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Dedicated to the Conservation of Cycads through Education and Scientific Research

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Message from the Editor

Dear Members of the Cycad Society:

I am pleased to announce that I have recently assumed the duties of editor of the Cycad Newsletter. It is an exciting new endeavor for me. Having studied the taxonomy and biology of *Zamia* and the other New World cycads for more than twenty years, I believe that this position will be a natural extension of the enjoyment I have had all these years dealing with cycads and cycad enthusiasts; after all, I am a "cycad nut" myself! So, I would be happy to look over anything you cycad lovers all over the world care to submit to the newsletter. I would prefer to receive these as e-mail attachments in Microsoft Word or plain text files, but if you care to mail a floppy disk, this too is acceptable. I would like the newsletter to appeal to all "cycad people" from academics to those who simply enjoy watching these marvelous plants grow in their gardens and greenhouses year after year. I will look forward to working with you!

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The Cycad Society
Since 1977

In This Issue:

The Search for the Ultimate Cycad Seed Cleaning Procedure

Tom Broome

One of the difficult aspects of growing zamias is the chore of cleaning the seeds. Unlike the seed coats of other cycad seeds, most zamias have a very rubbery seed coat that sticks to the seed. I have seen hundreds of thousands of seeds wasted because people did not have the time or the method to clean them.

In my early years of growing cycads I would only produce 100 seeds or less at a time. I would watch TV at night, scraping the seeds one at a time with my pocket knife. I had to find a better way than this. Next, I put the seeds in an empty pot and placed it near a fire ant mound. Within a week the ants would pick the seeds clean. This worked pretty well but the ants wouldn't clean more than a couple of hundred seeds before they would lose interest. Dr. Bijan Dehgan at the University of Florida told me his favorite method was using a wire brush on a drill. He instructed me to put the seeds in a coffee can, cut a hole in the lid, and insert the wire brush into the drill through the lid so that when it was placed on the can it would keep any extra material from flying out when the drill was turned on. This worked very well but I needed something that would clean thousands of seeds at a time. I improved on this method by taking a length of "all thread" (a metal shaft with threads all the way up and down), and placing three large wire brushes on the shaft with nuts in between each brush. I would fill an entire five gallon bucket full of seeds, add water and a little sand, and scrape the seeds for almost an hour. I would then use a pressure hose to clean off most of the residue, but not all seeds were perfectly clean. I have seen other nurserymen over the years use rock tumblers, cement mixers, and potato peelers to clean their seeds but they found that many of the seeds would be damaged. One nurseryman used to nick the seed coat, place his seeds on a bed of clean sand, cover with a screen, and pile oak leaves on everything. After a month or so the bugs and natural enzymes would clean the seeds. Even though it sounded bizarre, this was the only natural way I had ever heard of.

In 1992, an old grovesman told me a story about a product he had used in the 1950's to separate the seeds from oranges so that they could be used to plant rootstock material for grafting citrus. He told me how they would throw massive amounts of oranges in a large cow trough and then cover the oranges with water. He would next pour a cup full of an unknown liquid into the trough. In approximately a week the oranges would break down into pulp, and the seeds would sink down to the bottom of the trough. The most important aspect of this method was that the seeds were still viable. I wondered if something like this would work with cycad seeds. The man didn't even know how to read and could not give me any clues as to what this product may have been.

After months of searching (most people didn't even know what I was asking about) I discovered that product was a pectinase enzyme. From what I was told the enzyme breaks down the cellular structure of fruit but wouldn't harm other materials such as seeds or plant material. In Florida this enzyme is still used to separate the orange seeds from the fruit in mass quantities. In North Carolina it has been used to make apple juice. By using the enzyme, more juice can be produced from each apple because there is no wasted material, except for the seeds, to throw away. I thought I would check all this for myself so I procured some enzyme and conducted a few experiments. I put some *Zamia floridana* seeds in three different cups, and put three different strengths of enzyme solution to test for speed of cleaning. I used 1/2, 1, and 1 1/2 teaspoons of enzyme per pint of water for the three different cups. After a week, there was what appeared to be a liquid wax floating on the top, and after two weeks only a few seeds were clean. I assumed the enzyme was having a hard time penetrating the seed coat. I tried scraping the seed coat a little for my next experiment. Eureka! The enzyme entered the wound and broke down the coat from underneath. Depending upon the size of the hole the seeds were perfectly clean in as soon as five days using the 1 1/2 teaspoon rate. All I had to do after that was to rinse them in water

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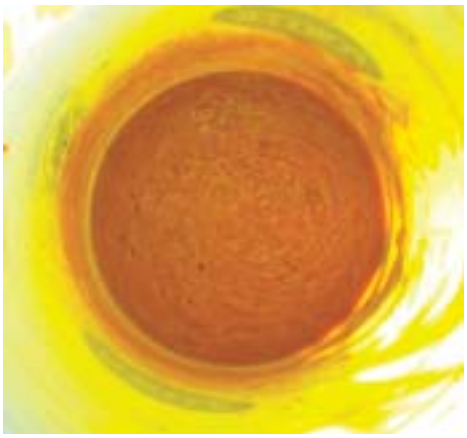
***Zamia floridana** seed prior to cleaning.*

Scarring seeds after three days soaking.



"Seed soup" ready to wash

Rinsing off the cleaned seeds

President's Message

I would like to welcome all our new members as well as our returning members to a new year with the Cycad Society. This is my first official year as president and I hope it will be a good one for everyone. At our last board meeting, we took a great deal of time discussing what we could do to improve the society, and the quality of the product our members receive. As the year goes on, you will continue to see the improvements we have planned.

First, I would like to welcome Dr. Bart Schutzman as our new editor. Bart is well known in the cycad world for his work with zamias, and has described quite a few *Zamia* species. He is also a member of the IUCN Cycad Specialist Group. Bart has a lot of experience with producing publications that dates all the way back to the time he worked on his high school and even junior high school newspapers, to the present where he puts together the newsletter for the Department of Environmental Horticulture at the University of Florida. I'm sure Bart will be a great asset to our society. See his editor's report for his contact information so you can send any pictures, articles, or questions you may have to be included in the newsletter.

I would like to thank Debra Waters for the many years she has worked on The Cycad Newsletter. She not only took our newsletter to a whole new level, but spent a great deal of her own time searching for articles. She even attended all of our board meetings. She was also responsible for putting together the majority of our two-day meeting in New Orleans this past year. This really shows her dedication to our society, particularly because she was never a member of the board or even a member of our society. I hope as time goes on, both of these things will change. Debra has already joined our society, and hopefully someday, if she is still willing, she would make a great addition to our board. Debra, I'm sure I can speak for all of our members and say thank you very much for everything you have done.

You may have noticed one of our new improvements already, in that this is our first issue that has been professionally printed. This issue will be our first issue printed in full color. Color is expensive, but is worth the price if we have pictures of good quality. At this time, I would like to ask our members to send in quality photos of cycads, and to write articles that will include some good color photos. We are wanting to use color for our entire issue, so we would like some nice pictures that will look good for these purposes. I hope everyone is pleased with our improvements.

Darin is doing a great job with our seed bank. He has put out two lists in the short time he has been in charge. His last list had 18 species available, which is probably close to an all-time record. Darin has even taken upon himself to find people with coning plants that are not pollinating them, and helping them produce seeds. He has also been working with a few botanical gardens to help them produce seeds. As time goes on, and if everything turns out right, there should be seeds available to our seed bank from these and other sources. For our new members, the seed bank makes available many rare species of cycad seeds. Seeds are made available in usually small quantities so our members are able to afford to get these rare species in their collections. Darin is going out of his way to make sure that the seeds you get are as true to name as possible and you can be sure that the seeds are all safe and legal. Sorry, but seeds of Appendix 1 species are not allowed to be exported to countries outside of the U.S. Darin cares a lot about cycads and cycad conservation, and should be commended for all his efforts.

As you can see from the treasurer's report, funds and especially donations are on the increase. We have many members that care about our society and because of their efforts and donations, our society is becoming more financially secure. I have had good feedback from our members in regard to what they would like to see happen with the society, and where improvements need to be made. As we become more secure, we can take on new projects and make more improvements. I would like to thank everyone who has donated money and time to the society. I would also like to thank Terrence for the great report, I know it takes a lot of time and effort to put something like this together.

As always, feel free to write to me by mail or e-mail with any comments or suggestions you may have for our society. This is our society, and it should be a society that all our members are proud to be a part of.

Tom Broome

This article was originally presented at the Second International Symposium on Ornamental Palms and other Monocots from the Tropics, Tenerife, Canary Islands, 3-6 February 1997, and was subsequently published in: Acta Hort. 486, ISHS 1999, pp. 123-131.

PROPAGATION AND CULTURE OF CYCADS: A PRACTICAL APPROACH

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"In the end,
We will conserve only what we love,
We will love only what we understand,
We will understand only what we are taught"
Baba Dioum

Abstract. Cycads are a geologically primitive group of threatened or endangered gymnosperms whose ancestors were widespread when dinosaurs were still roaming the earth. Today, the ±180 remaining species are restricted to specific tropical and subtropical regions of the Old and the New Worlds. Recent recommendations of the World Conservation Union (IUCN) include encouraging extensive propagation and culture of these magnificent ancient plants. Through our original research and publications in the past two decades, we have made long strides towards facilitating their commercial production. Methods of artificial pollination to ensure seed production and finding the proper treatments to expedite seed germination have been reported. Mechanical removal of the fleshy seed coat (sarcotesta), scarification of bony layer (sclerotesta) with sulfuric acid (H_2SO_4), and promoting rapid embryo development by soaking in the growth regulator gibberellic acid (GA_3), all have collectively increased germination of several species. Root growth and branching has been enhanced significantly by decapitation of the original seedling taproot and dipping the cut end in yet another growth regulator, indolebutyric acid (IBA). Appropriate irrigation frequency and applications of liquid and slow-release fertilizers that contain micronutrients, have resulted in exceptionally rapid growth and elimination of deficiencies. And finally, in what may be the most significant contribution towards cycad conservation, vegetative propagation has been made possible by forcing plants to branch profusely, despite absence of any lateral buds homologous to that of angiosperms and conifres. This has allowed their multiplication through division of segments. To the best of our knowledge, protocols for commercially feasible micropropagation of cycads have not been reported.

Cycads range in size from the small *Zamia pygmaea* Sims of about 20cm and leaves of fewer than 10 leaflets to *Lepidozamia hopei* Regel of about 20m and 150-200 leaflets per leaf. Most are caudiciform, at least when young, and all possess pinnately compound leaves, except *Bowenia* spp., which have bipinnately compound leaves. Without exception, cycads are dioecious, with male and female cones (or micro- and megastrobili) occurring on separate plants. Only in *Cycas* spp. do the female cones consist of loosely arranged, concentric groups of seed-bearing, leaflike structures, each having from one to as many as nine seeds, depending on the species. The seed and pollen-bearing segments of cones are referred to as mega- and microsporophylls, respectively. Both the male and the female cones of genera other than *Cycas* consist of tightly organized peltate (in *Bowenia*, *Ceratozamia, Encephalartos, Microcycas, Lepidozamia, Macrozamia*, and *Zamia*), or leaflike, overlapping, more or less triangular, palaceous (in *Dioon* and *Stangeria*) sporophylls. Unlike palms and other flowering plants, cycads do not possess an ovary and therefore lack a fruit. The seed, although resembling fruit, is said to be naked (not enclosed within an ovary). In general, the megasporophylls of genera other than *Cycas* each hold two seeds. Artificial pollination and seed propagation necessitate an intimate familiarity with cones and seed structure.

Nearly all cycads are endangered, threatened, or commercially exploited to excess. In some cases they nearly or completely have disappeared from the wild, either as a result of overcollecting or agricultural activities. Accordingly, it has been suggested for many years (Dehgan, 1983, 1996, Dehgan and Almira 1993, Giddy 1993) and recently agreed upon by IUCN (Giddy, 1996), that if the demand for cycads is met through propagation and large scale commercial production, the decimation of wild populations by unscrupulous collectors will no longer occur. Thus, a major challenge to nurserymen and conservationists is to produce superior plants which would make collection of wild specimens unnecessary and economically unjustifiable. To accomplish this, it is necessary to discuss the needed steps in commercial production (also, see Dehgan, 1993, 1996a).

Seed Production: Artificial Hand Pollination

Seed propagation is the only practical method of large-scale, commercial cycad production. However, often seeds are not available for purchase, species planted distant from their native range cannot be pollinated because the specific insect pollinators are absent, or production and maturity of male and female cones are asynchronous. Regardless of the cause, hand pollination is requisite for maximum seed production.

Often the male cone begins to shed pollen long before the female is ready for pollination. If so, collect the entire male cone when pollen first begins to shed, place on a large piece of paper (newspaper usually functions well) or paper sack (not plastic) and keep in a dry, warm location where there is no air flow. The pollen should be completely released within a few days. Collect and store the pollen in a jar together with a package of desiccant and place in a refrigerator. Properly stored pollen will remain viable for about one year. Recognizing when the female cone is ready for pollination requires more frequent observation and recognition of the signals. *Cycas* megasporophylls

continued next page

Cycad Propagation (from previous page)

appear as a somewhat rigid, well-organized rosette when fully expanded. When ready for pollination, they will have a pinkish-gray color and a distinct musty odor. If a male cone is shedding simultaneously, remove it with a sharp knife or a pair of sheers and gently shake while holding atop the female cone. Leave the male cone in proximity of the female for a few days, if possible. Additional pollen may be shed and transported by beetles to the ovules during the night. If no fresh pollen is available, then use the stored pollen by gently and evenly blowing onto the open female cone. It may be necessary to mix the pollen with a small amount of talcum powder to increase the volume. Use a small straw to deposit the pollen on or into the cone, as necessary. The window of opportunity for pollination of *Cycas* may be as long as two to three weeks.

The process is somewhat more complex in the female cone of genera other than *Cycas*. The megasporophylls are tightly arranged in a true cone and not readily amenable to pollen entry. However, when ready for pollination, long cracks appear in one or more locations on the cone. A distinct musty odor emanates from these cracks. Deposition of the pollen within the cracks may be accomplished in one of several ways. A cotton swab may be slightly moistened, dipped or rolled in pollen, and rubbed onto the exposed areas in the cone. A recent method suggested by a nurseryman involves mixing the pollen with water and using a syringe to deposit the mixture into the cracks. And still another alternative entails direct pollen deposit into the cracks with toothpicks or other devices. There is no shortage of innovative methods for assuring pollen transfer to the female cones and much success has been achieved regardless of the method utilized. A problem may arise with species of *Dioon*, however. In this case, the opening occurs at the very base of the cone and results in some mechanical difficulty in pollen deposition and its transfer to the upper portion of the cone. Pollination may have to be done with care and several times in a period of two or more weeks.

Seed Germination: Treatments and Strategies

Seeds of most species of *Bowenia*, *Ceratozamia*, *Dioon*, *Lepidozamia*, *Macrozamia*, and *Stangeria* will germinate without much difficulty, as long as their embryo is fully developed and the sarcotesta is removed before planting (unpublished data). *Microcycas calocoma* (Miq.) A.DC. seeds have been successfully germinated by the staff of Fairchild Tropical Garden and reported to have a short period of maturation time, occasionally germinating as the cone falls apart (Hubbuch, 1987). In contrast, despite normal appearance, *Encephalartos* spp. seem to have the peculiar difficulty of not being properly pollinated and/or fertilized when under cultivation (Hubbuch, 1987, pers. obs.). Although the seeds may appear normal, the embryo is frequently absent. However, seeds from hand pollinated cones of *E. gratus* Prain at Fairchild Tropical Garden germinated nearly 100% without any treatment. When soaked in GA_3 for 24 and 48 hours, they germinated quickly and uniformly. Seeds collected from wild plants of *Encephalartos* spp. were reported by Giddy (pers. comm.) to germinate without difficulty, while

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Cycad Society Seedbank Report
January 2002

Dear Members,

On Jan 14th, 2002 we mailed out the first seed list of the year which included the following species: *Bowenia spectabilis*, *Ceratozamia microstrobila*, *Ceratozamia norstogii*, *Cycas littoralis*, *Cycas siamensis*, *Cycas siamensis* (Dwarf), *Cycas simplicipinna*, *Cycas* sp. ("Nova Wilailak"), *Dioon holmgrenii*, *Encephalartos lehmanii*, *Encephalartos manikensis* (Vanduzi), *Lepidozamia peroffskyana*, *Macrozamia miquelii*, *Zamia amblyphyllidia*, *Zamia kickxii*, *Zamia neurophyllidia*, *Zamia portoricensis*, and *Zamia soconuscensis*. Due to their rarity, some species were in very short supply so we were not able to fill everyone's requests 100%. I believe it is of greater benefit to offer a few seeds to as many members as possible than to not have purchased them at all. The timing of my mailing of the lists is as fair as I can make it for everyone to have an equal opportunity to purchase the seeds they desire. It is imperative for you to call or fax me your seed wishes as soon as possible to ensure seeds are still in stock.

Seed lists: can be obtained by sending several self-addressed, stamped, business style envelopes to my above address or by joining our online seed list. See the June 2001 issue of the Cycad Newsletter for instructions on joining the online seed list or email me at the above address for help.

Seed sources: We are always actively seeking new seed sources and we are interested in obtaining seeds of almost every species. As always, our seed sources are kept confidential. We welcome any quantity of seed we can get and I can be contacted at the above numbers and email.

Many Thanks,
Darin Yeatman

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The Cycad Society Treasurer's Report for Fiscal Year 2001

This report is the second financial report I have produced for TCS Members as treasurer of The Cycad Society. For your reference, the first financial report was published in Volume 24 Number 1 issue of *The Cycad Newsletter.*

As of January 1, 2002 TCS was maintaining two bank accounts: a general checking account and a savings account. Both of the accounts are with Tech Federal Savings Bank in Lafayette, Louisiana. Table 1 documents TCS's assets and liabilities for the start of the following three years: 2000, 2001, and 2002.

Table 2 reports expenses TCS incurred in 2001 and in 2000. TCS uses categories to identify the source of income and expenses. These categories are listed in the left column. Some categories such as "Newsletter" contain subcategories for better detail of expenses.

For 2001, TCS had an income of $11,919.29 and expensed $8,485.65. Contributions increased by 154% in 2001 when compared to 2000. A sizable contribution was received in 2001 from the Cycad Society Seedbank. The benefit of paying by credit card through PayPal has been appreciated by TCS Members. Payment to PayPal for membership dues increased 74% from 2000.

In 2001, newsletter production costs showed an increase of 67% compared to 2000. However, a significant portion of 2001 newsletter expenses was associated with 2000 newsletter production. Obtaining invoices from the company handling the newsletter can often take months.

A detailed income and expense report has been submitted to all TCS officers. This report includes detail for all monies received and paid out in 2001 from the Treasurer's office. An electronic copy of the accounting file maintained by the TCS Treasurer has been submitted to the President.

The above report is submitted to The Cycad Society Officers, Directors, and Members on January 17, 2002 by Dr. Terrence Walters, Treasurer of The Cycad Society.

Acknowledgments: The author would like to thank and acknowledge the support of Directors Garrie Landry, RL Frasier, Jody Haynes, and Tom Broome and Debra Waters. Their support of the duties and responsibilities associated with TCS Treasurer position is greatly appreciated.

Dr. Terrence Walters
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Table 1. Net Worth for The Cycad Society for the start of the years 2000, 2001, and 2002.

The Cycad Society Financial Review	1/1/2000 Balance	1/1/2001 Balance	1/1/2002 Balance
Assets			
Cash and Bank Accounts			
Checking - General	$2,262.57	$7,113.05	$10,546.66
Checking - Editor	1,775.49	0.00	0.00
Savings	1,054.59	1,073.05	1,088.58
Total Cash and Bank Accounts	5,092.65	8,186.10	11,635.24
Total Assets	5,092.65	8,186.10	11,635.24
Liabilities	0.00	0.00	0.00
Overall Total	$5,092.65	$8,186.10	$11,635.24

Table 2. Income and Expense Comparison Summary for The Cycad Society for Fiscal Years 2000 & 2001

Category	1/1/2000 12/31/2000	1/1/2001 12/31/2001	$ Difference	% Difference
Income				
Assorted Income	$6.00	$0.00	($6.00)	-100.00%
Back Issues	0.00	57.50	57.50	N/A
Contribution:				
Restricted	3.24	17.04	13.80	425.93%
Restricted-Brochure	100.00	0.00	-100.00	-100.00%
Unrestricted	998.00	2,787.02	1,789.02	179.26%
Total Contribution	1,101.24	2,804.06	1,702.82	154.63%
Membership:				
Mail	7,216.00	8,147.00	931.00	12.90%
Pay Pal	338.11	590.73	252.62	74.72%
Total Membership	7,554.11	8,737.73	1,183.62	15.67%
Newsletter Ads	0.00	320.00	320.00	N/A
PayPal Deposit	5.00	0.00	-5.00	-100.00%
Total Income	$8,666.35	$11,919.29	$3,252.94	37.54%

Category	1/1/2000 12/31/2000	1/1/2001 12/31/2001	$ Difference	% Difference
Expenses				
Bank Charges	$59.24	$17.80	($41.44)	-69.95%
Consultant Fee	1,200.00	1,600.00	400.00	33.33%
Contracts	313.00	253.00	-60.00	-19.17%
Events	62.40	0.00	-62.40	-100.00%
Legal	5.00	5.00	0.00	0%
Logo	40.29	0.00	-40.29	-100.00%
Miscellaneous	0.00	92.96	92.96	N/A
Newsletter:				
Assorted	0.00	33.00	33.00	N/A
Envelope	124.65	130.65	6.00	4.81%
Four Color Plates	1,296.00	1,718.00	422.00	32.56%
Labels	51.94	0.00	-51.94	-100.00%
Postage	1,197.61	2,274.19	1,076.58	89.89%
Printing	614.00	1,470.00	856.00	139.41%
Stuffing	110.00	165.00	55.00	50.00%
Two Color Plates	395.00	562.00	167.00	42.28%
Total Newsletter	3,789.20	6,352.84	2,563.64	67.66%
Postage	122.23	144.10	21.87	17.89%
Supplies General	0.00	19.98	19.98	N/A
Total Expenses	$5,591.36	$8,485.68	$2,894.32	51.76%
Total Income/Expenses	$3,074.99	$3,433.61	$358.62	11.66%
Transfers:				
To Checking Account	-1,194.66	0.00	1,194.66	100.00%
To Checking-Editor	-3,000.00	0.00	3,000.00	100.00%
From Checking Account	3,000.00	0.00	-3,000.00	-100.00%
From Checking-Editor	1,194.66	0.00	-1,194.66	-100.00%
Total Transfers	$0.00	$0.00	0.00	0%
Overall Total	$3,074.99	$3,433.61	$358.62	11.66%

Panamanian Paradise Revisited

by
***Russell Adams**, Gainesville Tree Farm*
Adapted from the Montgomery News, Deena Decker Walters, Editor

"Big game hunting" in the wilds of Panama leads to a sizeable trophy.

The year 2001 brought about a second Panama Expedition involving three great institutions and a reunion among three old friends. The group included myself as representative of the Montgomery Botanical Center, Dr. Dennis Stevenson from the New York Botanical Garden, and Dr. Alberto Taylor from the University of Panama. We were joined on this excursion by world traveler and cycad enthusiast Alan Whittington of Florida. Our goal was to explore the northwestern region of Panama, including the states of Cocle, Veraguas, Chiriquí, and Bocas Del Toro. We were especially interested in the *Zamia skinneri*/*Z. neurophyllidia* complex and targeted several localities for this group.

From Panama City, we traveled west to the town of Santa Fe. This was to be our starting point for what we knew would be a very long and difficult day of travel. We planned to drive our four wheel drive Pathfinder as far as the road would allow and then continue on foot over the continental divide and down the Caribbean slope to the headwaters of the Calovebora River. This location is where Dr. Bob Dressler reported finding a plant that was a "perfect match" for Warscewicz's 1851 sketch and description of *Z. skinneri*.

*Dennis Stevenson hard at work in the field pressing leaves of **Zamia lindleyi**.*

The price of our taxi ride to El Guabal was to unload the trucks.

With our shiny new SUV buried to the frame only two kilometers outside of Santa Fe (see photo above), our hopes of a successful trip were greatly diminished. Alberto was dispatched back to Santa Fe for help, while Dennis, Alan, and I set our backs to the task of extracting the vehicle from the giant mud hole. Two hours later, we were much muddier but no closer to freeing the vehicle from the suction of the giant hole. At this moment, the most wonderful sight we could imagine rounded the corner — a caravan of four-wheel-drive trucks, right out of the "Dukes of Hazard", complete with giant knobby tires and, even better, snow chains for traction. Riding shotgun in the lead truck was our dear friend Alberto. The caravan was taking school desks and building supplies to a small town at the end of a new road on the Calovebora River. We were saved! The trucks were completely filled with people in the cab and school desks in the back, but we were able to stand on the bumper and hold on to the steel frame that encased the truck bed. The next two hours were an incredible mix of pleasure and pain. The pain was

The end of the road was just the beginning.

*Mature female megastrobilus of **Zamia neurophyllidia**.*

brought about by leg cramps from constant flexing as the trucks forded small rivers, traversed giant boulders, and scaled inclines as steep as 50 degrees. The constantly shifting chairs would occasionally smash into our also cramping hands, forcing us to relinquish our white-knuckled grip, but only for a second. This pain was offset by the sheer ecstasy of the sights unfolding before us. This new road was less than one month old and we were literally traveling through miles of virgin rainforest.

As we neared the divide, we began to see massive *Z. pseudoparasitica* plants settled in their lofty perches like venerable gray-green gentry looking down upon us. Were they contemplating the consequences

Zamia lindleyi in its cloud forest habitat

of this new road, which was sure to bring a flood of people? Because of time constraints, we were not able to collect any specimens but we did allow ourselves the luxury of stopping to admire their magnificence. A little further along the road, we began to see the real quarry of our quest - *Z. skinneri*. Like garnet and ruby fountains in an emerald green sea, the massive new leaves arched skyward from trunks measuring a meter tall. Leaves were produced in numbers from one to five, but mostly in sets of three. Some leaves were over 2.5 m long with leaflets up to 60 cm long and 20 cm wide. The anthocyanins, which gave the new leaves a ruddy hue, stood out in stark contrast to the green forest behind.

Once in the town of El Guabal, we quickly unloaded the trucks with the help of the entire town and headed into the forest. Zamias were very abundant and we soon had all the plants, herbarium vouchers, and DNA samples we needed. The steady rain that had accompanied us all day now became a downpour and we rushed to leave before the road became totally impassable. We arrived back in town as night fell—bruised, tired, and hungry, but giggling like school children at the day's events.

The next morning, we were up early, driving west to the town of Chiriquí, then turning north on one of only two roads to transect Panama from the Pacific to the Caribbean coast. Near midway along this road is the continental divide and the Fortuna Dam area. This is an incredibly diverse botanical region protected by the national park system of Panama. Here, in cloud forest at 1,200 m elevation, we found the rare and beautiful *Z. lindleyi*. The plants were scattered sparsely along the top of the ridge. The trunks averaged about a meter tall, although all sizes from seedlings to much larger trunks were observed. Each plant held about five to six leaves per flush. New leaves were a bright shiny green; the older leaves were dull green and almost completely covered with bryophytes. A leaf was composed of 20 to 30 pairs of narrow leaflets, each leaflet measuring 2.5 cm wide by about 20 cm long.

Zamia pseudomonticola *in volcanic soil near the Costa Rican border.*

As we continued down the mountain toward the town of Chiriquí Grande we again observed *Z. pseudoparasitica*. In the hills above the town, and along the costal road, which continues northwest to the Costa Rican border, we collected Z. neurophyllidia. This plant is described basically as a dwarf form of *Z. skinneri*. The emergent leaves of this species are bright green as opposed to the reddish bronze color of *Z. skinneri*, and they tend to sport twice as many leaves at any one time. Leaflets of *Z. neurophyllidia* are generally smaller and more numerous than those of *Z. skinneri*. However, we found some mature *Z. neurophyllidia* individuals with leaves over 2.2 m long and leaflets 15 cm wide by 50 cm long. We found at least one large female plant with a trunk over 3 m tall. This is much larger than any trunks of *Z. skinneri* that I have personally seen. Plants were abundant all throughout this area, but are being threatened by deforestation.

Next, we headed to the barrier islands on the seaward side of Laguna de Chiriquí. We landed on the southern or mainland side of the island and made our way over the tall ridge that runs down the center and then started down to the northern side. At the bottom of the ridge was a low swampy area. From here, the ground rose gently but steadily toward the beach. It was here that I saw something that I will never forget. It was a forest of *Z. neurophyllidia*. This forest was narrow, starting at the beach and continuing back toward the swamp for maybe 100 meters. It continued for about 1.5 km and contained literally thousands of individuals, maybe tens of thousands of plants. Plants were in

*Russell Adams with an ancient specimen of **Zamia neurophyllidia**.*

all stages of development, from seedlings to mature plants with trunks 3 m tall. There were emergent male cones, emergent female cones, female cones with ripe seeds, and cones at every stage in between. Zamias were the dominant understory plant as well as the dominant ground cover. This was due in part to the fact that the indigenous people keep the underbrush down with their machetes. The zamias, like the great Hydra of myth, seem to sprout anew with each swing of the blade. The severed apex, likewise, falls to the ground, becomes rooted, and continues growing. This has created the the most robust population of cycads I have ever seen. I only hope some steps towards conservation are made in this area, as beach-front real estate, even in these remote islands, is at a premium. The first beach house on this part of the island already decimated the eastern end of the cycad population.

*The dominant understory plant on the windward side of this Caribbean barrier island was **Zamia neurophyllidia**.*

On the next leg of our journey, we traveled back to the mainland, over the Cordillera de Talamanca, and into the State of Chiriquí. Near the border with Costa Rica, at an elevation of 1,300 m, we found the beautiful and controversial *Z. pseudomonticola*. The plants were growing along steep slopes in dark volcanic soils in the forest remnants between coffee plantations. Trunks were up to 1.2 m tall with leaves up to 2 m long. The bright glossy green leaflets had a slight crease down the middle, and the petiole was lightly armed with prickles.

On our way back to Panama City, we stopped in the State of Cocle near the town of El Valle to look for the diminutive *Z. acuminata*. We found them in abundance along the slopes of an extinct volcano. This is a subterranean species with small glossy green leaves less than 60 cm long.

The 2001 Panama Expedition was an unqualified success. Over 50 accessions of cycads and palms were collected. Collaborations developed during this and the previous Panama expedition will continue to benefit MBC and the scientific community at large for years to come.

*Dr. Alberto Taylor measuring a leaflet of the red-emergent **Zamia skinneri**.*

Open Letter from Mike Michaelson to the Cycad Society

In June, 2001, Mike Michaelson resigned his position as the director of the Cycad Society Seed Bank after more than nine years of excellent service to our members. Mike has requested that we print this letter as part of a plea agreement between his attorney and those of the U.S. Fish and Wildlife Service.

Dear Members,

On July 6, 2001 I purchased approximately 500 *Encephalartos* seeds that were smuggled into the US. I have lived to regret that transaction very much.

On January 24, 2002 I was sentenced to six months house arrest, five years probation, and a five thousand dollar fine.

Please let me warn you to not purchase any seeds or plants that are not from a reputable person. I would further suggest that if you do purchase seeds or plants, ask to see the documentation from CITES.

With deep remorse,

Mike Michaelsen

those collected from cultivated plants often germinate erratically. In a recent report Osborne(1990), indicated that thousands of plants of *E. transvenosus* Stapf & Burtt Davy (the Modjadji Cycad) have been produced and distributed to the public. Moreover, seeds from artificially pollinated cones of *E. laurentianus* De Wild. were reported to have 60% germination (Crosiers & Malaisse, 1995). Inviability of *Encephalartos* seeds from artificially pollinated cones may be the result of spermatozoid rejection by egg cells (Steyn et al. 1996).

The major difficulty seems to be with some of the commonly cultivated genera. *Zamia* and especially *Cycas* suffer from what is referred to by Nikolaeva (1977) as "morphophysiological complex dormancy" (Dehgan & Johnson, 1983; Dehgan & Schutzman 1989). This may involve actual physiological dormancy, embryo immaturity, chemical inhibitors in the sarcotesta (the fleshy outer seed coat), and thick impermeable sclerotesta (the bony inner seed coat). *Zamia floridana* A.DC., for example, does not have embryo dormancy if cones are allowed to disintegrate before the seeds are collected. Removal of the sarcotesta and treatment of seeds with H_2SO_4 for about one hour results in excellent germination in 20 to 30 days. However, if seeds are treated with H_2SO_4 followed by 24 hr. GA_3 soak at 1000 ppm, uniform germination of up to 100% may occur in about two to four weeks (Dehgan and Johnson, 1983). In *Z. furfuracea* L.f., the optimal treatment periods are 15 to 20 minutes in H_2SO_4 and 24 hours in GA_3, respectively (Dehgan & Schutzman, 1983). Best germination in both cases occurred under intermittent mist. Similar results have been reported for *Macrozamia communis* L.Johnson by Ellstrand et al. (1990).

Although they appear mature, seeds of some *Cycas* species are particularly difficult to germinate. In this case, the embryo is actually in the early stages of development. Storage in a warm environment usually results in relatively rapid embryo development but also rapid loss of viability. By contrast, cold storage results in slow development of the embryo but minimal loss of viability. Best results were obtained when seeds were collected as they appeared fully developed, kept in a 5°C storage for four months so as to allow development of the embryo. Seeds kept in room temperature (22°C) for the same time period had well-developed embryo but only 45% of the seeds germinated rapidly after removal of the sarcotesta. The remaining 55% did not germinate (Dehgan and Schutzman, 1989). Treatment with H_2SO_4 for 20 and 30 min. gave mixed results. Subsequent studies, however, have indicated no need for H_2SO_4 treatment but a decidedly positive benefit from 24 hours of GA_3 soak (Dehgan and Almira, unpub. data). Field collected seeds of several Australian *Cycas* spp., when allowed to mature for about two months, germinated without any treatment.

It is noteworthy that cycad seeds are recalcitrant: they cannot be rehydrated once their water content falls below a critical minimum. This is often indicated by the complete separation of the female gametophyte tissue (the endosperm) from the sclerotesta, resulting in rattling of seeds and their floatation in water (Dehgan and Yuen, 1973). Floatation of

Bowenia serrulata megastrobilus

Dioon spinulosum with megastrobilus

Cycas revoluta megastrobilus

germinating *Zamia* seed

seeds in water, however, is not always indicative of seed inviability. For example, the presence of spongy tissue in seeds of *Cycas rumphii* Miq. complex [apparently erroneously published as *C. circinalis* L. by Dehgan and Yuen (1983) but since shown by Hill (1995) to be *C. rumphii*] results in buoyancy irrespective of viability. In general, all mature cycad seeds appear to respond positively to a GA_3 soak as indicated by our studies, as well as others (e. g. Butt, 1990; Ellstrand et al. 1990).

Cycad seeds germinate best when planted in a well-drained medium, in a horizontal or lateral, but not vertical, position. While watching germination stages, two very important facts may be noted: (a) cycad seeds are haustorial and remain attached to the seedling for as long as two or more years after germination. They should not be forcefully removed; and (b) leaves appear from the upper portion of a very short stem soon after germination and will not develop properly if seeds are planted vertically. Also, if planted vertically, water accumulates in the seed and may result in seed or seedling decay.

Root Pruning: Improved Water and Nutrient Absorption

The results of experiments by Dehgan and Johnson (1987) with *Z. floridana* and more recently (Dehgan and Almira, unpublished data) with *Dioon califanoi* De Luca & Sabato, *Cycas revoluta* Thunb. and other species has shown that when the primary seedling root is severed near its junction with the stem, and the cut end is dipped in 2000 ppm IBA (or higher concentration if K-IBA is used) for 5 sec., usually two or more roots replace the original single root, which is characteristic of all cycads. Use of Benzyladenine (BA) which was recommended in the original publication, although effective in promoting additional root branches, has since been discouraged because it results in development of short, stubby roots that require a long time before resumption of normal growth. The earlier hypothesis that slow growth of cycads is at least in part attributable to inherently inadequate root development, has proven accurate. It is a matter of simple logic that if one root absorbs a certain amount of water and nutrients, additional roots can accomplish the same task more efficiently. Consequently, the plants grow more quickly and, if fertilized and irrigated properly (see below), they appear superior to any that may be collected from the wild.

Branching: Vegetative Propagation

Although some success in micropropagation of cycads has been reported (Chavez, et al., 1992; Jager and Vanstaden, 1996a, 1996b; Rinaldi, and Leva, 1995), commercially practicable protocols have not yet been achieved. Cycads do not possess lateral buds and therefore do not generate lateral shoots or branches (Stevenson, 1990). Except for very rare occurrence of "crested" plants, where multiple branches appear in a row(s), similar to a rooster's comb, dichotomous branching occurs only in male plants of some species. In this case, following cone production, the apical meristem divides once in one direction and in the following year at a 90 degree angle in relation to the first division. True division of branches is much less common in female plants and usually occurs at the base of the plant. However, the commonly known "pups" or "bulbs" which occur in some species, are adventitious in origin and may be used to vegetatively propagate cycads. A detailed discussion of this propagation method has been presented by Giddy (1974). Remove the "side shoots" with a knife, wash to dislodge debris or soil from the leaf bases, treat with a fungicide, and allow to remain in a cool location for about a week. Quick dip the cut end in IBA at 5000 to 10,000 ppm and plant in a well-drained medium. Keep moist but not wet until roots are formed. Be patient, it may take some time for adventitious roots to develop, perhaps as long as a year or longer for some species.

The adventitious branches are usually limited in number and often not feasible

BA treatment effects on *Zamia* seedlings

for commercial purposes. Localized application of certain growth regulators, such as Promaline (GA_4/GA_7 + BA) has been shown to increase the number of shoots dramatically (Dehgan and Almira, 1995). This method has proven so successful with *Z. floridana, C. revoluta* , and several other less common species. As a consequence of branching induction and unusually rapid development of the caudex, young plants appear very large, reaching a size usually expected of 50- or more year- old wild individuals. Although the primary intent of forced branching was conservation of rare and endangered plants for which seeds are generally unavailable, the method has shown considerable commercial potential. Additional studies are underway to further facilitate the practice.

Planting and Maintenance: Irrigation and Fertilization

It is a myth among nurserymen that most cycad species develop much too slowly for large scale production to be economically feasible. Admittedly some cycads are slow to develop and usually even much slower in reaching reproductive maturity. Stem growth is primarily dependent on annual leaf production, and in turn leaf development and elongation appears to be directly related to healthy root growth. Therefore, it follows that stimulating good root development would directly impact the plant growth. For plants to grow quickly and in good health, the soil mix must be well-drained, have an optimal pH and nutrient balance, and be kept sufficiently moist to meet the needs of the plant, but not so much as to create anaerobic conditions. In terms of large scale production in containers, one can only discuss watering and fertilization in relation to the soil mix. It has been pointed out that growth of cycads is negatively affected by severe reduction in soil moisture (Dehgan, 1983). Under cultivation, however, too frequent irrigation, as opposed to dryness, is often the problem that results in reduced soil oxygen and directly affects nutrient uptake and utilization.

Our soil mix recommendations of the past (Dehgan, 1983; Dehgan and Almira, 1993) made a distinction between species of the mesic and xeric habitats. While the basic principles upon which this division was based remain viable, some changes have become necessary to lower the weight of the soil mix and its cost. The following soil mix is recommended for all species, but with serious consideration given to their native habitat. Soil moisture should be primarily controlled by irrigation frequency rather than water-holding capacity of the soil mix. Thus, plants of the more mesic habitats, such as most species of *Zamia*, some *Ceratozamia* spp., *Bowenia* spp., *Cycas* spp., *Microcycas calocoma*, *Macrozamia* spp., *Lepidozamia* spp., and *Stangeria eriopus*. (Kunze) Baillon, require more frequent irrigation and a higher soil moisture than species of the more xeric habitats, such as *Z. furfuracea, Encephalartos* spp., *Dioon* spp., and somesome *Ceratozamia* species. A typical soil mix should have equal parts by volume of peat moss + sharp sand + perlite + pine bark, to which should be added 2.25 kg/M^3 (51b/yd^3) of dolomite and 1.25 kg/M^3 (3lb/yd^3) perk micronutrients.

Experience indicates that plants grown in acid soils (pH < 6.5) usually perform poorly. For example, Dehgan et al. (1994) recently noted that such problems as "frizzle top" (similar to that of palms) and micronutrient (specifically Mn,) deficiencies are indirectly caused by low soil pH. For best results the optimal soil pH should be 6.5 to 7.0, hence addition of dolomite. In general, except in acid soils, micronutrient deficiencies can be corrected with addition of micronutrients or application of "complete fertilizers". Availability of micronutrient-amended slow release fertilizers have made possible maintenance of a consistent, reasonable level of fertility in the soil for relatively long periods of time and avoidance of too frequent fertilization (Dehgan and Almira, unpublished data). However, a direct correlation between fertilizer amounts and shade levels has been shown by Keever and Cobb (1986) for *Z. furfuracea* and subsequently confirmed by Dehgan and Almira (unpublished data) *for Z. floridana, Cycas revoluta, C. taitungensis* C. F. Shen et al. (= *Z. taiwaniana* Carruth.), and other species. Higher growth rate and substantial increase in leaf number were observed in 30-50% shade and weekly application of liquid fertilizer at 200 to 300 ppm. Shading greater than 50% results in abnormally long, spindly leaves.

Conclusions

The recent escalation of interest in cycads by botanical scientists, professional nurserymen, and amateur collectors has contributed to both a greater appreciation of and endangerment to cycads. Several notable private collections around the world are of considerable significance in terms of germplasm availability, but the demand for plants has far exceeded the supply, resulting in decimation of many cycad populations. We can no longer allow wholesale destruction of these magnificent ancient plants. It befalls to horticulturists and nurserymen to produce superior plants so as to prevent plant poaching. Such an endeavor is possible only through horticultural research. It is a certainty that, despite the efforts of CITES and some governmental agencies, decimation of wild populations will continue as long as the demand for these valuable plants is not met through horticultural production. Research results of the past two decades have encouraged commercial production of cycads, which in concert with the Cycad Specialist Group of the IUCN and positive actions of CITES and concerned individuals has significantly frustrated, though by no means prevented, the pilfering of natural cycad populations.

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The Search for the Ultimate Cycad Seed Cleaning Procedure

(continued from pg. 2)

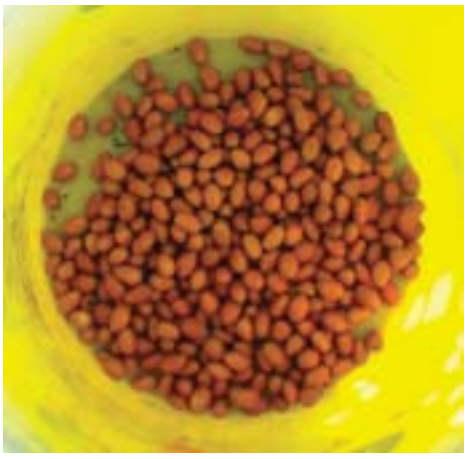
and I had perfectly cleaned seeds. Having to manually scrape each seed still took too long. I found that if I soaked the seeds in a bucket for three days and then used the wire brushes for a couple of minutes, the seed coats would be damaged enough to let the enzyme work. For those who don't have a drill, I found that after the three day period, if I put some gloves on and worked the seeds through my hands for ten minutes I would get the same results.

The next question was still critical. How would the use of the enzyme affect germination? I found that even after soaking seeds for up to three weeks, I had no loss of germination. I then soaked some seeds that had recently germinated in the enzyme and after three days, the radicles weren't adversely affected. I think the key is that this is a very specific enzyme and does not work like an acid that could damage seeds.

After experimenting with this enzyme for years, I have found that the enzyme reacts best at 95°F. If temperatures are lower than 80°, the enzyme doesn't work as well, and below 70°, the seed cleaning procedure may take several weeks, which can rot some of the seeds.

This product is not readily available to the average homeowner but is used for people in the citrus and fruit juice industry. I have been wanting to package this product in small quantities for cycad enthusiasts to use, but there are regulations in labeling where it can not be sold for purposes other than the specific tested use of the product. As with many chemicals, this enzyme comes with instructions on how to use it properly, otherwise known as a Material Safety Data Sheet (MSDS). I have found one retail outlet for pectinase. With the growing popularity of home-brewed beer there are stores that cater to this new hobby. The enzyme is used in making home-brewed beer and can be found in these specialty stores in some of our larger cities.

I now use this for most of my seed cleaning needs. Sometimes I purchase seeds that are not completely clean but have found that soaking them for a couple of days will clean them the rest of the way and help keep fungus from growing on the seeds. For all you "palm people" out there, I have found that the enzyme will perfectly clean any of the fruity palm seeds like *Arenga* and *Butia* by just soaking them for a few days. In the case of Arengas, the seedcoat is toxic and should not be handled, so this procedure is an easy way to clean these seeds without handling them. I am always testing ways to make my job easier and improve plant growth, but I think that in this case I may have the ultimate seed cleaning procedure.



Completely cleaned seeds

Related Societies

Cycad Society of South Africa

The Cycad Society of South Africa is a nonprofit international organization that is based in South Africa. It is devoted to education and the conservation of cycads. Its quarterly magazine, "*Encephalartos*", is sent to members by airmail and *inter alia* contains information on the discovery of new cycad species. Please contact one of the following correspondents:

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