

Informe final* del Proyecto CE033
Apoyo para difusión (camisetas con el logo de la Conabio) de la reunión internacional de Cycadas 2005

Responsable: Dr. Andrew Peter Vovides Papalouka
Institución: Instituto de Ecología AC
Dirección: Km 2.5 Antigua Carretera a Coatepec, Xalapa, Ver, 91000 , México
Correo electrónico: N/D
Teléfono/Fax: N/D
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Resumen:

La UICN/CSS Grupo especialista de Cycadas coordina reuniones internacionales relacionadas a la biología y conservación de las cycadas cada tres años y atrae un rango variable de profesionistas y personas interesadas en la biología, cultivo y conservación de las cycadas. La sede de la próxima reunión será en Xalapa, Ver., en el Instituto de Ecología, AC, en enero de 2005 y es una reunión particularmente importante. México ha estado a la vanguardia de varias iniciativas de investigación y conservación como el manejo sustentable en viveros. Es la primera vez que esta reunión internacional se realizará en México, el cual tiene el 2º lugar a nivel mundial en diversidad de cycadas. El estado de Veracruz es una de las regiones más privilegiadas en riqueza de cycadas. Con esta reunión los delegados pretenden contribuir a desarrollar un programa global de conservación de las cycadas, especialmente en canalizar muchos de los excelentes trabajos que se habían realizado en la región a un Plan de Acción Global de conservación de este importante grupo de plantas. Conferencias anteriores en esta serie demostraron ser muy estimulantes en la promoción de investigación científica sobre este grupo antiguo de plantas el cual está en verdadero e inminente peligro de extinción, y las Actas de estas conferencias constituyen fuentes valiosas de referencias e información. Uno de los simposios de la reunión está dedicado completamente a los aspectos de conservación; en estas conferencias también se ha conducido a la promulgación de leyes locales e internacionales para detener el comercio en plantas, a la conservación ex-situ, y la publicación para realizar un Estado inspeccional y un plan de acción de conservación para las cycadas. También se ha llegado a el descubrimiento revolucionario de polinización de un insecto especializado el cual está siendo investigado y consideramos que tendrá implicaciones de gran alcance para la filosofía de conservación de las cycadas.

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ABSTRACTS – PLENARY ADDRESSES / RESÚMENES – PONENCIAS MAGISTRALES

PL1. FIRST PLENARY ADDRESS: CYCADS OF MEXICO / [CÍCADAS DE MEXICO]

Andrew Vovides

The first Mexican cycad to be cultivated in Europe was *Zamia furfuracea*, grown in the Royal Garden at Hampton Court, England, in 1691. During the botanical explorations of the 19th century there was a proliferation of cycad species descriptions from the New World by botanists and plant hunters alike. The early 20th century was marked by the extensive work of Charles Chamberlain, followed by a relative vacuum up until the late 1970's, when renewed interest blossomed amongst various workers at home and abroad. There has since been an increase of more than 300% in the number of named species, over the nine or so species known in the late 1960's and early 1970's. This has placed Mexico as second worldwide in the number of cycad species. An outline is presented of species, distribution, vegetation-types and current basic and applied research being done on Mexican cycads. Molecular and genetic research has shown that cycad speciation in Mexico is relatively recent and we have a better understanding of distribution patterns in *Dioon* particularly. Many cycad species in Mexico appear to be correlated with floristic refugia of the Cenozoic. Sustainable management projects have developed from this research and follow-up studies in cultivation improvement are underway.

PL2. SECOND PLENARY ADDRESS: CYCADS – THEN, NOW AND FOREVER / [CÍCADAS – AYER, HOY Y PARA SIEMPRE]

Derrnis Stevenson

Neither the analysis of molecular data alone nor morphological analysis of extants can provide a complete picture of the phylogeny and pattern of change in a group. In order to understand the phylogeny of a group of organisms, fossils must be included in the phylogenetic analysis to understand the minimum age of the group and subgroups and to understand where in the phylogeny apomorphic states have developed. Thus, a cladistic analysis was done of the 11 extant cycad genera and 21 fossil cycad genera with ginkgo, eusporangiate ferns, conifers, gnetopsids and magnolid angiosperms as outgroups. Only morphological data was used at this time. Only those fossil taxa that have a cycad synapomorphy or a synapomorphy of a group within the cycads (but not known to occur elsewhere in seed plants) were included. The analysis resulted in 14 most parsimonious trees with excellent resolution except for the base of the Encephalarteae. *Nilssoniocladus* does not group with the cycads. *Michelilloa* and *Antarcticycas* are ladderized on the cycad stem lineage. *Cycas* and *Crossozamia* are sister genera and the first cycad branch. *Bjuva*, *Ctenis*, *Sueria* and *Mesodescolea* are ladderized respectively on the stem lineage of the Stangeriaceae with *Mesodescolea* as the sister taxon to *Bowenia* and *Stangeria*. NILANBE, a composite terminal composed of *Nilsonia* + *Androstrobus* + *Beania*, is at the base of the Zamiaceae followed by *Ticoa* and *Kurtziana* in that order. *Almargemia* is the sister taxon to the Zamioideae. *Dioonopsis* is the sister taxon to the Encephalartoideae. Within the latter, *Lyssoxylon* and *Dioon* are sister genera and together they are the sister group to the Encephalarteae. *Charmogia* is on the stem lineage of the Encephalarteae. The

Encephalartea is still resolved with Encephalartos as the sister taxon to Macrozamia and *Lepidozamia* but the Encephalartea forms an unresolved clade with *Bororoa*, *Menucoa*, *Centricycas*, *Chamberlainia*, *Worsdellia* and *Fascisvarioxylon*. Most of the fossil genera are represented by either leaves or stems that are unattached. Thus, except for NILANBE and Crossozamia, synapomorphies with extant cycad genera and clades consist of either leaf characters or stem characters with numerous unscored characters. The fact that the fossil genera are represented by either stem or leaves, but not both, removes possible character conflict, which may explain the high resolution in spite of a significant percentage of missing values. While this is a problem, the results indicate predictable features to be found in the leaf and stem genera. This analysis demonstrates that the cycads are a Pangean group in contrast to the usual interpretation of them as primarily Gondwanan based upon the distribution of extant genera. The fact that the cycads are minimally the sister group to the other gymnosperms means that, as long as there are seed plants, cycad genes are present.

PL3. THIRD PLENARY ADDRESS: BIOMAGNIFICATION OF CYANOBACTERIAL NEUROTOXINS AND NEUROGENERATIVE DISEASE: AMONGST THE CHAMARRO PEOPLE OF GUAM/ [BIOENGRANDECIMIENTO DE NEUROTOXINAS DE CYANOBACTERIAS Y LA ENFERMEDAD NEURODEGENERATIVA ENTRE LOS CHAMARROS DE GUAM]

Paul Cox

The possible connection between cycads and neurological illness in Guam was first proposed by Kurland and Whiting in the late 1950's. Through the years, five different international conferences on cycads and amyotrophic lateral sclerosis/parkinsonism-dementia complex (ALS/PDC) were held. In the late 1980's, Spencer hypothesized that the non-protein amino acid B-N-methylamino-L-alanine (BMAA), then known only from cycads, caused the disease. This hypothesis was discounted when Duncan found that the Chamorros would have to eat hundreds of kg/day of cycad flour to attain anything close to a toxic dose. Sandra Banack, Susan Murch and I found that BMAA is biomagnified from the sarcotesta of the seeds of *Cycas micronesica* to flying foxes (*Pteropus mariannus mariannus*) that forage on them. The flying foxes, in turn, are the prized food item of the Chamorros. Ingestion of a single flying fox can provide the B M M dose equivalent of over 1000 kg of cycad flour. B M M is produced in the coralloid roots of *C. micronesica* by cyanobacteria of the genus *Nostoc*. There is a 10,000-fold increase in concentrations of BMAA from cyanobacteria to flying foxes. BMAA occurs in brain tissues of Chamorros who have died of ALS/PDC but not in healthy control patients. BMAA is incorporated into proteins at all levels of the ecosystem, at approximately 100 times its concentration as a free amino acid. Thus both flying foxes and cycad flour provided significant inputs of BMAA into the Chamorro diet. We are studying BMAA production by cyanobacteria outside of Guam, including areas of high incidence of neurodegenerative disease. The finding of BMAA in brain tissues of patients with neurodegeneration in North America suggests that exposure to cyanobacterial neurotoxins occurs in areas devoid of cycads. Thus, cycads may have served to alert the world to the danger posed by biomagnification of cyanobacterial neurotoxins.

ABSTRACTS – ORAL PRESENTATIONS / PRESENTACIONES ORALES

*The name of the person delivering the presentation is underlined
Abstracts are listed in the sequence of presentation*

**TO1. CERATZAMIA EN LA SIERRA MADRE DEL SUR, OAXACA, MÉXICO/
[CERATZAMIA IN THE SOUTHERN SIERRA MADRE, OAXACA, MÉXICO
*Alma Delia Chávez-González, Beatriz Rendón-Aguilar y Azucena de Lourdes Luna-José***

El estado de Oaxaca es uno de los más ricos en cuanto a diversidad florística se refiere, ya que presenta una gran variedad de ecosistemas, muchos de los cuales aún no han sido estudiados, por lo cual es posible encontrar especies que aún no han sido reportadas para ciertas zonas, como es el caso de Zamiaceas en la Sierra Madre del Sur. Los objetivos de este trabajo son: (1) realizar una revisión bibliográfica y de herbario para el género *Ceratozamia* en el estado de Oaxaca, resaltando la distribución y los usos y (2) reportar el estado actual de la población de *Ceratozamia* localizada en Buenavista Loxicha, Oaxaca. El género *Ceratozamia* se reporta únicamente para México, Belice, Honduras y Guatemala. Para Oaxaca se reportan 5 especies las cuales están en los niveles de raras, amenazadas o en peligro de extinción. Una está reportada para la Sierra Mixe; otra se localiza en Valle Nacional y las tres restantes se reportan para la Sierra Norte de Oaxaca. En cuanto a los usos, se utiliza para festividades religiosas, para elaborar insecticidas y como planta ornamental. La población localizada en T. Buenavista está conformada por 38 individuos (dentro de un área de 50 x 50 m), con un promedio de altura de 1.39 m y un rango de 0.4 a 3 m, distribuidos en pequeños grupos de 3 a 5 individuos. La presencia de *Ceratozamia* en esta localidad sugiere la existencia de un paleo refugio.

T02. REDESCRIPTION OF *DIOON MEJIAE*: TOWARD A TAXONOMIC DESCRIPTION STANDARD / [RE-DESCRIPCIÓN DE *DIOON MEJIAE*: HACIA UNA DESCRIPCIÓN TAXONÓMICA ESTANDARIZADA]

Jody Havnes and Mark Bonta

Cycad taxonomy and systematics are plagued by insufficient and inconsistent species descriptions. Problems associated with the inadequate description of *Dioon mejiae* were perpetuated for over 50 years, and include (1) unfounded and inaccurate reports of mature plant size, species distribution, and population numbers; (2) incomplete and/or erroneous descriptions of the type locality; and (3) inaccurate designations of conservation status. This paper represents a redescription of *Dioon mejiae* and is offered as a case study of and justification for a taxonomic description standard—following the taxonomic description guidelines set forth by Walters and Osborne. Included are (1) name, GPS coordinates, number of adult plants, area encompassed, plant density, habitat type, soil type, underlying geology, and reproductive status of all known populations; (2) map of all known populations; (3) comprehensive suite of diagnostic vegetative and reproductive morphological traits; (4) taxonomic key of the species and its closest relatives; (5) designation of 'tiusinte' as the standard common name; (6) discussion of cultural geography and ethnobotany; (7) discussion of threats,

conservation status, and proposed in-situ conservation recommendations; and (8) more current estimates of total number of adult plants in the wild, domestic plants in Honduras and Nicaragua, and cultivated plants in ex-situ collections in public and private gardens/parks, private collections/seed colonies, and nurseries worldwide.

TO3. VARIACION GENÉTICA Y MORFOLOGICA DE *DIOON EDULE*: COMPARACIÓN CON OTRAS CÍCADAS / [GENETIC AND MORPHOLOGICAL VARIATION IN *DIOON EDULE*: COMPARISON WITH OTHER CYCADS]

Jorge González-Astorga, Andrew Vovides y Carlos Iglesias

En esta investigación evaluamos la variación morfológica y genética de *Dioon edule* en todo su rango de distribución, desde el centro de Veracruz hasta Nuevo León (del centro al noreste de México). Encontramos que el ancho de los foliolos disminuye proporcionalmente respecto al incremento de la latitud de las poblaciones. En esta parte discutimos los resultados en términos de adaptaciones diferenciales a ambientes locales. Por otro lado, en cuanto a la genética de las poblaciones de *D. edule*, encontramos que la diversidad genética de la especie es relativamente alta, comparado con otras especies de distribución restringida y/o endémicas, pero es similar a otras especies de cícadas. También, encontramos que la diversidad genética disminuye linealmente respecto al aumento de la latitud de las poblaciones. A su vez, la diferenciación genética entre las poblaciones de *D. edule*, es relativamente baja comparado con otras cícadas. En general, los resultados se discuten a dos niveles: evolutivo y en términos de la conservación de la especie.

TO4. LAS CÍCADAS EN CUBA / [THE CYCADS OF CUBA]

Lutgarda González Géigel

Se presentan los resultados obtenidos en el estudio de las Zamiaceae cubanas, especialmente en el género *Zamia*. Las zamias cubanas comprenden 7 especies. Se presentan las mismas incluyendo su distribución y notas ecológicas. Se añaden comentarios sobre el cultivo y uso como plantas ornamentales de *Cycas*, *Dioon* y *Zamia*.

TO5. MICROSATELLITE DNA STUDIES IN THE CARIBBEAN *ZAMIA PUMILA* COMPLEX / [ESTUDIOS CON MICROSATELITES DE DNA EN EL COMPLEJO CARIBEÑO *ZAMIA PUMILA*]

Alan Meerow, Javier Francisco-Ortega and Dennis Stevenson

The *Zamia pumila* complex is a monophyletic, diploid ($2n = 16$) and distinctive assemblage of cycad populations restricted to the West Indies and southeastern USA that has been treated as comprising as many as 14 or as few as one species. We have developed a microsatellite (simple sequence repeat, SSR) DNA library from *Z. integrifolia* that we will use to study variation in the complex and apply these data to various evolutionary and biogeographic questions. Our overall goal is to document the patterns of microsatellite DNA variation across populations of the *Zamia pumila* complex throughout its range, infer population structure and biogeographic and demographic history of the complex, and attempt to understand the processes of speciation within the group. We will sample

individuals from populations from each island in the West Indies known to harbor extant *Zamia* populations [Bahamas (Andros, Eleuthera, Grand Bahama, Great Abaco, Long Island, New Providence), Cuba, Grand Cayman, Jamaica, Hispaniola, Puerto Rico], and 15-20 populations from Florida and southeast Georgia in the southeastern USA. We hypothesize that *Zamia* in the Caribbean will exhibit conformance to the stepping stone model, given the limited gene flow exhibited by most cycad species. We further hypothesize that we will uncover genetic evidence of bottlenecks within some populations, apropos to the history of the Greater Antilles. Finally, we intend to address the hypotheses that the *Z. pumila* complex represents no less than five species, that pollinator mediated isolation restricts gene flow between species in the complex, and that every species in the *Z. pumila* complex will have a unique pollinator association. We have already designed 7 SSR primer pairs that are successfully capturing polymorphism in *Zamia*, and have only screened 15% of our library of potential SSR containing clones.

TO6. TAXONOMY, DISTRIBUTION AND CURRENT CONSERVATION STATUS OF SPECIES OF ZAMIA IN ECUADOR / [TAXONOMÍA, DISTRIBUCIÓN Y ESTADO ACTUAL DE CONSERVACIÓN DE ZAMIA EN ECUADOR]

Fernando Nicolalde-Morejón

Five species in the genus *Zamia* are known to occur in Ecuador. *Zamia poeppigiana* occurs in a variety of habitats such as dry forests in Tumbes (Peru), transition forests in the coastal cordillera near Pedernales (Ecuador), and moist tropical forest in the northwestern Ecuadorian corner. In this last site population size vary with conservation status of the forests. *Z. roezlii* is the species with the widest range, in the southern end of the biogeographical Chocó, where habitat destruction (log cutting, agriculture and cattle) is the main threat for that species. In that same region, populations of *Z. gentryi*, an endemic recently-described species, are the most threatened by human habitat destruction. However, populations in the Awa Indians Reserve appear to be the most suitable for future biological studies. *Z. amazonum*, a relatively common and widely distributed species, is very poorly known in Ecuador and its actual status and distribution in that country needs to be investigated. The same is true for *Z. ulei*, which is known from only one Ecuadorian population

TO7. CYCADS IN THE VERNACULAR—A COMPENDIUM OF LOCAL NAMES/ [CICADAS Y LO VERNACULAR—UN COMPENDIO DE NOMBRES LOCALES]

Mark Bonta and Roy Osborne

We present the first-ever worldwide compilation of traditional cycad names and discuss the significance of our findings. Using all available cycad literature and much personal consultation, we have compiled a table of scientific names, localities, languages, vernacular names and, where known, their translations. We have uncovered at least one vernacular name for almost half the presently known cycad species and a total of about 400 vernacular names in more than 100 different languages. Patterns of meaning revealed in our compendium include cycad-palm and cycad-fern homologies; a strong maize analogy (especially in Mesoamerican countries); toponymic references, allusions to morphological features; non-Western binomial taxonomies, references to local folklore and economic uses of cycad products.

TO8. CLASSIFICATION OF *ENCEPHALARTOS* / [CLASIFICACIÓN DE *ENCEPHALARTOS*]

Piet Vorster

The classification of *Encephalartos* is explained in view of morphological and ecological data, a molecular dataset, and geographical data that are used as a reference framework for the other data. Because it is assumed that speciation has a time component (difficult to measure with available tools) and a spatial element, geographical data are considered to be one of the most important clues to speciation and species radiation. Morphological data are difficult to interpret, yet certain groups of characteristics correlate with geographical data. Ecological data are still incomplete, but phenology shows definite pattern groups which can be linked to present-day geographic distribution. A powerful type of supporting evidence comes from associated insect species, but the available data are still very incomplete over much of the geographic range of the genus. A recent molecular dataset correlates well with morphological, ecological and geographical data, yet contains anomalies which are difficult to accept. This means that a fairly robust classification system can be proposed for *Encephalartos*, in spite of deficiencies of the component datasets.

TO9. SUBDIVISION OF *ENCEPHALARTOS* / [SUBDIVISIÓN DE *ENCEPHALARTOS*] **Piet Vorster**

The subdivision of the genus *Encephalartos* into several genera (*Rugostrobus*, *Acanthozamia*, *Pyrrhostrobus*, *Xanthostrobus*, *Inezamia*, *Glaucostrobus*, *Lverostrobus*, *Viridistrobus*, *Tanzamia* and *Congostrobus*), as published by Cooper and Goode in *The Cycads and Cycad Moths of KwaZulu-Natal* (2004), is discussed in view of the authors' motivation as well as available morphological and molecular data. Some new species described in this book are assessed also.

T10. *CYCAS ANNAIKALII*, A NEW SPECIES FROM THE WESTERN GHATS OF INDIA, WITH A DISCUSSION ON THE SPECIFIC LIMITS OF *C. CIRCINALIS* / [*CYCAS ANNAIKALII*, UNA NUEVA ESPECIE DE LOS GHATS DEL OESTE DE INDIA, CON UNA DISCUSIÓN SOBRE LOS LÍMITES ESPECÍFICOS DE *C. CIRCINALIS*]

Rita Singh, P. Radha and Prabha Sharma

The Western Ghats of India has been identified as one of the hot spots of the world and a centre of biodiversity. Linnaeus established the genus *Cycas* and its type species *circinalis* from the illustrations of Van Rheedee's *Todda Panna*. Rheedee's locality of *Todda Panna* also falls within the limits of Western Ghats. An extensive exploration over the last three years of all the disjunct and relictual populations in suburban Kozhikode and dense hilly forest areas of Palaghat has been made. Several morphological, anatomical, reproductive and cytological distinctions have been identified within the populations of these two areas of the Western Ghats. A new species, *Cycas annaikalii*, has been identified and is described in this paper, and its affinities discussed. The need for specific delimitations of *C. circinalis* is also emphasized and discussed.

T11. GENOMIC STUDIES IN CYCAS / [ESTUDIOS GENÓMICOS EN CYCAS]

Eric Brenner, Dennis Stevenson, José Eduardo de la Torre, Manpreet Katari, Stephen Rudd, Suzan Runko, Rob Martienssen, Richard McCombie and Gloria Coruzzi

Despite the critical role that cycads play as 'living fossils' of early seed plants, little work has been done to understand their molecular developmental profile. This is partly because cycads are difficult to work with on the genetic level. To correct this deficiency, we have undertaken a genomics approach to isolate, discover and study genes involved in cycad evolution and development. In this endeavor, we have created a cycad EST database made from developing cycad leaves and ovules. To date, we have sequenced 5,200 genes from cycads. By taking a comparative-genomics approach, we have determined that a number of genes in cycads are unique to gymnosperms and lower plants but are not found in angiosperms. Such 'gymnosperm specific' genes may have been lost in the evolutionary advance towards higher plants. Conversely, in this comparison we have found other genes in cycads with high similarity to genes in angiosperms. In angiosperms these genes regulate key developmental processes in the production of the flower. The study of these genes in the formation of the cycad reproductive and vegetative structures will help understand the evolution of such important characters as the seed (ovule) in early spermatophytes.

T12. A NEW GENUS OF CYCADALEAN PLANT IN EARLY TRIASSIC FROM WESTERN LIAONING, CHINA—*MEDIOCYCAS* GEN. NOV. AND ITS EVOLUTIONARY SIGNIFICANCE / [UN NUEVO GÉNERO DE CYCADALES DEL TRIÁSICO TEMPRANO DEL OESTE DE LIAONING, CHINA—*MEDIOCYCAS* GEN. NOV. — SU IMPORTANCIA EVOLUTIVA]

Nan Li, Yong Li, Wu Zhang and Shao-lin Zheng

A new genus, *Mediocycas*, of fossil cycad megasporophylls is reported. The specimens were collected from Yangshugou village, Kazuo county, western Liaoning Province, China. The stratigraphy of the plant-bearing bed belongs to the Lower Triassic Hongla Formation. The specimens previously posed a problem with insufficient material for a full description. These fossils, however, have important significance in early cycad evolution and thus we have made new studies of them. In this paper, the authors provide a description of *Mediocycas kazuoensis* sp. nov. and discuss its significance in the origin and early evolution of cycad megasporophylls.

T13. CYCAD-INDUCED NEURODEGENERATION IN A MOUSE MODEL OF ALS-PDC: IS THE CULPRIT REALLY BMAA OR IS A NOVEL TOXIN TO BLAME? / [NEURODEGENERACIÓN INDUCIDA POR CYCADAS EN RATONES MODELO DE ALS-PDC: ¿ES BMAA REALMENTE EL CULPABLE O HAY UNA NUEVA TOXINA A QUIEN CULPAR?]

Christopher Shaw, Jason Wilson, Reyniel Cruz-Aguado, Swaraj Singh, Erin Hawkes, Vivian Lee and Thomas Marler

The strongest epidemiological correlate for ALS-Parkinsonism dementia complex (ALS-PDC) is consumption of the seed of the cycad (*Cycas micronesica*) known to contain various toxins. Much previous work focused on cycasin and its aglycone (MAM), as well as on various excitatory amino

acids, notably BOAA and BMAA. None of these compounds is contained in significant concentrations in cycad seed 'chips' prepared by traditional Chamorro washing procedures. Cycasin/MAN and BOAA do not induce neurological symptoms resembling ALS-PDC. BMAA, a weak NMDA receptor agonist, has also routinely failed to induce ALS-PDC-like outcomes. Recent work by Cox and colleagues suggests that BMAA contained in cycad reaches levels able to induce neurodegeneration in ALS-PDC following biomagnification up the food chain. We have re-examined the 'cycad hypothesis' for ALS-PDC in *in vivo* experiments on adult male mice fed washed cycad pellets (up to 25% of total diet). The cycad pellets contained nil to trace concentrations of cycasin/MAN, BOAA or BMAA. Cycad-fed mice rapidly developed typical motor and cognitive behavioural phenotypes strongly resembling both ALS and Parkinsonism dementia. Histological analysis of the CNS of these mice showed neuronal loss with apoptosis, as well as the presence of activated astrocytes in spinal cord, substantia nigra, hippocampus, cortex and olfactory bulb. In contrast, pure BMAA at high dosages did not give rise to behavioural deficits or pathological outcomes. Other neurotoxins such as methionine sulfoximine or 3-nitropropionic acid showed spinal cord or basal ganglion associated deficits, respectively. BMAA thus appears unlikely to play any significant role in ALS-PDC. The bound BMAA reported in restricted regions of the brains of neurological disease victims may be an artifact of fixation techniques. We have isolated other potential cycad neurotoxins and find that the most toxic are steryl glucosides that induce HSP, tau expression and caspase-3 in neural cell cultures. These data support the original hypothesis that cycad consumption is causal to ALS-PDC on Guam, but do not support a primary role for BMAA in disease onset or progression.

T14. EFECTO NEUROPROTECTOR DE PROGESTERONA EN RATAS MACHO INTOXICADAS CON CÍCADA *DIOON SPINULOSUM* / [NEUROPROTECTIVE EFFECT OF PROGESTERONE IN MALE RATS INTOXICATED WITH THE CYCAD *DIOON SPINULOSUM*]

Eduardo Rivadeneyra Domínguez y Virginia Saavedra Vélez

Dioon spinulosum o 'palma de chicalite' es una cícada, cuyo fruto es utilizado como sustituto de maíz entre los chinantecos de los Estados de Veracruz y Oaxaca. Su consumo prolongado se asocia con Esclerosis Lateral Amiotrófica y alteraciones tipo Parkinson. El metilazoximetanol, principio activo de las cícadas, se le atribuyen efectos neurotóxicos, e induce actividad cerebral similar a la epilepsia. Un estudio previo determinó que la ingesta prolongada de semillas liofilizadas de *D. spinulosum* indujo cambios en la actividad motora de los animales. La progesterona es una hormona que se le atribuyen efectos neuroprotectores y neuromoduladores a nivel experimental, y se desconoce si las alteraciones conductuales y neuroanatómicas asociadas al consumo prolongado de cícada son revertidas con progesterona. En el presente trabajo se emplearon 32 ratas macho de la cepa Wistar distribuidas aleatoriamente en cuatro grupos. Al grupo A se le administró cícada (5 g/kg) y aceite de maíz. El grupo B recibió progesterona (3 mg/kg) y solución salina fisiológica. El grupo C fue tratado con cícada y progesterona. El grupo D recibió solución salina fisiológica y aceite de maíz. Los tratamientos farmacológicos fueron administrados diariamente durante 40 días. Los animales se sometieron a pruebas conductuales de nado forzado y actividad locomotora a los 20, 30 y 40 días de tratamiento. Ninguno de los tratamientos de progesterona y de vehículo promovió cambios en la actividad locomotora e inmovilidad. Los resultados mostraron que el grupo cícada

presentó conducta de giro en comparación con el grupo progesterona que no se da. En conclusión, la administración de progesterona bloquea los efectos adversos de la cícada sobre la actividad motora.

T15. ESTUDIOS PRELIMINARES PARA LA CARACTERIZACION ISOENZIMATICA DE *MICROCYCAS CALOCOMA* / [PRELIMINARY STUDIES ON THE ISOENZYME CHARACTERISATION OF *MICROCYCAS CALOCOMA*]

Ania Pinares de la Fe, Clara González Arencibia y Dalia Pérez Montesino

Microcycas calocoma es una planta endémica de Cuba, categorizada en peligro crítico de amenaza. Se encuentra distribuida en el área centro norte de la provincia Pinar del Río, con poblaciones dispersas en localidades de llano y montaña. Por varios años se han realizado estudios para la conservación de esta especie, analizándose aspectos relacionados con la ecología, propagación, polinización, reproducción, entre otros. Sin embargo hasta el presente no se conoce acerca de la variabilidad genética entre las poblaciones existentes, ni se cuenta con una metodología para la identificación del sexo. En este trabajo se aborda por primera vez estudios sobre la caracterización isoenzimática de esta especie. Se muestrearon 11 plantas de dos de las localidades de llano mas amenazadas y se analizaron tres sistemas de isoenzimas: Peroxidasa, Polifenoloxidasa y Anhidrasa Carbónica. Los resultados mostraron que solo el sistema Anhidrasa carbónica es polimorfo, observándose diferencias entre individuos de las poblaciones estudiadas y en el patrón de bandas entre individuos femeninos y masculinos.

T16. PHOTOSYNTHETIC CHARACTERISTICS AND LEAF AGE OF *CYCAS MICRONESICA* / [CARACTERÍSTICAS FOTOSINTÉTICAS Y EDAD DE LA HOJA DE *CYCAS MICRONESICA*]

Thomas Marler

Cycad leaves are costly to construct, and longevity can be measured in years for *Cycas micronesica*. This study was conducted to determine the influence of leaf age on photosynthetic characteristics of *C. micronesica* leaves to more fully understand overall plant carbon economy. Chlorophyll fluorescence and gas exchange characteristics were determined on leaves from 2 to 24 months in age. On sunny days, quantum efficiency under active photosynthesis and maximum quantum efficiency declined more for the older leaf cohorts than for the 2-month cohort. Photosynthesis of the oldest leaf cohort was about 75% of that for the youngest cohort on sunny days. Maximum quantum efficiency and photosynthesis did not differ among the cohorts on cloudy days. Light compensation and light level for photosynthetic saturation increased with leaf age. Apparent quantum yield decreased with leaf age. These results indicate the leaves up to 2 years in age substantially contribute to the plant's overall carbon economy. This sustained photosynthetic activity is important in paying back the high leaf construction costs, but also underscores the detrimental effects of losing older leaves to tropical cyclone or herbivore damage.

T17. WATER ECONOMY OF *MACROZAMIA RIEDLEI* IN THE JARRAH (*EUCALYPTUS MARGINATA*) FORESTS OF SOUTHWESTERN WESTERN AUSTRALIA / [ECONOMÍA HÍDRICA DE *MACROZAMIA RIEDLEI* EN EL BOSQUE DE JARRAH (*EUCALYPTUS MARGINATA*) DEL SUROESTE DE AUSTRALIA] John Marshall

Macrozamia riedlei is found mainly in the jarrah (*Eucalyptus marginata*) forest of southwestern Western Australia at latitudes 32-35°S. The climate is extreme Mediterranean-type with cool, wet winters and hot, dry summers. Annual rainfall is 500-1200 mm with over 70% falling between April and November. Dawn leaf water potential (DLWP), an indicator of the potential of the water source, of *M. riedlei* was measured twice a year over 5 years. Average rainfall for the field site was 720 mm. Measurements were made in October, when soil water was fully recharged from winter rains, and in April when soil water was at its annual minimum. At these times, DLWP was also measured on plants representing other growth forms (herbs, shrubs, grass trees, mid-storey trees and canopy trees). DLWP of *M. riedlei* was similar to, though generally higher than, that of other growth forms in October. However, by April, the herbs were no longer alive and the DLWP of the shrubs was very low, indicating a shallow root system. The taller grass trees were less water-stressed than the mid-storey trees. The deepest-rooting forest trees forming the canopy were the least stressed of these other growth forms. *M. riedlei* was an exception in that it maintained a comparatively high DLWP potential by April. This is interpreted as *M. riedlei* managing its water economy by having a large internal subterranean water storage reservoir. This interpretation is discussed in relation to survival and distribution.

T18. UTILIZING BMAA TO UNDERSTAND THE ROLE OF GLUTAMATE RECEPTORS IN PLANTS / [UTILIZANDO BMAA PARA ENTENDER EL ROL DE LOS RECEPTORES DE GLUTAMATO EN PLANTAS]

Eric Brenner, Dennis Stevenson, Suzan Runko, Nora Barboza and Gloria Coruzzi

Plants produce a variety of compounds that have acute effects on the human nervous system. One such compound is BMAA [S(+)- β -methyl- α,β -diaminopropionic acid], a compound produced in cycads, which is the suspected cause of Guam's dementia. In the animal nervous system, BMAA acts upon glutamate receptors (iGluRs), which are ligand-gated ion channels that transmit synaptic signals necessary for a variety of functions including vision and memory. It is not known if BMAA has a physiological role in plants; however, genes with high sequence similarity to animal iGluRs have been identified in a number of plant species. We have taken a pharmacological approach to uncover the role of plant glutamate receptor (AtGLR) genes by examining the effects of BMAA, a cycad-derived iGluR agonist, on *Arabidopsis* morphogenesis. When grown in the presence of BMAA, *Arabidopsis* seedlings show a two- to three-fold increase in hypocotyl length and a significant inhibition of cotyledon opening. The effect of BMAA on hypocotyl elongation is light-specific and can be reversed by the simultaneous application of glutamate, the native iGluR agonist in animals. A genetic screen was devised to isolate *Arabidopsis* mutants with a BMAA-insensitive morphology (*bim*). When grown in the light on BMAA, *bim* mutants have shorter hypocotyls than the wildtype. Analysis of the *bim* mutants has uncovered genes downstream of a putative glutamate receptor signaling pathway.

**T19. SEED GERMINATION OF *CERATUZAMIA MEXICANA* X *MICROSTROBILA* /
[GERMINACIÓN DE LA SEMILLA DE *CERATUZAMIA MEXICANA* X
MICROSTROBILA]**

Miguel Angel Domínguez-López, Griselda Sánchez Rotonda and Mario Vázquez Torres

Experimental nurseries in Mexico propagate native cycads from seeds. Proper schemes of seed management are of utmost importance in propagation and preserving these plants. Some species' seeds take up to nine months to germinate and become an established seedling. We are reporting the shortening of the germination period down to two months. The procedures are practical and easy to apply because most of the Mexican cycad nurseries are rural. Physical (hot water and stratification), chemical (GA_3 , NaCl, H_2O and H_2SO_4) and mechanical (intemperization and scarification) stimuli were applied to 120 seeds of an artificial hybrid of *C. mexicana* X *microstrobila*. These treatments applied to other species' seeds (*C. mexicana* and *Zamia furfuracea*) showed significant differences on germination, growth and seedling establishment in comparison with standard methods.

T20. MÉTODOS MULTIVARIADOS APLICADOS AL ESTUDIO DE VARIACIÓN MORFOLÓGICA DE *DIOON* EN LA VERTIENTE DEL PACÍFICO / [MULTIVARIATE ANALYSIS APPLIED TO THE STUDY OF MORPHOLOGICAL VARIATION IN *DIOON* ON THE PACIFIC SLOPE]

Georgina Vargas Amado, Jorge Alberto Pérez de la Rosa, José Pablo Torres Morán y Waldina Patricia Reyes Velásquez

La mayor diversidad de taxa del género *Dioon* en México se encuentra en la vertiente del Golfo, sin embargo, es en la del Pacífico donde hay más conflicto en la taxonomía de sus representantes. La falta de claridad del concepto de especie en las poblaciones del área y la carencia de un suficiente número de ejemplares para encontrar y comprender la variación morfológica, fueron el motivo para la realización del presente estudio, con el objeto principal de encontrar un enfoque original acerca de la clasificación del grupo. Se visitaron 13 localidades en las que se colectaron 25 muestras en cada una y se evaluaron 34 variables vegetativas por muestra, mismas que han sido concentradas en una matriz de datos. Con el auxilio de diversas técnicas de análisis multivariados se generaron resultados que contribuyeron a la determinación del complejo, los cuales fueron interpretados y comparados como parte del procedimiento de clasificación.

T21. MORPHOLOGICAL AND GENETIC VARIATION IN THE *CERATZAMIA MIQUELIANA* COMPLEX / [VARIACIÓN MORFOLÓGICA Y GENÉTICA DEL COMPLEJO *CERATZAMIA MIQUELIANA*]

Miquel Pérez-Farrera, Andrew Vovides, Dolores González, Luis Hernández and Mahinda Martínez

Material from the species of the *Ceratozamia miqueliana* complex (*C. becerrae*, *C. miqueliana*, *C. zoquorum* and *C. euryphyllidia*), all located in southern Mexico, was analyzed and evaluated with morphometric and genetic analyses. Seventeen vegetative and six reproductive parameters of 48 individuals from four populations were analyzed by discriminant analysis. A total of 58 leaflets was collected from four species out of five populations and analyzed using a dominant marker (RAPD'S). The morphometric results show clear differences between the four species (Wilks $\lambda^2 = 373$, $P < 0.001$). However the Nei genetic distance shows that the *Ceratozamia miqueliana* species complex is clustered into three groups. Low level genetic diversity within and among populations ($H_s = 0.19$; $G_{st} = 0.12$) is found in this complex. The genetic high value identity (0.95-0.97) and a correlation between genetic distance and altitude (Mantel test $r = 0.67$, $P < 0.05$) appear to show a recent divergence, probably late Miocene to Pleistocene, and a possible ecological speciation or allele differences not yet fixed between species.

T22. VESSELS IN *STANGERIA* LEAVES / [VASOS CONDUCTORES EN LAS HOJAS DE *STANGERIA*]

Yu-yuan Huang and Li-jun Wei

Leaf material of *Stangeria eriopus* was dissociated by nitric acid-chromium acid solution and examined by optical microscopy and electron microscopy. Vessels were found in the leaf vascular tissue. The types of vessel are annular vessels, spiral vessels, scalariform vessels, reticulated vessels

and pitted vessels. This discovery is of important significance to understanding the evolutionary relationship in the three families of Cycadopsida, and the adaptive mechanism to harsh environmental conditions. These facts are also of relevance to conservation, population dynamics, cycads systematics, anatomy and ecology.

**T23. VASCULARIZATION OF *CERATUZAMIA MEXICANA* SEED /
[VASCULARIZACIÓN DE LA SEMILLA DE *CERATUZAMIA MEXICANA*]
*M. Ydelia Sánchez-Tinoco, Mark Engleman and Andrew Vovides***

The vascular supply of the seed of *Ceratozamia mexicana* consists of internal and external vascular systems. Four to six vascular bundles from the megasporophyll enter the seed through the hilum and form a plexus. Within the plexus the bundles divide, anastomose and are organized in a coroniform arrangement. This corona is observable prior to lignification of the sclerotesta. Vascular bundles emerge from the plexus and pass through the sclerotesta to form the internal and external vascular systems. The external system consists of ten bundles, and the inner system of up to forty at the level where the nucellus becomes free from the integument. The term 'pachychalaza' is introduced for the description of gymnosperm seeds. These vascular systems are illustrated in detail. The implications of this vascular structure are discussed with respect to the synangial and neosynangial hypotheses of the origin of the integument.

**T24. SEX CHANGE IN CYCADS: CASES, CAUSES AND CHEMISTRY / [CAMBIO DE SEXO EN CÍCADAS: CASOS, CAUSAS Y QUÍMICA]
*Roy Osborne and Root Gorelick***

Thirty-two cases of sex reversals in six cycad genera and sixteen species are summarised. Unidirectional male-to-female and female-to-male changes have been observed and are typically associated with gross physical damage or severe environmental changes. We propose that sex expression in dioecious plants is governed by the presence or absence of methylation of DNA cytosine residues on genes that regulate production of gametes and/or sex hormones.

**T25. EVOLUTION OF DIOECY AND SEX CHROMOSOMES IN CYCADS / [EVOLUCIÓN DE LA DIOECIA Y CROMOSOMAS SEXUALES EN CÍCADAS]
*Root Gorelick and Roy Osborne***

Sex determination in cycads—and most other plants and animals—is a function of cytosine methylation and/or chromatin formation down-regulating genes that control female or male function. Sex change probably occasionally occurs in cycads because there was no genetic assimilation of these epigenetic signals. In plants, allopolyploidy is the only escape from such canalised dioecy, but allopolyploidy never occurs in cycads. Cycads never developed a pair of unequal length sex chromosomes because their haploid stages are large, complex and long-lived.

T26. THE EFFECTS OF HABITAT DISTURBANCE BY HUMANS ON THE EVOLUTIONARY DYNAMICS OF POPULATIONS OF *ZAMIA FAIRCHILDIANA* IN COSTA RICA

Cristina López-Gallego

The objective of this project was to determine if populations of *Zamia fairchildiana*, in habitats affected by selective logging, are diverging adaptively from those in undisturbed habitats. During the seed dispersal season of 2004, four populations in mature and disturbed forest habitats were sampled in southwestern Costa Rica and life-history traits and patterns of natural selection among habitats were compared. Plants in disturbed habitat produce more cones and cone size is similar among habitats, resulting in some trade-offs. Here, the plants have lower growth rates, produce smaller seeds and seedlings, and leaves with fewer prickles—important for mechanical defense. These differences among habitats may affect the ecological and evolutionary dynamics of populations. A preliminary analysis of phenotypic selection showed that in the mature habitat, only stem length is under directional selection, whilst in the disturbed habitat, the number of new leaves is under strong selection. This trend may be explained if accumulated resources in reproduction are more important in the undisturbed habitat where light is limited. Understanding how populations respond to environmental changes is relevant for conservation, as provides information about the long-term viability of populations in a changing environment in human-dominated landscapes.

T27. VARIABILITY AND STRUCTURE OF NATURAL POPULATIONS AND IMPLICATIONS FOR *ZAMIA* SPECIES IN WESTERN PANAMA / [VARIABILIDAD Y ESTRUCTURA DE LAS POBLACIONES NATURALES PARA LAS ESPECIES DE *ZAMIA* EN EL OESTE DE PANAMA]

Alberto Taylor, Jody Haynes, Greg Holzman and Jorge Mendieta

The Isthmus of Panama is host to at least 12 described *Zamia* taxa, some of which occupy a very wide swath of western Panama. Many natural populations have been extensively and intensively studied for both vegetative and reproductive variability, taking into account such parameters as position, size and relationship of stem, leaves, and cones; coning period; and reproductive mechanism. Data for seven more-or-less separate population groups have been obtained and analyzed and the results are given herein, with the aim of clarifying population dynamics, species plasticity, and the development of a coherent postulate of population structure of the species implied.

T28. DEMOGRAPHIC ISSUES OF *ZAMIA FURFURACEA* / [ASPECTOS DEMOGRÁFICOS DE *ZAMIA FURFURACEA*]

Hermann Bojórquez Galván, Leonel Torres Hernández and Mario Vázquez Torres

Zamia furfuracea is a popular horticultural cycad known as 'cardboard palm' or 'palma bola'. It is also named 'la zamia' in its native habitat, the south-central coast of Veracruz, Mexico, where it is endemic. Some of the demographic and distributional aspects of this threatened and legally protected plant were studied under a wide scale scheme throughout its entire natural distribution area during a two-year period. We distinguished two distinct populations, one extending along the sand (beach) or rock (cliff) littoral and the other inhabiting the inland sand dunes. The former inhabits 4.2 km², with

a mean density of $6,093 \pm 4,189$ plants/km² and $25,593 \pm 17,596$ individuals. The latter extends through 59 km², with a mean density of $2,042 \pm 1,449$ plants/km² and $120,502 \pm 85,541$ individuals. The entire *Z. furfuracea* population in the wild is estimated at 43,000 to 250,000 individuals. 84 male plants and 83 female were found in the plots, practically a 1:1 ratio, but 78% of the plants showed no sexual structures during the research. Such a large fraction of undetermined plants raises questions other than certainties on the sex ratio of the population. Age structure was based on the number of leaf crowns per plant. Young adults (one crown, 4-10 years old) were the most frequent in the plots: 35%, followed by the oldest adults (>1 crown, >10 years): 38%. Immature plants (seedlings and juveniles) were the least: 18.5%, and 8.5% of the plants were inaccessible for crown counting.

T29. LAS POBLACIONES DE *DIOON CAPUTOI* EN LA RESERVA DE LA BIOSFERA DE TEHUACÁN-CUICATLÁN/ [POPULATIONS OF *DIOON CAPUTOI* IN THE TEHUACÁN-CUICATLÁNBIOSPHERE RESERVE]

Juan Carlos Flores Vázquez, Silvia Salas Morales y Alfredo Saynes Vázquez

Dioon caputoi es una especie endémica de México que se distribuye en un área muy reducida dentro de la Reserva de la Biosfera Tehuacán-Cuicatlán. Nuestro objetivo fue registrar las características demográficas básicas en dos poblaciones y verificar la presencia de otras poblaciones en la región. Ambas poblaciones presentan una estructura tipo j-invertida, el porcentaje de individuos en estado reproductivo es mayor al 50% en ambos casos y la proporción sexual es casi 1:1 siendo ligeramente mayor el número de individuos masculinos. Además, realizamos recorridos de campo en la región encontrando tres nuevas localidades, las cuales tienen un mayor tamaño poblacional que las poblaciones anteriormente mencionadas. De cinco localidades en total, tres presentan un deterioro muy avanzado de la vegetación.

T30. A SUMMARY OF THE RESULTS OF THE MONTGOMERY BOTANICAL CENTER / INSTITUTO DE ECOLOGIA / SERBO 2004 *DIOON* EXPEDITION TO WESTERN MEXICO / [UN RESUMEN SOBRE DE LA EXPEDICIÓN *DIOON* 2004 DEL MONTGOMERY BOTANICAL CENTER / INSTITUTO DE ECOLOGIA / SERBO AL OESTE DE MÉXICO]

Tim Gregory, Jeff Chemnick, Silvia Salas Morales and Terrence Walters

This expedition was undertaken to assess the status of populations of *Dioon* in western and southern Mexico, and to collect seed for the MBC and Jardín Botánico Clavijero. During the one month duration of the expedition, 33 populations of 6 species of *Dioon* were recorded and 19 were visited. Herbarium vouchers were collected from 18 populations and seed were collected from 11. A total of five populations, all of *D. sonorensis*, were found to have been exterminated years ago for the production of alcohol. All of the remaining populations were in good condition based on the numbers of adult individuals, the presence of seedling and juvenile plants, and the fertility of cones. No evidence of illegal collection for the nursery trade was found in any of the surveyed populations. The primary threats to the populations at this time are habitat destruction for agriculture, timber cutting and road building. Leaf and megastrobilus morphology across the ranges of *D. sonorensis*

and *D. tomasellii* was found to be consistent for each species, and no evidence of an intermediate form between the two species was found. Two populations in the lower valley of the Rio Balsas were found to have several leaf, cone and trunk characters that are divergent from those of *D. tomasellii*. The expedition had hoped to confirm the identity of a suspected third population of *D. holmgrenii* west of the type locality but failed to actually locate it. Overall the expedition was extremely successful in achieving its objectives.

T31. HOT AND SMELLY SEX! THE ADAPTIVE SIGNIFICANCE OF CONE THERMOGENESIS AND VOLATILES IN CYCAD REPRODUCTION / [SEXO CALIENTE Y OLOSOSO! LA IMPORTANCIA ADAPTATIVA DE LA THERMOGÉNESIS DEL CONO Y COMPUESTOS VOLÁTILES EN LA REPRODUCCIÓN DE CÍCADAS]

John Donaldson

Cone thermogenesis and/or the production of volatile odours during the pollination period appears to be widespread in cycads. The incidence of both events at a time when insect pollinators are most active has led to speculation about their functional role in cycad pollination. Most often, heating and odours are assumed to attract pollinators and/or maintain pollinator fidelity in the same way that occurs in flowering plants. However, all the insects that are currently known to pollinate cycads are phytophagous with varying levels of host specificity within cycad genera. This raises the possibility that cycad pollination has evolved within the context of existing specialised interactions and that cone thermogenesis and volatile odours have an alternative function. In this paper, I examine several alternative hypotheses for cone thermogenesis and volatile odours, particularly the 'the reluctant pollinator hypothesis'.

T32. DETECTION OF *MACROZAMIA COMMUNIS* CONE ODOURS BY TRANES WEEVILS / [DETECCIÓN DE LOS OLORES DEL CONO DE *MACROZAMIA COMMUNIS* POR EL CURCULIÓNIDO *TRANES*]

Rolf Oberprieler and Florian Schiestl

The south-eastern Australian cycad *Macrozamia communis* is pollinated by a host-specific weevil, *Tranes lyterioides*, but the underlying host recognition system has remained unknown. We sampled male and female cone odours of *M. communis* using dynamic head-space techniques and analysed the volatile compounds and the reactivity of the weevil antenna to them by means of gas chromatography with electroantennographic detection (GC-EAD). Both male and female cones emitted three major compounds, 3-octanol, 1-octen-3-ol and linalool, the former two in similar concentrations throughout the afternoon but the last at much higher concentration after 19h00 and coinciding with cone thermogenesis. Both sexes of weevils responded equally to all three compounds, with 1-octen-3-ol (mushroom alcohol) eliciting the strongest and most consistent responses. We also tested the antennal response of two Western Australian *Tranes* species, *T. vigorsii* and *Tranes* sp., which are involved in the pollination of *Macrozamia riedlei* and *M. fraseri* to the volatile compounds of *M. communis*. Both these species responded similarly to 3-octanol and 1-octen-3-ol but not to linalool, instead detecting a different compound present in too low a concentration in *M. communis* to permit identification. We discuss the evolutionary implications of these findings.

T33. HERBIVORES AND CHEMICAL DEFENSES IN CYCADS—AN ECOLOGICAL AND EVOLUTIONARY APPROACH / [HERVÍBOROS Y DEFENSAS QUÍMICAS EN CÍCADAS-UNA PERSPECTIVA ECOLÓGICA Y EVOLUTIVA]

Citlalli Castillo-Guevara

This research includes an ecological and evolutionary view about cycad herbivores. First, I show an ecological study of the interactions between the licenid caterpillars *Eumaeus minyas* and *E. debora* and their host cycads *Zamia loddigesii* and *Dioon edule* in an oak forest near Chavarrillo, central Veracruz, México. Here, I describe herbivory levels recorded during two years. Second, I explore the association between herbivory (by caterpillars, weevils, and others) and the amount of azoxyglycosides in the Cycadales using phylogenetic independent contrasts. These azoxyglycosides (macrozamin and cycasin) may have played an important ecological role as antiherbivore defenses.

T34. RESPONSE OF POLLINATING THRIPS AND WEEVILS TO THEIR *MACROZAMIA* CYCAD HOST VOLATILES / [RESPUESTA DE LOS POLINIZADORES THESANÓPTEROS Y CURCULIÓNIDOS A LOS COMPUESTOS VOLÁTILES DE SU CÍCADA HOSPEDERA *MACROZAMIA*]

Craig Hull, Chris Moore, Irene Terry and Gimme Walter

Macrozamia species pollinated only by *Tranes* sp. weevils have cones that heat and release volatiles during the early evening, whereas those pollinated only by *Cycadothrips* have cones that heat and release volatiles during the day. Cones of *Tranes*-pollinated species release volatiles comprising a few monoterpenes, primarily linalool and much lower levels of beta-myrcene, whereas 'thrips-only' cycads lack linalool and release numerous monoterpenes, dominated by B-myrcene emitted at very high rates. Insect movement between male and female cones occurs during the cone heating and volatile emission phase of their specific host. Preliminary evidence from both olfactometer and field volatile studies suggest that insects are attracted to their host's cone volatiles. Preliminary electroantennograms (EAGs) suggest that each insect responds neurologically to specific components within their host cone's volatile mix. Both field and laboratory studies are being used to determine which volatile components mediate specific behaviors in these two pollinator types.

T35. MOLECULAR SYSTEMATICS IN AMORPHOCERINE WEEVILS ON *ENCEPHALARTOS* / [SISTEMÁTICA MOLECULAR DE LOS CURCULIÓNIDOS AMORFOCERINOS EN *ENCEPHALARTOS*]

Douglas Downie and John Donaldson

Weevils in the tribe Amorphocerini have been implicated in pollination of *Encephalartos* species in southern Africa. The services they render these plants and the unique attributes of the cycad-weevil interaction make them important from both conservation and evolutionary standpoints. Oberprieler, using morphological characters, proposed a tentative hypothesis of relationships among the Amorphocerini but it is useful to estimate their phylogeny from molecular markers as well. Preliminary results are presented of DNA sequence data from one mitochondrial and one nuclear gene. This represents the initial step of a more comprehensive study to: (1) estimate relationships and the direction of evolution among species of *Amorphocerus* and *Porthetes*, (2) test the hypotheses

that *Porthetes* species are host restricted and that speciation has been host plant mediated, and (3) estimate levels and patterns of genetic variation within species of Amorphocerini.

T36. SEED DISPERSAL AGENTS FOR SELECTED MEXICAN CYCADS—AN ANALYSIS OF ANECDOTAL, REPORTS AND THEORETICAL CANDIDATES / [AGENTES DISPERSORES DE SEMILLAS PARA ALGUNAS CÍCLDAS MÉXICANOS-UN ANÁLISIS DE REPORTE ANECDÓTICOS Y CANDIDATOS TEÓRICOS]

Jeff Chemnick

Seed dispersal agents of the world's cycads are poorly known. Animal interactions with cycad seeds are likely responsible at least in part for the current distribution of cycad populations. Long distance seed dispersal and subsequent speciation of closely related forms among recent cycads is probably the result of avian interactions. A theoretical analysis is discussed and anecdotal observations are presented as evidence to establish a profile for dispersal agents among Mexican cycads.

T37. A GLOBAL ASSESSMENT OF CYCAD CONSERVATION-SUCCESSSES, FAILURES AND UNCERTAINTIES [EVALUACIÓN GLOBAL DE LA CONSERVACIÓN DE CÍCADAS-EXISTOS, FRACASOS Y INCERTIDUMBRES]

John Donaldson

The IUCN Red List for cycads provides a baseline for assessing the conservation status of the world's cycads. Despite differences in criteria, it is possible to detect trends in populations and to determine whether cycads are better or worse off now than they were 20 years ago or, more realistically, to determine trends related to specific taxa and regions. In this paper, I examine the status of the world's cycads and examine trends in relation to trade, habitat destruction, and conservation actions.

T38. PROPAGATION OF *CERATZAMIA MEXICANA* AND *ZAMIA FURFURACEA* IN RURAL NURSERIES IN VERACRUZ, MEXICO / [PROPAGACIÓN DE *CERATZAMIA MEXICANA* Y *ZAMIA FURFURACEA* EN VIVEROS RURALES EN VERACRUZ, MÉXICO]

Mario Vázquez Torres, Adela Smith Portilla and José Martínez Gandara

Ceratozamia mexicana and *Zamia furfuracea* are cycads endemic to Veracruz, Mexico. They are both threatened by the severe transformation of their natural habitat as well as by the smuggling of plants and seeds. In order to prevent these threats and to propose a legal management scheme, we established two rural nurseries in association with inhabitants of these plants' localities. A *C. mexicana* nursery was established in Tlachinola, in the central highlands of Veracruz, where a particularly dense population of this species occurs. There are currently 4,000 young plants available for sale and for reintroduction. A similar nursery was established at Ciénega del Sur, in the coastal dunes of Alvarado, Veracruz, for the propagation of *Z. furfuracea*. It helped establish nine other nurseries along the Los Tuxtlas coast. Altogether, more than 300,000 plants are available. Three to four year-old *Z. furfuracea* plants at the nurseries are sexually mature. Nowadays each nursery

produces its own seeds so that the local seed demand is not focused on the wild populations. However, persistent illegal extraction has prevented the rural nurseries from becoming prosperous or even functional. In Mexico the wildlife black market is still more profitable than the legal efforts of management and conservation, as our experience with native cycads supports.

T39. PHYLOGENETIC RECONSTRUCTION AND CONSERVATION GENETICS OF SOUTH AFRICAN *ENCEPHALARTOS* / [RECONSTRUCCIÓNFILOGÉNICA Y GENÉTICA DE LA CONSERVACIÓNDE *ENCEPHALARTOS* SUR AFRICANOS]

Gail Reeves, Amelia Mabunda, John Donaldson, Michele Pfab, Jacqui Bishop and Terry Hedderson

Although CITES regulations are theoretically considered a significant deterrent to international trade in wild-collected cycads, the implementation of this legislation is fraught with difficulties. A problem expressed by law enforcement agencies in South Africa is that prosecution of suspected illegal traders is difficult because the wild origin of the plants cannot be proved. DNA based forensic methods have great potential to address these shortcomings and we have piloted the use of amplified fragment length polymorphism markers (AFLP) for the purposes of producing genetic profiles for individual plants. These markers can be used for parentage and population assignment. The AFLP technique is particularly amenable to the study of rare or endangered species because it only requires small amounts of tissue from each individual. However, correct species identification is a prerequisite for such conservation genetic efforts and, particularly at the seedling stage, this can be problematic. Therefore, in parallel to the conservation genetic efforts we are reconstructing a phylogenetic framework for the genus *Encephalartos*—both to understand species relationships and to assist in the identification of cryptic taxa. Variation in DNA sequence regions commonly exploited as a source of phylogenetic information is low at the species level, and thus we have also explored the use of AFLP markers for reconstruction of species relationships in this group.

T40.A RECOVERY PLAN FOR *CYCAS MEGACARPA* / [UN PLAN DE RECUPERACIÓN PARA *CYCAS MEGACARPA*]

Paul Forster

Cycas megacarpa is currently listed as Endangered. A population survey for the species found that there was a minimum area of occupancy of >25 km² with at least 46 populations and a projected number of 372,962 plants. A minimum viable population size for *C. megacarpa* is in the range of 3,500 – 4,500 plants. Only 7 populations of *C. megacarpa* are considered viable in the long-term. *C. megacarpa* is present in three National Parks, seven State Forests and five Forest Reserves, although the populations are often small and fragmented. Analysis of the population survey data indicates that a more appropriate conservation coding listing is Vulnerable. A translocation protocol for this species is outlined.

T41. MANAGING CYCAD AULACASPIS SCALE, *AULACASPIS YASUMATUSI*, AT MONTGOMERY BOTANICAL CENTER, FLORIDA, U S A / [MANEJANDO EL INSECTO ESCAMA *AULACASPIS YASUMATUSI* EN EL CENTRO BOTANICO MONTGOMERY DE FLORIDA, USA]

Christine Weise

Since it was first introduced into South Florida in 1995, *Aulacaspis yasumatsui* (cycad aulacaspis scale, CAS) has been attacking popular landscape cycads and spreading rapidly. This pest is now found in Florida, Texas, Puerto Rico, U.S. Virgin Islands and Hawaii. Plant death and damage caused by CAS is having a marked effect on the ornamental cycad industry and has become a major concern for nursery professionals. The spread of CAS to other countries through plant sale and trade is also a serious concern as it could threaten native cycad populations. Previous research indicates that maintaining CAS populations at a rate that will not threaten the health of plants requires multiple control measures. This paper discusses a series of control measures (monitoring, mechanical control, biological control and chemical control) that were implemented at Montgomery Botanical Center from autumn 2003 to autumn 2004 in an effort to develop a system of managing CAS as part of a broader integrated pest management program.

T42. USES OF THE CYCAD COLLECTION AT GANNA WALSKA LOTUSLAND / [LOS USOS DE LA COLECCIÓN DE CICADAS EN GANNA WALSKA LOTUSLAND]

Virginia Haves

Ganna Walska Lotusland is a 37 acre (15 hectare) botanical garden in Santa Barbara, California. Of its many garden areas, which include succulents such as cacti, euphorbias and aloes, as well as subtropical collections of ferns, bromeliads, aquatic plants and more, the cycad collection is recognized as one of the foremost in public gardens worldwide. In addition to the public's enjoyment of its beauty, visitors to Lotusland are exposed to information about the need for conservation of these and other endangered plants while on their docent-led tours. The cycad collection also serves as a living laboratory for all levels of local educational institutions. It plays a pivotal role in the Junior Botanist curriculum that is part of Lotusland's Fourth Grade Outreach Program. High school students also participate in field trips to the garden. Classes of students from the community college and the University of California regularly visit the garden to spend time in the cycad collection learning about these primitive and unique plants. Lotusland is committed to supporting the work of all parties involved in growing and conserving cycads. Requests for plant material from researchers for morphological and taxonomic studies have been granted. Textbook illustrations have been prepared from specimen cycads at the garden. Seeds, pollen, and plants have been distributed to other institutions. Financial assistance and participation have been provided on two expeditions to study the cycads of Mexico in 2001 and 2004.

T43. PRESERVATION THROUGH PROPAGATION — THE DILEMMAS FACING A CYCAD NURSERY 1 [PRESERVACIÓN A TRAVÉS DE LA PROPAGACIÓN-LOS DILEMMAS ENFRENTADOS POR UN VIVERO DE CÍCADAS]

Maurice Levin

The author addresses the challenges facing a grower and nurseryman whose stated mission is to increase and preserve the worldwide population of cycads. What are ways in which this can be accomplished within the context of a commercial enterprise? What are some of the steps a responsible nursery owner or grower must undertake to insure that his or her actions do not result in threat to species survival? What actions must be avoided? This presentation will address the dilemmas faced, as well as several suggested steps to take. Data and analysis will be presented to describe actual and planned actions to achieve preservation through propagation.

T44. *IN VITRO* MORPHOGENESIS OF *DIOON MEROLAE* FROM MEGAGAMETOPHYTE AND ZYGOTIC EMBRYOS / [MORFOGÉNESIS *IN VITRO* DE *DIOON MEROLAE* A PARTIR DE MEGAGAMETOFITOS Y EMBRIONES]

Sandra Cabrera, Víctor Chavez, Judith Guzmán and Francisco Sosa

Organogenic cultures were induced from zygotic embryo and megagametophyte explants of the endangered cycad *Dioon merolae* of Chiapas, Mexico. Plant growth medium consisted of B5 major salts, Murashige and Skoog minor salts and organics, 400 mg/l glutamine, 100 mg/l arginine, 100 mg/l asparagine, 60 g/l sucrose, 4 g/l gellan gum, supplement with kinetin (0-13.94 μ M) and 2,4-dichlorophenoxyacetic acid (2,4-D) (0-9.05 μ M) arranged as a 5 x 4 factorial in a randomized block design. Cultures were maintained in darkness at 25°C and callus was subcultured onto fresh medium at 4 week intervals. Callus became friable and yellow after 2-4 weeks; initiation occurred on a wide range of medium formulations from megagametophyte explants. In comparison, callus initiation from explanted zygotic embryos occurred on fewer medium formulations, and adventitious shoot induction occurred from callus on formulations with 9.3-13.9 μ M K and 2.3-9.05 μ M 2,4-D. Proembryos developed on induction medium, but were more numerous after being subcultured in phytohormone-free medium, which also enabled suspensors to elongate. This technique has great potential for preservation of highly endangered cycads.

T45. CONSERVACIÓN *EX SITU* DE GERMOPLASMA DE *MICROCYCAS CALOCOMA*, *ZAMIA AMBLYPHYLLIDIA*, *Z. INTEGRIFOLIA*, *Z. OTTONIS* Y *Z. PYGMAEA* EN EL JARDÍN BOTÁNICO NACIONAL DE CUBA / [EX SITU CONSERVATION OF GERMOPLASM FROM *MICROCYCAS CALOCOMA*, *ZAMIA AMBLYPHYLLIDIA*, *Z. INTEGRIFOLIA*, *Z. OTTONIS* AND *Z. PYGMAEA* IN THE NATIONAL BOTANICAL GARDEN OF CUBA]

Julio C. Lazcano Lara

La efectividad de la conservación *ex situ* de especies silvestres es muy discutida, especialmente por las limitaciones que imponen el espacio y los costos de mantenimiento de colecciones, lo suficientemente grandes, como para preservar la integridad genética de las mismas. Sin embargo, la

conservación *ex situ* ha probado su importancia a través de acciones como el rescate de germoplasma amenazado, oferta de material de propagación para reducir la presión que ejercen los coleccionistas sobre las poblaciones silvestres, la educación ambiental y la investigación entre otras. Las cícadas se encuentran amenazadas a escala mundial, por lo que muchas especies están protegidas por los Apéndices I y II de CITES. En Cuba, las cícadas están representadas por la Familia *Zamiaceae*, con dos géneros. El género endémico *Microcycas* representado solamente por *M. calocoma* y el género *Zamia* con siete especies: *Z. amblyphyllidia*, *Z. angustifolia*, *Z. integrifolia*, *Z. pumila*, *Z. ottonis*, *Z. pygmaea* y *Z. stricta*, las tres últimas, endémicas. En el presente trabajo se muestra el desarrollo de una colección científicamente documentada, en la que se conserva, en condiciones *ex situ*, germoplasma amenazado de las siguientes especies: *Microcycas calocoma*, *Zamia amblyphyllidia*, *Z. integrifolia*, *Z. ottonis* y *Z. pygmaea*. Además, se muestra la creación de bancos genéticos de campo de *Z. amblyphyllidia*, *Z. integrifolia* y *Z. ottonis* en zonas del Jardín Botánico Nacional. Se realiza una caracterización de la colección y se discute la importancia y eficacia de la misma para la conservación de las especies consideradas.

T46. THREATS TO *ENCEPHALARTOS* AND *STANGERIA* IN SOUTH AFRICA FROM OVER-COLLECTION FOR MEDICINAL USEAGE / [*ENCEPHALARTOS* Y *STANGERIA* EN PELIGRO POR UNA COLECTA EXCESIVA CON PROPÓSITOS MEDICINALES]

Chris Dalzell

Populations of *Encephalartos* and *Stangeria* are under severe threat through over-collecting by traditional healers in South Africa. An early example relates to the reasons for the transfer of the last wild specimen of *Encephalartos woodii* from the Ngoye Forest to the Durban Botanic Gardens in 1903 and 1907, not only for the preservation of the species but also because of the destruction of the remaining stems by traditional healers. There are many subsequent examples of the medicinal uses of *Encephalartos* bark by traditional healers in South Africa and in particular in kwaZulu-Natal and we are now at a critical stage of losing many species as a result. A prime example is the destruction of one of the largest colonies of *E. natalensis* just outside Durban. This talk will describe this large population that we are trying to save through the help of the local CITES authorities in kwaZulu-Natal and whether the planned programme is feasible. A second project carried out over the past four years is the collection of *Stangeria* material from populations in kwaZulu-Natal. The latter project has been very successful and to date we have collected from 28 populations and captured all the details on a specific database. This talk highlights the threats to these two genera in South Africa and what the Durban Botanic Gardens has tried to do to save the populations. It will also look at the development and the successes of the database.

ABSTRACTS – POSTER PRESENTATIONS/RESÚMENES DE CARTELES

*The name of the person delivering the presentation is underlined
Presentations are listed alphabetically by the first author surnames*

PO1. VARIABILITY IN *ENCEPHALARTOS NUBIMONTANUS*/ [VARIABILIDAD DE *ENCEPHALARTOS NUBIMONTANUS*]

Diekie de Klerk, Phil Grobler and Ben Jordaan

Encephalartos nubimontanus is indigenous to the Wolkberg mountains in South Africa's Limpopo Province. Its name is derived from the Latin *nubilus* ('grey blue') and *montanus* ('on a mountain'). The species was first described by Hurter in 1995, predating a description by Vorster in 1996 under the name *E. venetus*. Generally, male and female cones and seeds vary with different leaf forms. Data for eleven variants have been obtained and are presented. The differences in leaf, pinna and cone morphology are especially relevant in differentiating between variants.

PO2. A COMPARISON OF THE RECOVERY PLAN PROCESS FOR SIX ENDANGERED SPECIES OF CYCADS FROM SOUTHERN QUEENSLAND, AUSTRALIA / [UNA COMPARACIÓN EN EL PLAN DE RECUPERACIÓN DE SEIS ESPECIES AMENAZADAS DE CÍCADAS DEL SUR DE QUEENSLAND, AUSTRALIA]

Paul Forster

All cycads can be considered as 'flagship' species for conservation biology as they have unusual life histories, are in general restricted in distribution with over 50% of species threatened globally, and are of much commercial interest to horticulture or agriculture. Recovery plans have been prepared for six species of cycad from southern Queensland that are currently listed as Endangered, namely *Cycas megacarpa*, *C. ophiolitica*, *Macrozamia cranei*, *M. lomandroides*, *M. pauli-guilielmi* and *M. platyrhachis*. Populations have been impacted upon, or are decreasing due to poor long-distance dispersal, land-clearing, and selective eradication or harvesting. Individual numbers of plants have been reduced or are still decreasing due to land-clearing, selective eradication and harvesting, natural attrition, pollination failure and recruitment failure. Critical life history requirements are the pollination mutualisms with insects (beetles or thrips), dispersal by vertebrates and the establishment of new individuals. Environmental variables that affect the life history requirements are minimum thresholds of pollination function and efficiency, fire history, dispersal efficiency, and drought. A comparison is presented for recovery objectives, required actions, costs and biodiversity benefits for the six species.

PO3. LOS JARDINES DIDÁCTICOS DE CÍCADAS: UNA HERRAMIENTA PARA LA DIFUSIÓN Y LA CONSERVACIÓN [THE CYCAD GARDENS: AN OUTREACH AND CONSERVATION TOOL]

Yaqueline Antonia Gheno-Heredia, Ramón Farías Feliza, Julieta Hernández Reyes y Héctor Oliva Rivera

A partir de reconocer que la falta de conciencia sobre la situación ambiental hace que la tarea educativa sea cada vez más relevante para lograr nuevas actitudes y nuevas formas de comportamiento. La Facultad de Ciencias Biológicas y Agropecuarias de la Universidad Veracruzana en Córdoba, Veracruz, México, promovió la creación de 'Los Jardines de Cícadras', para contribuir a generar espacios, materiales y actividades didácticas que apoyen el proceso de enseñanza aprendizaje en la sensibilización sobre el uso y aprovechamiento de las cícadras. Se establecieron el Jardín de Cícadras 'Biol. Antonio Bustos Melgarejo' en los terrenos de la FCBA y en el Parque Ecológico Paso CoyolA.C. del mismo municipio. Se diseñaron y elaboraron materiales didácticos, gráficos e interactivos sobre la importancia ecológica, económica, problemática y alternativas de conservación de las cícadras así como conferencias de apoyo y se establecieron los jardines. Se considera que los 'Jardines de Cícadras' están cumpliendo con el objetivo de contribuir al conocimiento y conservación de las Cícadras a través del desarrollo de habilidades, destrezas y aptitudes tanto de los estudiantes como del público en general.

PO4. RELACIONES FILOGENÉTICAS DEL GÉNERO *DIOON* BASADAS EN SECUENCIAS GENICAS / [PHYLOGENETIC RELATIONSHIPS OF THE GENUS *DIOON* BASED ON DNA SEQUENCE DATA]

Dolores González, Andrew Vovides y Cristina Bárcenas

El género *Dioon* comprende aproximadamente 11 especies distribuidas en México y una en Honduras. Las hipótesis de relaciones con caracteres morfológicos y con RFLPs del ADN de cloroplasto que existen, indican la presencia de dos grandes clados dentro del género: *D. spinulosum* y *D. edule*. Sin embargo, las relaciones entre las especies aún permanecen sin resolver. En este trabajo se secuenció la región del ITS del ADN ribosomal nuclear en todas las especies del género con por lo menos un duplicado. Se encontró que a pesar de que la tasa de mutación en esta región intergénica se considera apropiada para resolver las relaciones a nivel de género, en *Dioon* es limitada. No obstante las pocas substituciones encontradas en las secuencias, se detectaron dos indels de 8 y 4 pares de bases en varias especies del género, las cuales se incluyeron en los análisis como presencia-ausencia. Los resultados indican que el género a nivel molecular es poco divergente en contraste con la gran variación morfológica que presenta que puede ser indicador de especiación reciente. La exploración de nuevos marcadores moleculares con una tasa de substitución más alta puede dar luz a esta hipótesis.

PO5. KEY TO THE SPECIES OF *DIOON* / [UNA CLAVE PARA LAS ESPECIES DE *DIOON*]

Tim Gregory, Jody Haynes and Jeff Chemnick

A dichotomous key is presented that allows the taxa in *Dioon* to be distinguished. The key includes the currently recognized species and three potential new taxa. It is based on morphological characters of both vegetative and reproductive structures.

PO6. THE TREE DIOONS 1 [LOS ÁRBOLES DE *DIOON*]

Jody Haynes

Dioon spinulosum, *D. rzedowskii* and *D. mejiae* comprise a morphologically unique and evolutionarily distinct group of Neotropical cycads referred to as the 'tree Dioons' due to their impressive stature and palm tree-like appearance. Various authors have published accounts of the three species and have offered comparative morphological traits to distinguish them, but a comprehensive review of the group has never been attempted. This presentation reviews the taxonomy, biogeography and evolution, conservation status, ethnobotany and comparative morphology of the tree Dioons and presents basic life history information and a comprehensive suite of diagnostic morphological traits.

PO7. MAPPING 5S RIBOSOMAL DNA ON SOMATIC CHROMOSOMES OF FOUR SPECIES OF *CERATZAMIA* AND *STANGERIA ERIOPUS* / [MAPEO DEL DNA RIBOSOMAL 5 SEN CROMOSOMAS SOMÁTICOS DE CUATRO ESPECIES DE *CERATZAMIA* Y *STANGERIA ERIOPUS*]

Goro Kokubugata, Andrew Vovides and Katsuhiko Kondo

There are approximately 20 known species of *Ceratozamia* in Mexico, with three in Belize, Guatemala and Honduras. On the other hand, the genus *Stangeria* is a monotypic genus with the sole species, *S. eriopus*, distributed along the east coast of South Africa. In most previous references, *Ceratozamia* and *Stangeria* have had little taxonomic or cytological connection with each other within the living Cycadales. However, we and others reported that some cytological characters are shared. Molecular-cytological techniques such as fluorescent in situ hybridisation (FISH) have been recently applied to cytotaxonomic studies on some cycads and it has been shown to be a powerful method for analyzing inter- and infrageneric cytotaxonomic relationships. In the present study, somatic chromosomes of *Ceratozamia hildae*, *C. kuesteriana*, *C. mexicana*, *C. norstogii* and *Stangeria eriopus* were observed and compared by the FISH method using 5 s ribosomal (rDNA) probes. The four *Ceratozamia* species and *S. eriopus* have the same chromosome number of $2n = 16$ and a similar karyotype comprising twelve metacentric (m), two sub-metacentric (sm) chromosomes and two telocentric (t) chromosomes. The four *Ceratozamia* species exhibited a proximal 5 s rDNA site in the interstitial region of two m chromosomes and *Stangeria eriopus* exhibited a distal 5S-rDNA site in the interstitial region of two m chromosomes. We conclude that the two genera differ in chromosome structure by a probable paracentric inversion in one genus.

P08. THE ONTOGENY OF THE PINNA EPIDERMIS AND STOMATAL APPARATUS OF ENCEPHALARTOS GRATUS / [LA ONTOGENIA DE LA EPIDERMIS DE LA PINNA Y EL APARATO ESTOMATAL DE ENCEPHALARTOS GRATUS]

Jun-Xia Su, Nan Li, Yong Li and Jian-Zhao Lin

The ontogeny of the pinna epidermis and stomatal apparatus of *Encephalartos gratus* was observed by light microscopy. The results show that the stomata are haplocheilic, the subsidiary cells are perigenous and the mature stomata are monocyclic. Premature stomata occurred on the young epidermis. The lower epidermal cell morphological changes are not great; they grow mainly in length and the cell wall thickens during the development of the pinna. The epidermal cells formed over the vein are more regular than those in the stomatal area. Although they all tend to be in longitudinal rows, the former are more ordered than the latter. The stomatal density peak time in the basal, central and apical region of pinnae is, respectively, 276/mm² on day 9, 541/mm² on day 12 and 416/mm² on day 15 after the frond flush. However, the whole pinna stomatal density stabilizes at the level of about 50/mm² after pinna maturation. The epidermis matures acropetally in the studied species.

P09. CLASSIFICATION AND TYPIFICATION OF ZAMIA / [CLASIFICACIÓN Y TIPIFICACIÓN DE ZAMIA]

Anders Lindström

Classification of *Zamia*, a large and significant South and Central American genus comprising about 57 known species, is still incomplete. Although new species are still being discovered and described, taxa are almost never put into a larger classification concept neither by subgenus nor by their relationship with other species. Although much maligned, Schuster's (1932) treatment of *Zamia* is presently the only attempt to classify the genus. The author proposes a modified treatment and segregation of the genus into sections and subsections. The author has found that *Z. amplifolia*, *Z. roezlii*, *Z. wallisii*, *Z. montana* and *Z. obliqua* have been unnecessarily neotypified and that *Z. lindenii* has been unnecessarily lectotypified.

P10. THE WORLD LIST OF CYCADS / [LA LISTA MUNDIAL DE CÍCADAS]

Ken Hill, Dennis Stevenson and Rov Osborne

The authors present an update of the World List of Cycads. This is a list of the valid names of all extant cycads, together with details of their countries of occurrence, the primary publication references and information as to herbarium localities for the types. The data given for each genus is followed by a list of synonyms. The number of species on the current list is as follows: *Bowenia* (2), *Ceratozamia* (21), *Chigua* (2), *Cycas* (99), *Dioon* (13), *Encephalartos* (65), *Lepidozamia* (2), *Macrozamia* (40), *Microcycas* (1), *Stangeria* (1) and *Zamia* (59) to give a total of 305 species.

P11. CORRELATES BETWEEN MACROZAMIA CONE TRAITS AND THEIR SPECIFIC POLLINATORS BEHAVIOR / [CORRELACIONES ENTRE LAS CARACTERÍSTICAS DEL CONO DE MACROZAMIA Y EL COMPORTAMIENTO ESPECÍFICO DE SUS POLINIZADORES]

Chris Moore, Robert Roemer, Irene Terry and Gimme Walter

The cones of *Macrozamia* cycads have volatile profiles and thermogenic patterns that correlate with the behavior of their specific insect pollinators. Differences in these patterns across *Macrozamia* species apparently are related to pollinator type; the weevil, *Tranes* spp., or the thrips, *Cycadothrips* spp. Generally, pollinator movement into and out of cones coincides with periods of cone thermogenesis and increased odor emission: around sunset for *Tranes*, and mid-day for *Cycadothrips*. We have studied these relationships in more detail by measuring cone activities (temperature elevation and fragrance release) and behaviors of specific pollinators over several days during the pollination period. State and parameter modeling estimation techniques were used to predict metabolic activities that produce the empirically measured cone temperatures. Volatiles were collected over 30 min. intervals just before and during cone heating by dynamic head space techniques and were analyzed quantitatively by gas chromatography. The complementary experimental measurements and model predictions were used to: separate the effects of cone metabolism and ambient temperature on cone temperatures; examine the timing between cone traits (metabolism, volatile release, and temperature elevation) and pollinator cone - to - cone movement; and develop hypotheses regarding the evolution of thermogenic metabolic patterns in these cycads. Results indicate that insects move out of cones prior to the peak of cone temperature but after metabolic heating has started, and insects arrive at cones before cones cool to ambient temperatures. In some *Macrozamia* species fragrance emission correlates more closely with metabolic activity than with cone temperature.

P12. ZAMIA FURFURACEA AND ITS POPULATION CONSTRAINTS / [ZAMIA FURFURACEA Y SUS RESTRICCIONES POBLACIONALES]

Leonel Torres Hernández, Marisol Martínez Bello, Lorena Patricia Sánchez Morales, Eric Isai Ameza y Juárez and Hermann Bojórquez Galván

Zamia furfuracea is endemic to the coast of central and southern Veracruz. Its most favourable habitat is the coastal scrub, a strip of about 50 m wide and about 150 km long. The highest density occurs in this coastal margin, where about 50% of the population is made up of seedlings, juvenile plants and young adults while the other 50% is made up of mature and senile plants. The coast has been slightly deforested by local inhabitants. Nevertheless, there are severe erosive processes that gradually diminish the space suitable for *Z. furfuracea*. Its other habitat is the inland sand dune system, where *Z. furfuracea* density is lower but the dwelling area much larger (almost 60 km²). The natural dune vegetation has been severely transformed and fragmented by cattle raising. In a paradox effect, this disturbance has opened colonization opportunities for *Z. furfuracea*: its inland population is biased towards the youngest as 4/5 consist of seedlings, juvenile plants and young adults. The inland risk agents are deforestation, agricultural fires, cattle stamping and dehydration (young plants are vulnerable to excessive sunlight). Predation of seeds by man is a serious threat to the species survival. An estimated 30% of all female strobili are illegally harvested each year for the

international black market of cycads. Other threats to the individuals' fitness and survival in the long term is leaf damage due mainly to wind (shown by 44.5% of the population), herbivory (43.4%), competition (29.3%), as well as machete (4.2%) and animal transit (2%).

P13. ENTOMOPHILY IN A NATIVE POPULATION OF *CERATUZAMIA MEXICANA* / [ENTOMOFILIA EN UNA POBLACION NATIVA DE *CERATUZAMIA MEXICANA*]
Griselda Sánchez Rotonda and Mario Vázquez Torres

Cycads maintain ecological interactions with highly specialized insect species. Coincident geographical distribution is a clear evidence of their relationships. We report the pollination syndrome of *Ceratozamia mexicana* in its natural environment in central Veracruz, Mexico. Two coleopterans are the agents: *Pharaxonotha* sp. (Cryptophagidae) and an undetermined species of the Carabidae family. Wind and insect exclusion procedures were applied to various receptive female strobili. Those that permitted beetle access showed fertilization of up to 90% of the ovules, whereas those that avoided entomophily were almost completely sterile.

P14. EVO-DEVO IN CYCADS: ORGANISMAL PHYLOGENIES, HOMOLGY OF DEVELOPMENTAL GENES AND MORPHOLOGICAL INTERPRETATIONS IN THE CONTEXT OF EVOLUTIONARY STUDIES IN A CRITICAL GYMNASPERM GROUP / [BIOLOGÍA EVOLUTIVA DEL DESARROLLO EN CÍCADAS: FILOGENIAS ORGANISMICAS, HOMÓLOGÍA DE GENES DEL DESARROLLO E INTERPRETACIONES MORFOLÓGICAS EN EL CONTEXTO DE ESTUDIOS EVOLUTIVOS EN UN GRUPO CRUCIAL DE GIMNASPERMAS]
Francisco Vergara-Silva, Marie Englund and Peter Engström

Current work on seed plant molecular systematics suggests that gymnosperms might be monophyletic. Given that context, the position of the cycads is not necessarily consistent with the idea that this particular gymnosperm lineage represents an evolutionary link between ferns (sensu lato) and spermatophytes. In contrast, these results would indicate closer affinities between cycads and other gymnosperm taxa (e.g. *Ginkgo*, conifers). The presence of similarities between certain morphological character states in fossil and extant taxa of both ferns and cycads is unexplained, though, and the supposed relationship between the latter two groups, argued through the decades on palaeobotanical grounds, remains unclear. Also recently, a developmental-genetic perspective on homology between reproductive structures in the seed plant clade and close outgroups has become more mature. In principle, this approach could be useful not only in the elucidation of taxic relationships between cycads and their hypothetical allies, but also to establish the nature of autapomorphic features in specific cycad genera (e.g. those of the female seed-bearing structures of *Cycas*). Published work on the evolutionary developmental biology of cycads, however, has not taken into account important caveats, mainly but not exclusively related to the diverse morphological interpretations postulated through the years on the homology between gymnosperm reproductive structures and those of other plant groups. Here, we present phylogenetic and molecular evolutionary inferences based on selected cycad MADS-box gene homologues. With these, we attempt to illustrate the potential utility of information based on coding sequences that might be involved in the ontogenetic construction of strobili and other developmental events to

address evolutionary issues in the cycads. Our main purpose, though, is to underscore the importance of a proper understanding of the relationship between developmental-genetics, morphology, palaeobotany and ultimately systematics, in the construction of explanations in the evolutionary biology of gymnosperms.

**P15. ENTOMOPHILY IN A NATURAL POPULATION OF *ZAMIA FURFURACEA* /
ENTOMOFILIA EN UNA POBLACIÓN NATURAL DE *ZAMIA FURFURACEA*]**
Griselda Sánchez Rotonda and Mario Vázquez Torres

Zamia furfuracea is endemic to the coastal dunes of southern Veracruz. Its localities are few given the illegal looting of plants and seeds. The remaining wild populations have been reduced in number and are highly perturbed. Present-day detailed studies have shown that cycads are pollinated mainly by insects. This knowledge is relevant for cycad conservation and propagation. In *Z. furfuracea* the pollen carrier is *Rophalotria mollis* (Curculionidae). Several procedures were applied to test the ability and efficiency of this beetle as pollinator. This insect is responsible of 80% of the fertilized ovules and therefore of most of the seed production in the wild.

ACCOMPANYING PERSONS' ACTIVITIES/ ACTIVIDADES DE PERSONAS ACOMPAÑANTES

Accompanying persons should indicate their interest in participating in any of the activities below at the time of registration. A small fee may be required to cover costs. The coordinator for all accompanying persons' activities is Andrea Cruz

Monday 10 January (afternoon): Visit the Anthropology Museum

Tuesday 11 January (full day): Visit to El Lencero Hacienda

Wednesday 12 January (full day): Visit the coffee region of Xico or Coatepec

Thursday 12 January (full day): Visit downtown Xalapa

Friday 13 January: Accompanying persons join delegates on the cycad field trip

LIST OF PARTICIPANTS/PARTICIPANTES

Names, addresses and e-mail contact details of those giving oral or poster presentations, in surname order

Bojórquez Galván, Hermann Instituto de Investigaciones Biológicas, Universidad Veracruzana, Ave. Luis Castelazo s/n. Colonia Industrial Ánimas. A.P. 294. C.P. 91000. Xalapa, Veracruz, México. hierberito2@hotmail.com

Bonta, Mark. Division of Social Sciences, Delta State University, 203B Kethley Hall, Cleveland, Mississippi, 38733 USA. markabonta@yahoo.com

Brenner, Eric. The New York Botanical Garden, 200th St. and Kazimiroff, Bronx, New York, 10458 USA. ebrenner@nybg.org

Cabrera, Sandra. Laboratorio de Biotecnología, Universidad Autónoma Metropolitana-Iztapalapa. Av. San Rafael Atlixco No. 186, Col. Vicentina, Delegación Iztapalapa, 09340 México. cabrerahilerio_sl@hotmail.com

Castillo-Guevara, Citlalli. Obrero Mundial No. 5, Col. Obrero Campesina, Xalapa, Veracruz, 91020 México citlallig@hotmail.com

Chemnick, Jeff. Lotusland Foundation, 695 Ashley Road, Santa Barbara, California, 93108 USA. jeffchernnick@cox.net

Cox, Paul. Institute for Ethnomedicine, National Tropical Botanical Garden, U.S. Mainland Office: 1717 North 1450 East, Provo, Utah 84604 USA; National Tropical Botanical Garden, 3530 Papalina Road, Kalaheo, Hawaii, 96741 USA. pau_cox@comcast.net

Dalzell, Chris. Durban Botanic Gardens, PO Box 3720, Durban, 4000 South Africa. dalzellc@prcsu.durban.gov.za

de Klerk, Diekie. PO Box 2234, Polokwane, Limpopo Province, 0700 South Africa. deklerkk@mweb.co.za

Donaldson, John. Kirstenbosch Research Centre, National Botanical Institute, P/Bag X7, Claremont, 7735 South Africa. donaldso@nbict.nbi.ac.za

Downie, Doug. Department of Zoology & Entomology, Rhodes University, Grahamstown, 6140 South Africa. d.downie@ru.ac.za

Engleman, Mark. Colegio de Postgraduados, Cacamatzin 36, Texcoco, Edo. 56150 México. jerryeng@colpos.mx

Flores Vázquez, Juan Carlos. Sociedad para el Estudio de los Recursos Bióticos de Oaxaca, Asociación Civil (SERBO, A.C.) Porfirio Díaz 211 Altos, col. Centro.68000, Oaxaca, México. serbo@prodigy.net.mx

Forster, Paul. PO Box 2171, Ashgrove West, Queensland, 4060 Australia. paulforster@uq.net.au

Gheno-Heredia, Yaqueline. Calle San Jaun #52, UH San Román, Córdoba, Veracruz, 94570 México. ghenohy@hotmail.com; ghenoyac@yahoo.com

González, Dolores. Laboratorio de Sistemática Molecular, Departamento de Biodiversidad y Sistemática, Instituto de Ecología A.C., Apdo Postal 63, Xalapa, Veracruz, 91000 México. dolores@ecologia.edu.mx

González-Astorga, Jorge. Laboratorio de Genética, Departamentode Biología Evolutiva, Instituto de Ecología, Apdo Postal 63, Xalapa, Veracruz, 91000 México. astorga@ecologia.edu.mx

González Géigel, :Lutgarda.Jardín Botánico Nacional, Carretera El rocío Km 3.5, Calabazar, Habana, CP 19230 Cuba. hajb@ceniai.inf.cu

Gorelick, Root. School of Life Sciences, Arizona State University, Tempe, Arizona, 85287-4501 USA. cycad@asu.edu

Gregory, Tim. 564 Shoal Circle, Redwood City, California, '94065 USA. tim@gene.com

Hayes, Virginia. Lotusland Foundation, 695 Ashley Road, Santa Barbara, California, 93108 USA. vahayes@lotusland.org

Haynes, Jody. Montgomery Botanical Center, 11901 Old Cutler Road, Miami, Florida, 33156-4242 USA. jodyhaynes@bellsouth.net

Hill, Ken. Royal Botanic Gardens, Mrs Macquaries Road, Sydney, New South Wales, 2000 Australia. ken.hill@rbgsyd.nsw.gov.au.

Huang, Yu-yuan. Department of Horticulture, Zhongkai Agrotechnical College, Dongsha Street, Guangzhou City, Gaungzhou, 510225, China. lqxhyy@yahoo.com.cn

Ironmonger, Bruce. PO Box 754, Bonsall, California, 92003 USA. cycadcentre@msn.com

Kokubugata, Goro. Tsukuba Botanical Garden, National Science Museum, Tokyo Amakubo, Tsukuba City, 305-0005 Japan. gkokubu@kahaku.go.jp

Lazcano Lara, Julio C. Jardín Botánico Nacional, Carretera del Rocío Km 31/2, Calabazar, Boyeros, Ciudad Habana, C.P. 19230 Cuba. jlazcano@fbio.uh.cu

Levin, Maurice. 9560 Gloaming Drive, Beverly Hills, California, 90210-1715 USA. maurice@cycads.com

Li, Nan. Fairy Lake Botanical Garden, Lian-Tang, Shenzhen, Guangdong, 518004 China.
liandreal963@yahoo.com.cn

Lindström, Anders. Nong Nooch Tropical Garden, 3411 Sukhumvit Highway, Najontien, Sattahip.
Chonburi, 20250 Thailand. kampon@loxinfo.co.th

López-Gallego, Cristina. Dept. of Biological Sciences, University of New Orleans, New Orleans,
LA 70148, USA. mclopez1@uno.edu

Marler, Thomas. O CNAS-AES, University of Guam, Mangilao, Gaum, 96913 USA.
tmarler@uog.edu

Marshall, John. PO Box 552, Denmark, Western Australia, 6333 Australia. catpeg@omninet.net.au

Nguyen, Tien Hiep. Institute of Ecology and Biological Resources. Nghia Do, Cau Giay, Hanoi,
Vietnam. ntienhiep@hn.vnn.vn

Nicolalde-Morejón, Fernando. Instituto de Ecología A.C., Apdo Postal 63, Xalapa, Veracruz,
91000 México. nicolalde@ecologia.edu.mx

Oberprieler, Rolf. CSIRO Entomology, GPO Box 1700, Canberra, ACT, 2601 Australia.
Rolf.Oberprieler@csiro.au

Osborne, Roy. PO Box 244, Burpengary, Queensland, 4505 Australia. cycad@iprimus.com.au

Pérez de la Rosa, Jorge Alberto. Linda Vista, 1871, Guadalajara, Jalisco, 44100 México.
jalper@cucba.udg.mx

Pérez-Farrera, Miguel Angel. Escuela di Biología, Universidad de Ciencias y Artes de Chiapas
(UNICACH), Calzada Samuel León Brindis 151, Tuxtla Gutiérrez, Chiapas, 29000 México.
miguelangel@chiapas.net;perezfarreram@yahoo.com.mx

Pinares de la Fe, Ania. Carr. El Rocio Km 3.5, Calabazar, Boyeros, La Habana, 19230 Cuba.
pinares@fbio.uh.cu

Radha, P. Life Sciences, GGS Indraprastha University, Kashmere Gate, Delhi, 110006 India.
radhasudar@rediffmail.com

Randall, Lou. 54 Cockatoo Court, Caboolture, Queensland, 4510 Australia.
randall@mail.cth.com.au

Reeves, Gail. Leslie Hill Molecular Systematics Laboratory, Kirstenbosch Research Centre, Private
Bag X7, Claremont, 7735 South Africa. reeves@nbi.ac.za

Rendón-Aguilar, :Beatriz. UAM- Ixtapalapa, Av San Rafael Atlizco 186, México.
bra@xanum.uam.mx

Rivadeneira Dominguez, Eduardo. Facultad de Química Farmacéutica Biológica, Universidad Veracruzana, Apartado Postal 294, Xalapa, Veracruz, 91000 México.
rivadeneira2002@hotmail.com

Salas Morales, Sylvia. Serbo A.C., Porfirio Diaz # 211, Centro, Oaxaca, 68000 México.
serbo@prodigy.net.mx

Sánchez-Tinoco, M. Ydelia. Instituto de Investigaciones Biológicas, Universidad Veracruzana, Apartado Postal 294, Xalapa, Veracruz, 91000 México. ytinoco@uv.mx

Shaw, Christopher. Research Pavilion, University of British Columbia, 828 W. 10th Avenue, Vancouver, British Columbia, V5Z 1L8, Canada. csshawlab@hotmail.com

Singh, Rita. Life Sciences, GGS Indraprastha University, Kashmere Gate, Delhi, 110006 India.
ritasinghipui@yahoo.com

Stevenson, Dennis. New York Botanical Garden, Bronx, New York, New York, 10458 USA.
dws@nybg.org

Taylor, Alberto. Universidad de Panama, 6-4957 El Dorado, FOR-Z6 Panama. sidney@cwpa.net.pa

Terry, Irene. Department of Biology, University of Utah, 257 South 1400 East, Salt Lake City, Utah, 84112 USA. terry@biology.utah.edu

Torres Hernández, Leonel. Instituto de Investigaciones Biológicas, Universidad Veracruzana. Ave. Luis Castelazo s/n. Colonia Industrial Ánimas. A.P. 294. C.P. 91000. Xalapa, Veracruz, México. Itorres@uv.mx

Vargas Amado, Georgina. Instituto de Botánica, Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara, Apartado Postal 1-139, Zapopan, Jalisco, C.P. 45110 México. dumas_hija@hotmail.com

Vázquez Torres, Mario. Centro de Investigaciones Biológicas, Universidad Veracruzana, Apdo Postal 294, Xalapa, Veracruz, 91000 México. savazquez@uv.mx

Vergara-Silva, Francisco. Department of Botany, The Natural History Museum, Cromwell Road, London, SW7 5BD United Kingdom. f.vergara-silva@nhm.ac.uk
sveseq2004@yahoo.com.mx

Vorster, Piet. Department of Botany & Zoology, University of Stellenbosch, P/Bag X1, Matieland, Western Cape, 7602 South Africa. pjvor@sun.ac.za

Vovides, Andrew. Instituto de Ecología A.C., Apdo Postal 63, Xalapa, Veracruz, 91000 México.
vovidesa@ecologia.edu.mx

Weise, Christine. Montgomery Botanical Center, 11901 Old Cutler Road, Miami, Florida, 33156-4242 USA. montgome@fiu.edu

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**A HISTORY OF THE INTERNATIONAL CONFERENCES ON
CYCAD BIOLOGY / UN RECUENTO DE LOS CONGRESOS
INTERNACIONALES DE BIOLOGÍA DE CÍCADAS**

CYCAD 87: The First International Conference of Cycad Biology

Beaulieu-sur-Mer, Nice, France, 17-22 **April 1987**

Proceedings, D.W. Stevenson (ed.), 1990, *Memoirs of the New York Botanical Garden* 57

CYCAD 90: The Second International Conference of Cycad Biology

Townsville, Australia, 22-28 July 1990

Proceedings, D.W. Stevenson & K.J. Norstog (eds), 1993, Palm & Cycad Societies of Australia Ltd, Milton, Queensland, Australia

CYCAD 93: The Third International Conference of Cycad Biology

Pretoria, South Africa, 5-9 July 1993

Proceedings, P. Vorster (ed.), 1995, The Cycad Society of South Africa, Stellenbosch, South Africa

CYCAD 96: The Fourth International Conference of Cycad Biology

Panzhihua, Sichuan, China, 1-5 May 1996

Proceedings, C.-J. Chen (ed.), 1996, International Academic Publishers, Beijing, China

CYCAD 99: The Fifth International Conference of Cycad Biology

Fairchild Tropical Garden, Miami, Florida, USA, 7-10 August 1999

Proceedings, D.W. Stevenson (ed.), 2004, *Botanical Review* 70(1 & 2).

CYCAD 2002: The Sixth International Conference of Cycad Biology

Nong Nooch Tropical Garden, Pattaya, Thailand, 27 July-4 August 2002

Proceedings, A.J. Lindstrom (ed.), 2004, Nong Nooch Tropical Botanical Garden, Thailand.

CYCAD 2005: The Seventh International Conference of Cycad Biology

Xalapa, Veracruz, Mexico, 8-15 January 2005

Proceedings, A. Vovides & R. Osborne (eds), *in preparation*

CYCAD 2008: The Eighth International Conference of Cycad Biology

Venue and dates to be decided