior to the retirement of the Hon. Treasurer from BGCI and the transfer of the IOS funds a Community Account with Barclays Bank, administered by the officers of the IOS Executive Board. As of the date of the transfer, 14 October 2015, the credit balance was GBP 49,600.16 (HSBC statement Sheet 22; Barclays statement 11 November 2015). As

a ‘goodwill gesture’ Barclays credited the new account with GBP 25.00 on 24 December 2015, making the credit balance GBP 49625.16 as of 31 December 2015.

Income and expenditure 2015-2016

Since the suspension of the IOS membership fee in April 2014, IOS has received no income apart from an amount of GBP 25.00 received for printed copies of the IOS Bulletin in January 2016. The only disbursement in 2015–2016 was the Board’s approved grant of GBP1185. 00 to Isabel Larridon in support of her research on the genus *Eulychnia* (Cactaceae). The credit balance in the account as of 31 December 2016 was thus GBP 48465.16. (Barclays statement 11 March 2016),

Expenditure 2017

No income was received by IOS in 2017 except GBP 15.00 as noted below. Expenditure was mainly in grants and support for the 34th Congress, preceded by a grant of GBP 700.00 via Dr Grace to the Ethiopian PhD Student Eshetu Fentaw to enable him to attend the AETFAT Congress in Nairobi in May 2017.

	GBP	
Travel grant to Eshetu Fentaw	700.00	
Payments in support of the IOS 34th Congress,		
17 May 2017	1500.00	
10 October 2017	1000.00	
Bank charge	40.00	
Board member attendance allowances:		
15 June (Newton)	500.00	(485.00*)
10 October (Zappi)	500.00	
Total expenditure	4240.00	
Less repayment by Newton	15.00	
Net total expenditure	4225.00	
Balance at Barclays Bank 31 December 2016 (GBP)	48465.16	
Balance at Barclays Bank 31 December 2017 (GBP)	44240.16	

*Prof. Newton refunded GBP 15.00 for a copy of the IOS Bulletin.

The credit balance as of 31 December 2017 in the Barclays Bank Community Account stood at GBP 44240.16 (Barclays statement 11 October 2017)

Note: Following enquiries by the Secretary concerning the Swiss regional account, which had remained open after the initial transfer of funds to the IOS/HSBC account, the holder of the account transferred the remaining funds, amounting to GBP 223.43, to the Barclays Community Account in February 2018.

Bank statements attached

Copies of HSBC Bank Statements (4) 22 October 2013–21 April 2014; 22 April 2014–21 October 2014; 22 October 2014–21 April 2015; 22 April 2015–21 October 2015.

Copies of Barclays Bank Statements (9) 14 October 2015–11November 2015;12 November 2015–11 January 2016;12 January 2016–11 February 2016; 12 February 2016–11 March 2016; 12 March 2016–11 May 2016;12 May 2017–09 June 2017; 10 June–11 July 2017;12 June–11 October 2017; 12 October–09 February 2018.

David Hunt PhD
IOS Secretary
1 March 2018

Dr Carlos Ostolaza and Sidney Novoa were unanimously designated by the meeting participants to audit the financial report of the IOS's expenses during the last period sent by the Secretary:

Election of Executive Board members for 2018–2019
The meeting participants unanimously approved the following persons nominated by the Executive Board for the period 2018–2019.

Nominations:
President: Dr Héctor M. Hernández
Vice-President: Dr Daniela Zappi
Secretary: Dr David Hunt
Treasurer: (Vacant)
Assistant Secretary (Webmaster): Dr Rolando T. Bárcenas
Archivist: Professor Leonard Newton

Amendments to the Statutes (Art. 17)
The Board proposed the following amendments to the IOS Statutes to be considered by this meeting (modifications marked in blue). Most of these changes were recommended in view of the withdrawal of the Membership Fee. The meeting participants unanimously approved all changes:

Art. 5: Admission
Applications for Personal Membership shall be submitted on an official form provided by the Secretary or downloaded from the IOS website. All applications shall be considered by the Executive Board, at whose discretion admission shall be granted

Applications for Student Membership shall be approved and countersigned by the student's Supervisor. ~~Student Membership shall be for two years in the first instance, renewable on request for a further two years only. Student Members shall have the same privileges as other Personal Members but shall not be required to pay the biennial subscription and shall not have voting rights.~~

Art. 6: Withdrawal of membership
Membership of IOS may be terminated by resignation, ~~by non-payment of the subscription~~, or by decision of the Executive Board when the member no longer fulfills the conditions stipulated in these Statutes or acts against the interest of IOS, subject to appeal at the next Congress.

Art. 7: Management
The management of IOS shall be vested in an Executive Board consisting of the President, Vice-President, Secretary, Assistant Secretary, ~~and~~ Treasurer and Archivist.
The Executive Board shall be responsible for putting into effect the decisions of the Congress, for preparing the Organization's budget and carrying out its provisions, and shall assist the President in every activity that furthers the aims of the Organization. The Executive Board shall have the power to make, amend or delete bye-laws to assist the operation of the Statutes. Bye-laws may also be deleted by a simple majority vote at the Congress. It is desirable that the Executive Board should be composed of members of different nationalities.

Art. 10: Board Meetings
The Executive Board shall meet in person at least once per year when practicable. The quorum for a meeting shall be three members.

Art. 11: Election of Executive Board
Written nominations, proposed and seconded by members of IOS and bearing the consent of the member nominated, shall be invited prior to each Congress for all posts of the Board ~~the posts of President, Vice–President, Secretary, Assistant Secretary and Treasurer~~. Nominations in writing must be in the hands of the Secretary not less than three months before a Congress. If more than one nomination is received for any post, there shall be a postal ballot of all members, to be decided by a simple majority.

Art. 12: Finance
The activities of IOS shall be financed ~~by the subscriptions of members and~~ by donations, bequests and such other income as may be available. ~~The amount of the subscription for the succeeding two years shall be fixed by the Congress.~~

~~**Art. 13. Exemptions**~~
~~Honorary and Student members shall not be required to pay the subscription. Members who have been fully paid–up members for at least ten years and have attained 70 years of age, and who wish actively to continue supporting the IOS, may apply for exemption from payment of the subscription when renewing their membership.~~

Art. 16: General Meeting
A General Meeting of members shall be held at each Congress for the transaction of the following business: Presentation, discussion and ratification of the Organization's reports and accounts for the preceding inter-Congress period and plans for the future, with the appropriate budget; election of Honorary Members; election of the Executive Board for the ensuing inter-Congress period; election of auditors; ~~fixing of the subscription for the following two years;~~ discussion of other matters raised by or submitted to the Executive Board prior to the Congress.

IOS Congress Venue for 2019
The members present in the meeting gave favorable reception to an invitation sent to the IOS President by Dr José Manuel Fernández Zeballos (President of the Consejo Directivo of Sociedad Peruana de Cactus y Suculentas - SPECS) to hold the 35th IOS Congress in Ica, Peru (300 km S of Lima), during the second half (October?) of 2019. Carlos Ostolaza and Sidney Novoa responded to several questions on behalf of SPECS. The President promised to respond to the invitation as soon as the IOS Board had considered Dr Fernández's proposal.

Postscript

With the agreement of Carlos Jiménez López, President of SPECS for 2018–2019 (e-mail 15 August 2018) the 35th IOS Congress will be held in conjunction with the 4th Congreso Nacional de Cactáceas y Suculentas of SPECS at Ica, Peru, during the week of October 15–21, 2019, followed by an excursion to Nazca–Pampa Galeras–Puquio–Abancay–Cusco and Machu Picchu. The assistance of the University of ICA, the regional government of ICA, and various other organizations is being sought.

For further information concerning programme arrangements, registration, accommodation, concessions for students, etc., IOS members interested in attending the Congress should contact either the President of IOS or the Secretary (addresses on inside front cover).