

Parasitic plants: Important components of biodiversity

By Marcos A. Caraballo-Ortiz

Parasitic organisms are generally viewed in a negative way because of their ability to “steal” resources. However, they are biologically interesting because their dependency on hosts for survival have influenced their behavior, morphology, and genomes. Parasites vary in their degree of necessity from a host, ranging from being partially independent (hemiparasitic) to being complete dependent (holoparasitic). Some parasites can live independently, but if they find potential hosts, they can use them to supplement their nutritional needs (facultative parasitism).

Parasitism is not a phenomenon unique to animals, as there are plants parasitic to other plants. Current biodiversity estimates indicate that approximately 4,700 species of flowering plants are parasitic, which account for about 1.2% of the total inferred number of plant species in the world. About half of the known species of parasitic plants belong to a single order, Santalales, which is diverse and mainly composed of hemiparasites. However, parasitism has evolved independently in 11 lineages of angiosperms comprising 27 families, some of them small and consisting of only one species. Parasitic plants have been able to colonize almost every corner of the world (except the polar regions), and many are common in lowlands and disturbed hab-

itats. Only a few parasitic plants yield economically important products such as the sandalwood, obtained from the tropical shrub *Santalum album* (order Santalales). Other products are local and include traditional medicines, food, and crafts like “wood roses”. Many parasites are also considered agricultural pests as they can impact crops and timber plantations.

It is difficult to describe a typical parasitic plant because they possess a wide diversity of growth habits such as trees, terrestrial or aerial shrubs, vines, and herbs. The largest

Continued on page 2

Tropical mistletoes are very diverse but still poorly known.

Herbaria house many unidentified and misidentified specimens.

*Marcos A. Caraballo-Ortiz,
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Mistletoes

Continued from page 1

known parasitic plant is the tree *Okoubaka aubreviellii* (order Santalales) from tropical Africa, which can reach up to 40 m tall and parasitize many species of trees, apparently killing the closest neighbors to minimize competition for light. The smallest parasite is likely the miniature mistletoe *Viscum minimum* (also in order Santalales), whose tiny stems and inflorescences measure up to 3 mm long and in nature, only grows on two species of spurges (*Euphorbia horrida* and *E. polygona*, Euphorbiaceae) from South Africa. It is notable that the largest flower in the world, the corpse lily (*Rafflesia arnoldii*, Rafflesiaceae), is a parasite that grows embedded into the stems of a woody vine (*Tetragastria* spp., Vitaceae) in the rainforests of Sumatra. Many other parasitic plants grow as vines such as dodders (*Cuscuta* spp., Convolvulaceae) and the laurel dodder (*Cassytha* spp., Lauraceae), which form dense masses of twining yellowish stems wrapping their hosts. Terrestrial parasites like broomrapes (*Striga* spp., Orobanchaceae) are known for their capacity to affect or even destroy agricultural crops such as rice, maize, sugarcane, and sorghum. Some parasitic herbs are not aggressive and are used as ornamentals in gardens such as the Indian paintbrush (*Castilleja coccinea*, Orobanchaceae) and



Aerial shrubby habit of a mistletoe (*Dendropemon purpureus*, Loranthaceae) on the branches of a calabash tree (*Crescentia cujete*) in Gonave Island, Haiti. (photo by M. Caraballo)

Orders and families containing parasitic flowering plants, with estimated numbers of genera and species. Names within quotes include taxa not properly recognized yet by the Angiosperm Phylogeny Group IV (APG Bot. J. Linn. Soc. 181:1–20; 2016). Estimates obtained and adapted from “The Parasitic Plant Connection” website by Daniel Nickrent (2019; <https://parasiticplants.siu.edu>).

Order	Families	Parasitic Genera	Parasitic Species
Boraginales	Lennoaceae	2	4
Cucurbitales	Apodanthaceae	2	10
Ericales	Mitrastemonaceae	1 (<i>Mitrastemon</i>)	2
Lamiales	Orobanchaceae	100	2,100
Laurales	Lauraceae	1 (<i>Cassytha</i>)	20
Malpighiales	Rafflesiaceae	3	35
Malvales	Cytinaceae	2	12
Piperales	“Hydnoraceae”	2	12
Santalales	16 “Families”	166	2,284
Saxifragales	Cynomoriaceae	1 (<i>Cynomorium</i>)	1
Solanales	Convolvulaceae	1 (<i>Cuscuta</i>)	215
Zygophyllales	Krameriaceae	1 (<i>Krameria</i>)	23
Total Number of Parasitic Plants	27	282	4,718

some species of louseworts (*Pedicularis* spp., Orobanchaceae).

The most recognized parasitic plants are probably mistletoes which are aerial hemiparasitic shrubs. Mistletoes are part of the folklore from many countries and are still included in modern traditions such as the Christmas custom of kissing under the mistletoe for enduring love. The Christmas mistletoe involves two species: the European *Viscum album* and its American counterpart *Phoradendron leucarpum*. However, mistletoes are a diverse group comprising about 1,663 species in 90 genera distributed around the globe, especially in the tropics. All mistletoes belong to order Santalales where they are classified in five families: “Amphorogynaceae”, Loranthaceae, Misodendraceae, Santalaceae, and “Viscaceae”.

All mistletoes have the capacity to create their own food through photosynthesis, hence the term “hemiparasites”. However, since mistletoes depend on hosts to obtain water and some mineral nutrients,

they are also considered obligate parasites. The relationships between mistletoes and hosts is complex and involves compatibility at the physical, physiological, and most likely genetic levels. Mistletoes, as well as other parasitic plants, can have unusual chloroplast genomes with major alteration or losses of genes and rearrangements of their genomes due to their dependence on hosts.

Most mistletoes also have intimate interactions with birds, depending on them for seed dispersal and sometimes pollination services. In fact, studies have shown that there are lineages of birds and mistletoes that have coevolved, where birds specialize in feeding on mistletoe fruits and track them across the landscape. In a similar way, some mistletoes have evolved specialization to grow only in one or a few species of trees. For example, the dwarf mistletoe (*Arceuthobium*, Viscaceae) parasitizes pines (Pinaceae), junipers and cypresses (Cupressaceae) exclusively. In spite of being parasites, mistletoes are important



Inflorescence of the American cancer-root (*Conopholis americana*, Orobanchaceae) parasitizing the roots of a red oak tree (*Quercus rubra*, Fagaceae) at the Shenandoah National Park, Virginia. Note the yellowish color of the plant which reflects its holoparasitic nature. (photo by M. Caraballo)

components of ecosystems and are even considered keystone species because of their capacity to attract and maintain biodiversity.

My current research project at the National Museum of Natural History is focused on the genetics and taxonomy of mistletoes from tropical America. With a concentration on the Loranthaceae mistletoes, I am exploring the structure of their chloroplast genomes and building a phylogeny that will include almost all known Neotropical genera. The results from this work will help clarify the generic delimitations of mistletoes and I will propose taxonomic changes if needed. As tropical mistletoes are very diverse but still poorly known, and herbaria often house many unidentified or misidentified specimens, my contribution of updated mistletoe identification keys will assist in the curation of herbarium specimens.

Another aspect of my research project is the study of mistletoes from island systems. Many tropical islands worldwide

harbor a rich endemic flora, and the Caribbean Islands are not an exception. The Caribbean island archipelago is one of the world's top five hotspots of biodiversity, containing one of the highest concentrations of endemic plant and animal species on the planet, but much of the endemic diversity remains little studied. An outstanding component of these island-endemic floras are mistletoes in the genus *Dendropemon* (Loranthaceae), which is one of the most species-rich of the 180 island-endemic plant genera of the Caribbean.

Dendropemon and its close relatives form an ancestral clade of small-flowered mistletoes, and is among the seven most diverse genera (out of 76) of Loranthaceae worldwide. The flowers of *Dendropemon* are among the smallest in the family and are easily distinguished by an extreme dimorphism of stamens, by the presence of staminodia, and by monads in the inflorescences. *Dendropemon* is also the most widely distributed island-endemic plant genus in the Caribbean, and presents a

showcase for the study of biogeography and diversification in the region.

During an integrative taxonomic revision in preparation, I have discovered several new species of *Dendropemon* and a series of nomenclatural and taxonomic changes in the genus, highlighting the importance of combining herbarium specimens, fieldwork, and modern molecular techniques to revise the taxonomy of this poorly known and diverse group. My work also incorporates the conservation of endangered parasitic plants, especially when they are island-endemic and depend on rare host trees for their survival.

In summary, parasitic plants such as mistletoes offer an excellent opportunity to study the evolution of interactions between plants from the genomic and ecological perspectives. My research emphasizes the need to conduct integrative taxonomic studies of poorly known groups of organisms using traditional herbarium studies and modern molecular techniques to assess their global diversity.



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On the cover: Laurel dodder (*Cassytha filiformis*, Lauraceae) twining around the stems of its host (*Croton* sp., Euphorbiaceae) on Providenciales Island, Turks and Caicos. (photo by M. Caraballo)

Linnean Medal awarded to Vicki Funk

Vicki Funk was awarded the Linnean Medal at the annual meeting of The Linnean Society in May 2019. It is bestowed annually to one or two biologists (in any field), as an expression of the Society's esteemed appreciation for service to science. Although Funk was unable to attend the May meeting in London the current President of the Society, Sandy Knapp, brought the medal to Washington DC, and presented it to Funk on 2 October with many colleagues from the National Museum of Natural History in attendance.

Funk was highly deserving of this career award which recognized her prodigious contributions as an indefatigable and innovative evolutionary biologist, a field and herbarium botanist, a pure taxonomist, and an enthusiastic mentor of many students and early career scientists which included a special emphasis on women in science. Her career hallmarks included prolific and transformative research, innovations to the ways we do systematic botany, including early emphasis on the use of

cladistics and biogeography, in addition to significance of field work, use of herbarium collections, and a lifelong interest with many significant contribution to the evolution of the largest angiosperm family, the Compositae.

Lamentably, Funk passed away on 22 October 2019. She will be greatly missed, but leaves an enduring legacy of unwavering research and mentorship. *The Plant Press* will feature an expanded article on her life and contributions in the next issue.



Sandy Knapp, president of the Linnean Society of London, presents Vicki Funk with the Linnean Medal, awarded to a botanist for their service to science. (photo by Ken Wurdack)

The Global Genome Initiative for Gardens at 5 years: Intern retrospectives

By Morgan R. Gostel, Farahnoz Khojayori, Jacob Suissa, Kadiera Ingram, Maryam Sedaghatpour, Monica Marcelli, Seth Hamby, and Vicki A. Funk

This year marks five years since the start of the Global Genome Initiative for Gardens (GGI-Gardens) program and it seems an appropriate time to reflect upon the program's accomplishments. In this time, we have partnered with more than 25 botanic gardens across four continents; moved our headquarters to the Botanical Research Institute of Texas (BRIT) in Fort Worth, Texas; collected over 3,000 vouchers; funded four GGI-Gardens partner awards; sequenced more than 5,000 plant DNA barcode loci; and are making genome-quality tissue and DNA sequences available for researchers through the Global Genome Biodiversity Network (GGBN).

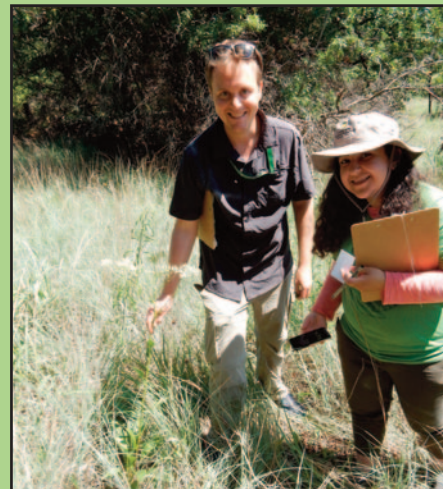
At the core of GGI-Gardens is building capacity for the next generation of botany, whether by mobilizing a worldwide voucher program through partnerships with botanic gardens or by training and supporting the next generation of botanists through internships and fellowships. More than 10 interns and fellows have been trained through the GGI-Gardens program and over half of them are still involved in botany! This summer a couple of GGI-Gardens alumni, Maryam Sedaghatpour and Jacob Suissa, presented at the annual Botany Conference in Tucson, Arizona and we wanted to highlight their (and other GGI-Gardens alumni) accomplishments. We asked a few past interns to share reflections and updates.

Are you interested in getting involved with GGI-Gardens? Your garden can join our partnership by signing our Memorandum of Cooperation (<http://ggi.si.edu/ggi-gardens>).

Farahnoz Khojayori

A summer among wildflowers under shadows of ancient trees, and filled with the trickling sounds of life is the gift of a GGI-Gardens fellowship. During the course of three months, Morgan Gostel, Seth Hamby, and I travelled across seven of the ten ecoregions of Texas. In our mission to collect genome quality tissues of the flora of Texas, we made over 250 collections at the genus level, representing 84 plant families from the tree of life.

Our adventures this summer took us from BRIT into 13 different botanical sites. Each excursion was a snapshot of the botanical field including: species conservation, horticulture of rare species, botanical education, discovery of new phenomena, and cultivation of a botanical culture. The most profound part of the experience, aside from meeting some of the most amazing human beings in the world, was witnessing the awe-striking morphological diversity of plants. I was mesmerized by the intricate leaf structures of ferns, the curious delicacy of epiphytic orchids, and the complex



Morgan Gostel and Farahnoz Khojayori collecting *Arnoglossum plantagineum* at the Fort Worth Nature Center. (photo courtesy of Bob O'Kennon)

arrangements of floral structures and their transitions to paradoxical fruit structures. I feel profoundly inspired by this indelible experience and am enthusiastic for a life in the study and appreciation of botanical wonders.

Jacob Suissa

Working with Vicki Funk and Morgan Gostel as one of the GGI-Gardens interns in 2017 was an opportunity that prepared me well as a current doctoral student in the Department of Organismic



Jacob Suissa visiting Chapada Diamantina National Park, Brazil as a Teaching Assistant for Harvard University's Plant Systematics course.

and Evolutionary Biology at Harvard University. As a GGI-Gardens intern I was able to enhance my skills in plant identification and specimen curation, both of which are insurmountable in my current work. My dissertation project as a doctoral student in the Friedman lab centers around untangling the 200 years of study on vascular arrangement in fern rhizomes to understand its evolution and functional implication. By taking both a broad scale macroevolutionary and a small-scale organismal approach, I bring a new arsenal of tools to answering these old botanical questions.

As I progress through my Ph.D., one thing that I value are the connections I made with my scientific mentors as an intern at the NMNH and as an undergraduate. I still keep in contact with many of the people I worked with, and it is rewarding to have impactful scientific collaborations developing from our relationships.

Continued on page 6

Kadiera Ingram

When I started my internship with GGI-Gardens I had a knack for deciphering which family or even genus a plant might belong to, but lacked the appropriate terminology to support this “hunch” or “feeling”. GGI helped me build my dictionary of morphological characteristics and become more comfortable using these terms in the field. The program also taught me how to properly preserve plant tissue for future laboratory analysis, and how to take good photos of field specimens—the kind that will allow you to key out and get a solid second opinion on your conclusions when you get back to the lab or herbarium.

My experience with GGI-Gardens

turned out to be immensely helpful in my next role as a field biologist for the US Geological Survey studying the aquatic locally invasive genus *Trapa* (Lythraceae). One of my roles as a technician is to help select an index of morphological traits that will allow us to visually distinguish the familiar and well-known *Trapa natans* from a genetically distinct, unknown *Trapa* recently discovered in the Potomac watershed. Field photography, detailed note taking, careful record keeping and preservation of plant tissue on silica gel for genetic analysis are all important functions of the job, and I was able to complete these tasks easily and with confidence owing to my experiences with the GGI Gardens team.



Kadiera Ingram sampling the aquatic invasive, *Trapa natans*, for genetic and morphological analysis with the US Geological Survey.

Maryam Sedaghatpour

In 2016 I was finishing the last year of my bachelor's degree at George Mason University and came across the opportunity to intern at GGI-Gardens



Maryam Sedaghatpour pressing plants after a day of collecting from Baniyas, Syria in July 2018.

with Morgan Gostel and Vicki Funk. I had met Morgan two years prior in Andrea Weeks' lab where he was doing final edits to his dissertation and I had started work on a population genetics study. When Morgan asked if I was interested in interning with GGI I knew it would be a great step forward for my career.

Our team at GGI worked towards archiving genome-quality tissue for all vascular plant genera in the world. Now, as a Ph.D. student at the University of California Berkeley, I will lead similar collecting expeditions for my own dissertation research on the phylogenetic investigation of the diversity of the Eastern Mediterranean flora. In addition to collecting specimens, conducting molecular lab work, and co-authoring my first publication, my time at NMNH was a pivotal point in my transition from an undergraduate research assis-

stant to a member of the broader research community. I applied for and was accepted into graduate school while working at NMNH where I had the unwavering support of the GGI team, specifically Morgan and Vicki, both of whom continue to be a source of encouragement and inspiration through the ebb and flow of academic life.

In my career I aim to bring to light the unique and diverse flora that exists in the Middle East, and to create substantial conservation impact in the region. I believe living with intention and pushing culture forward is largely what drives me, but in no small part the influence of supportive and uplifting mentors like the GGI community is what has brought me to where I am today.

Monica Marcelli

I had an unforgettable experience working with GGI. For me, it wasn't work, it was going to paradise. What can be better than collecting plant DNA at the National Arboretum, the U.S. Botanic Garden, and Smithsonian Gardens? In addition, Morgan Gostel was an amazing

supervisor. The team that I worked with was very nice, helpful and knowledgeable. I was fascinated by the hundreds of orchids that are in the SI greenhouses. Through networking at this job, I had the opportunity to meet colleagues at the Smithsonian Environmental Research

Center (SERC). One of these, Melissa McCormick, is now on my Ph.D. Committee—now that I have begun a Ph.D. program at George Mason University (GMU). Through GGI-Gardens I learned how to collect plant DNA, and curate

Continued on page 7

and mount herbarium specimens.

I started my Ph.D. at GMU at the beginning of 2019 and am now a Visiting Research Scientist at SERC, where I am working with *Cypripedium*. I am also learning lab techniques in molecular biology to be able to sequence and analyze my orchid data. I will attend two Restriction Amplified DNA (RAD) sequencing workshops in New York that are funded by a grant. My experience at SERC has exceeded all my expectations. I have had the privilege to do lab and field work with people who are as passionate about orchids and molecular biology as I am and also nice, friendly, smart, helpful and knowledgeable. I am also very lucky to have Melissa as a wonderful adviser and committee member.

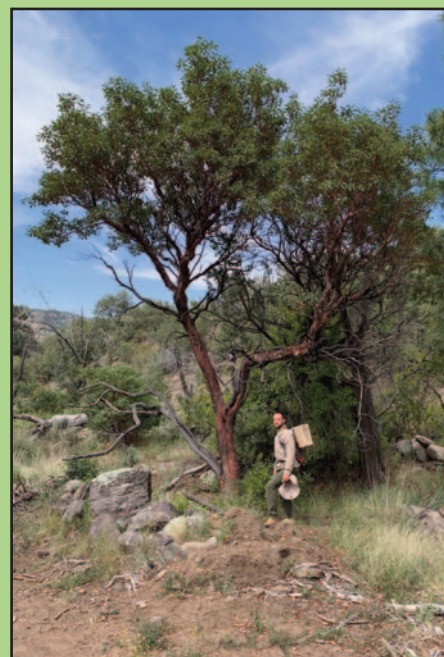


Monica Marcelli with SERC interns, Simone Evans and Thomas Chapin, hand pollinating *Platanthera* in the field.

Seth Hamby

Texas is a state that you can drive through for 7 hours and still be in Texas; believe me, we did it this summer! Because of its geographic location, geology, and rainfall gradient, Texas supports tons of different ecoregions, ecotones, and microhabitats that foster some of the highest biodiversity in the country, second only to California. Coming into the GGI-Gardens fellowship I didn't really know what to expect. I figured that we would devote most of our time to lab work and only get a few chances to go collecting out in the field. Little did I know that we would travel thousands of miles, spend countless hours in the field, collect amazing botanical wonders, and meet some of the coolest plant nerds on the planet. I can say with confidence that this summer has been one of the greatest experiences of my life. Not only did I gain valuable botanical and field experience, but there's nothing like spending a week in a car to discover who you really are as a person.

We ended our summer with the mother of adventures to the rugged and gorgeous Trans-Pecos region. My only experience in the area was from driving through twice, both times at night, so I was really taken aback by the stunning and seemingly impossible beauty. Superficially it seems as if the landscape is rather desolate with pockets of life few and far between. But upon further investigation you realize that the area is a rich biodiversity hotspot. I am reminded of a



Seth Hamby stands in front of a large Texas madrone (*Arbutus xalapensis*) at the Nature Conservancy's Davis Mountains Preserve in Fort Davis, Texas.

quote by Henry Miller that says, "the moment one gives close attention to anything, even a blade of grass, it becomes a mysterious, awesome, indescribably magnificent world in itself." During our trip to the Trans-Pecos, I accepted a position as Head Gardener at the Chihuahuan Desert Research Institute. I am forever grateful for my experiences this summer as a Fellow with GGI-Gardens.

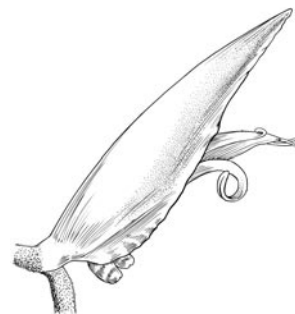
Congressional Night at the Museum

The 2019 Smithsonian Congressional Night was held at the National Museum of Natural History (NMNH) on the evening of July 17. NMNH partnered with the Smithsonian's Office of Government Relations to host the event which attracted 2,100 guests and 29 Members of Congress. The event encouraged Congressional staff to meet members of the museum's research staff, engage in educational activities, and visit the museum's exhibit halls. NMNH last hosted the event in 2013.

The success of Congressional Night was in part due to broad participation from across the museum's research departments.

Gary Krupnick and Liz Zimmer represented the Department of Botany who joined 90 other members of the NMNH community to share their research and volunteer their time to help the event run smoothly. Zimmer talked about her research in the molecular evolution of quillworts and the Vitaceae. She displayed specimens of *Isoetes* and ginseng roots. Krupnick spoke about how herbarium specimens are used in conservation biology research. He displayed specimens of *Xylosma serrata*, a critically endangered and possibly extinct species from Montserrat; coco de mer, a plant that produces the

largest seeds in the plant kingdom; and goldenrod in which its pollen grains have been shown to exhibit a decrease in protein content as atmospheric carbon dioxide has increased over time.



A splitting headache: a herbarium specimen conservation project

By Erika Gardner

Mixed sheets were created either “deliberately as past practice or accidentally because they have not previously been recognized as a mixture” (Forman & Bridson 1989. *The Herbarium Handbook*. Royal Botanic Gardens, Kew). Over a century ago, access to herbarium supplies were not readily available and very costly. Many botanists and institutions did not have funding to mount every specimen onto its own herbarium sheet. Compromises had to be made and multiple specimens were mounted onto one sheet to reduce cost and space. This was especially true in the 1930s during the great depression. The other scenario involves the collector unknowingly collecting different species from the same collection event and classifying it under one collection number. These mixed sheets are usually found when a researcher annotates specimens many years later.

Mixed sheets are often found filed away in cabinets of the US National Herbarium. It is unknown how many exist in the collection, but possibly hundreds of thousands. After we completely image and digitize the collection, we will have a better understanding for just how many we have. Usually the collection management staff are informed about these specimens when they are returned from being on loan. This

past summer, volunteer Shannon Hicks worked on a pilot project to dismantle, split, and remount about 90 mixed sheets. This project helped us learn about the process, challenges, and time needed to complete this conservation project.

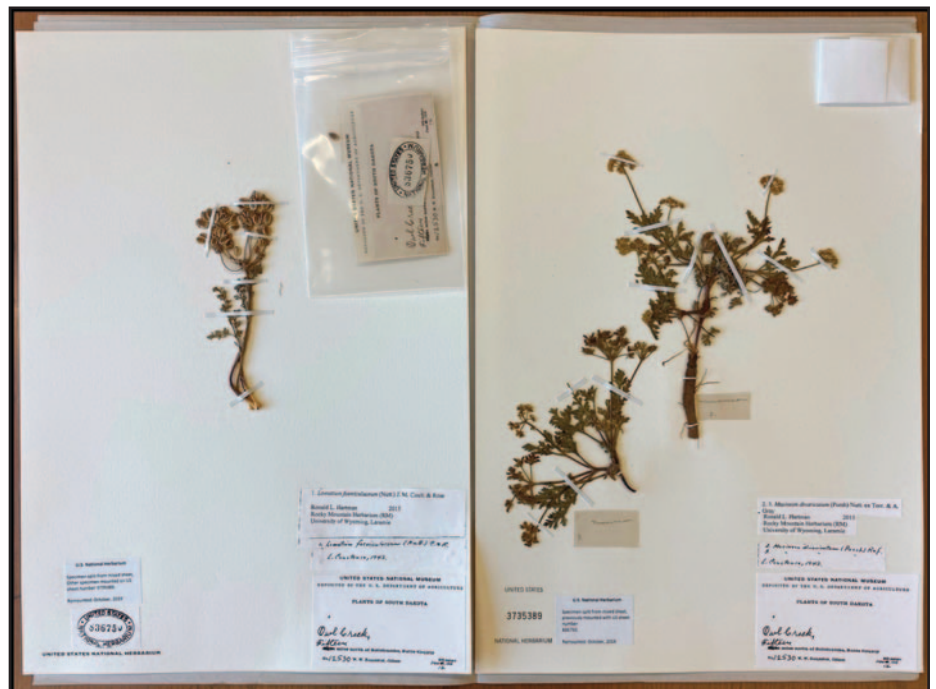
There are many reasons why splitting mixed sheets is desirable. Although it is much easier to place multiple sheet numbers and barcodes on a mixed sheet, for curatorial reasons it is much better for these specimens to be mounted on their own herbarium sheet. These specimens create a number of curatorial problems for staff and researchers:

1. Filing a mixed sheet with different species is difficult. Staff have to decide which name to file the specimen under. If the specimen is refiled it could potentially be filed under the other specimen name. If this occurs, the filed under name might not be updated in the database.
2. Data entry staff need to create two or more records for one sheet and then add cross-reference information in the notes field. When these specimens are imaged, one image is associated with two records. However, mixed sheets are often overlooked if they only have one label.
3. Researchers annotating specimens have to determine how to designate the

different species on the sheet using letters or numbers next to the specimen and then attach a corresponding annotation label. Citing these specimens also poses interesting challenges because two or more specimens can correspond to one sheet number, which can be confusing if not mentioned in the publication. In addition, when researchers use the specimens it is sometimes difficult to keep track of which specimen corresponds to which annotation.

Before making the decision to split specimens, it is useful to ask the following questions:

- Are there types on the sheet? Depending upon each collection's standards and operating procedures, mixed sheets with types require special curation by a higher-level staff member.
- Are the species the same, but the labels from different collecting events (ex. date and collection number different)?
- Are the species the same and collected from the same country or state? Depending upon the time and resources available, these might not need to be split because they will eventually be filed together. It is up to the discretion of the Collection Manager or



Left: A mixed herbarium sheet before the splitting process. Right: Two specimen sheets are the result of splitting a mixed sheet.

Curator to decide as these are considered a lower priority.

- How many mixed specimens are in the collection? Do I have the time and/or personnel to do this?

As Hicks was working though the bundle of mixed sheets we encountered some of the following issues and documented the various challenges. The following are things to note and should be taken into consideration when working with mixed sheets:

- If there is only one fragment packet on the sheet for multiple species and the researcher did not indicate which specimen corresponds to the fragments:
 - Solution 1: get an expert opinion.
 - Solution 2: place the fragments in a separate packet on one sheet and indicate on the packet that it is not clear which specimen it belongs. Cross-reference the other sheet and species name on the packet.
- If the annotation designates multiple species but the plant material is not clearly designated which species is which:
 - Solution: ask an expert to help identify the specimens.
- Data entry technicians need to enter cross-reference annotations in a notes field.
- Severely discolored labels not scanning to quality standards:
 - Solution: specimen labels should be transcribed and hand typed.

This procedure is a major time commitment. Keep in mind that dismantling specimens takes just as much time as mounting, and that one specimen is being split into two or more specimens. Each specimen takes time to mount. The work is actually tripled or more. Follow through with the entire process from beginning to end. Do not dismantle specimens and leave them for someone in the future. Also, split and remount only a few specimens at a time. Take into consideration how much time is needed if you are splitting 10 specimens, which will eventually be 20 or more specimens. The process of scanning, cutting and matching labels requires a lot of concentration. Write on the back of the labels the sheet number that corresponds with each label in order to keep the labels from getting swapped or lost. It is much easier to get a fair amount of these specimens completely conserved if two people

work together on this project. One person dismantles and remounts specimens leaving room on the sheet for the labels, while the other scans and cuts labels and then remounts the labels to the sheets.

In total, Hicks remounted 180 sheets and committed an entire month working on this project. Since our collection holds a considerable number of mixed sheets, we decided to prioritize which mixed sheets are the highest priority to split. Mixed sheets returned from being out on loan are given the highest priority since they most likely have not been imaged. Specimens pulled from the collection are evaluated, but we are cautious about the time these specimens require to be remounted. Overall, it is a worthwhile project but requires a lot of attention to detail to fulfill the process from beginning to end.

The Splitting process:

1. Identify the specimens that need to be separated. Use numbers (ex. 1, 2, & 3) to indicate the different species, then use a pencil to draw an outline around each species. There is only one specimen label and one sheet number on the sheet for multiple species.

2. Detach the specimens from the sheet. Tools: Scissors, tweezers, probe and flimsies. Straps and threads are cut off with tweezers or probes. US does not practice gluing specimens to sheets. If specimens are glued to the sheet, use scissors to trim around the specimen. Try to do as little damage as possible to the specimen.

3. Place specimens in individual flimsy/newspaper sheet. Keep all annotations, notes, and labels with the appropriate specimen. Nest flimsies together to keep track of which specimens were previously mounted together. Tip: write the original sheet number on each flimsy in case they are separated.

4. Fujitsu ScanSnap ix500 scanner. Configure ScanSnap settings to scan labels and annotations, especially those with paper damage or acid discoloration. Using the ScanSnap plastic sleeve, arrange the labels on a piece of paper (Tip: to scan multiple labels at once and to keep labels from sliding during the scanning process, place a tiny dab of glue on each label and adhere to blank piece of paper). Print on acid-free paper.

5. Remount specimens on separate sheets with unique sheet numbers. If there was only one sheet number, decide

which specimen will retain the original number and which specimen will receive a new sheet number. If there was only one specimen label, print a duplicate of the label for the other specimen. Before mounting, configure specimens to show the best characters. Attach newly printed labels, annotations and notes to appropriate sheets. Keep the original label and annotations with one of the specimens in a separate packet. All sheets should be given a cross-reference annotation label mentioning specimen was previously part of a mixed sheet. Cross-reference the other sheet number on the new annotation label.



Lorraine Eyde (1932-2019)

Dr. Lorraine Sylvia Eyde (née Dittrich) passed away on July 10, 2019 at the age of 87. She was the widow of Botany curator Richard Husted Eyde (1928-1990), whom she married in 1957. While Dick was completing his Ph.D., the couple lived in India (1960-1961) where Dick had a Fulbright scholarship. Subsequently, they moved to D.C. so that Dick could work at the Smithsonian. A strong proponent of women in the workforce, Laurie pursued her own independent career as a psychologist with the Office of Personnel Management. She continued to maintain an interest in Botany in retirement and served for many years as the Secretary of the Botanical Society of Washington. A son and a grandchild survive her.

A review of field guides to grasses of the western United States

By Robert J. Soreng

Over the last 12 (to 26) years several field guides to grasses of western United States were published. See the list of cited field guides below with notes on each of them.

Of these guides, those for Alaska (Skinner et al., 2012), Nevada (Perryman & Skinner, 2007), Oregon & Washington (Roché et al., 2019), Texas (for the most part) (Shaw, 2012), and Wyoming (Skinner, 2010) are fully illustrated with photographs of habits and diagnostic parts, sometimes supplemented by line drawings. One additional guide listed below, for Wisconsin (Judziewicz et al., 2014), covers many of north central prairie grasses, and is very thorough and excellently done.

Four other western guides are amply illustrated with line drawings (with or without a few photos): California (Smith, 2014), Colorado (Shaw, 2008), New Mexico (Allred, 1993), and the Intermountain Region (Anderton et al., 2009). You may also find two recent illustrated contributions from Chihuahua (Herrera Arrieta & Peterson, 2018), and Coahuila (Valdés-Reyna, 2015) useful for our southern border regions. Excellent illustrations in these guides are mainly reproduced from the *Flora of North America* (FNA; Barkworth et al., vol. 25, 2003 & vol. 24, 2007), *Vascular Plants of the Pacific Northwest* (Hitchcock et al., 1969), or *Manual of Grasses of the United States* (Hitchcock {Chase ed.}, 1951). I also recommend the 2nd edition of the *Flora of the Pacific Northwest* (Hitchcock et al., 2018), which has been extensively updated for taxa and taxonomy, and still has great illustrated keys. Grass species are still difficult to key out, and having good photos to aid identifications makes a world of difference!

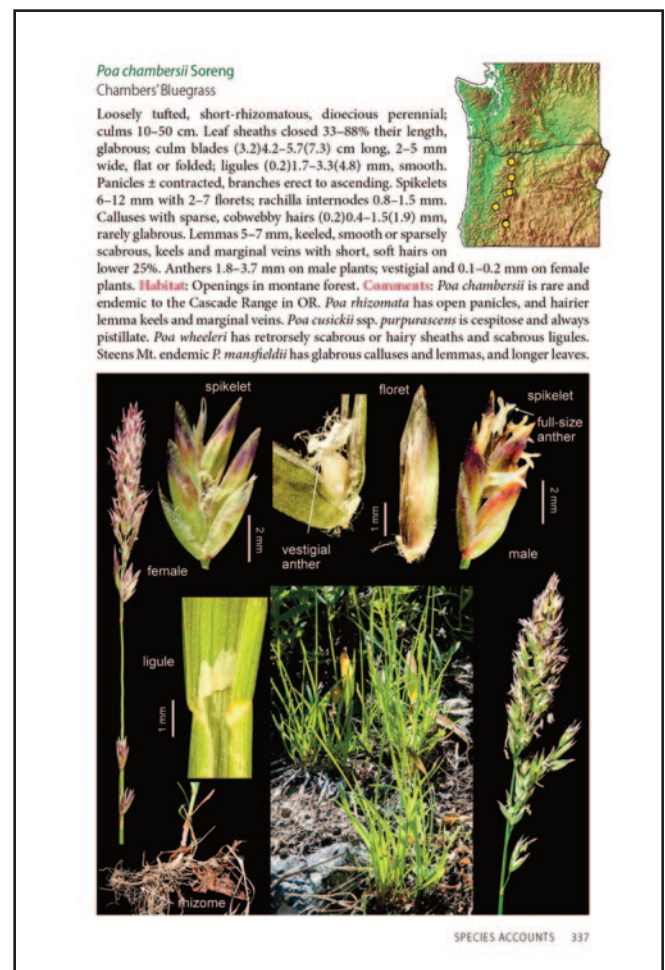
All treatments in all the grass guides listed, except the New Mexico volume, were completed after publication of FNA, and most follow the genera and species as presented there, and are comprehensive for species coverage in their states, except the California guide (Smith, 2014). Keeping up with changing classifications, genus circumscriptions, new species, and exotic introductions is a chore, and most of these accounts are inevitably a bit dated (I can't even keep the Catalogue of New World

Grasses up to date on Tropicos.org), but as accurate field guides to species identification go, these guides are great. Some taxonomic updates: *Vulpia* belongs in *Festuca* s.s., *Schedonorus* belongs in *Lolium*, *Scribneria* belongs in *Deschampsia* s.s., *Crypsis* and *Spartina* belong in *Sporobolus*, *Penisetum* belongs in *Cenchrus*, etc. (for a 2017 classification of grasses see <https://dx.doi.org/10.1111/jse.12262>). More recently, *Achnatherum* of North America mostly belongs in *Eriocoma* while a few others belong in *Barkworthia*, *Pseudoeriocoma*, *Thorneochloa* (<https://dx.doi.org/10.3897/phytokeys.126.34096>).

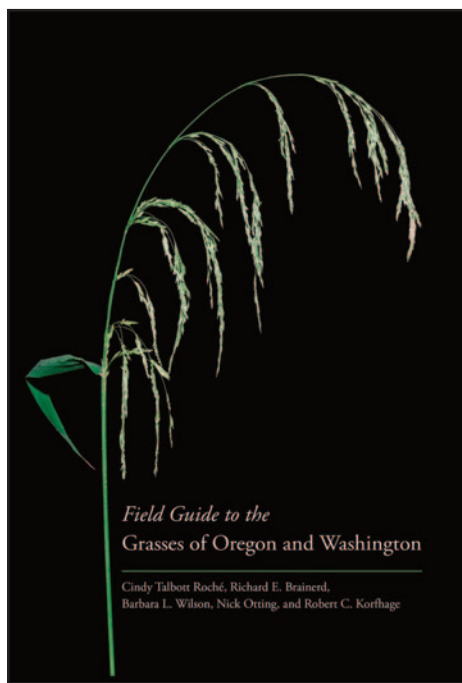
Three guides were sole authored, first authored or coauthored by Quentin Skinner (Alaska, Nevada, Wyoming) who taught Agrostology at University of Wyoming. These are fully illustrated by color photos with comprehensive species coverage. All these “Skinner” guides have excellent photos with field habit shots and close ups of diagnostic parts, descriptions, keys to genera and species, and detailed specimen dot maps on county base maps, or color base maps (Alaska). These guides set a high standard for photography for field guides to grasses. I highly recommend them.

The newest contribution is a *Field Guide to the Grasses of Oregon and Washington*, by Roché et al. (2019). After some 15 years in preparation it is finally published, and I am happy to see it. The book is well laid out with keys to genera, genera descriptions and keys to species, followed by species accounts. All genera and species are arranged alphabetically. Limited classification information is buried in keys to genera. Each species has a description, color photos of habits and

parts, and a full dot range map for Oregon and Washington on nice topographically colored base maps. The vouchers for these dots are all on-line via the Oregon Flora Project and/or the Consortium of Pacific Northwest Herbaria websites, and were carefully vetted, although the Crater Lake and a few other dots on the map below belong to *Poa cusickii* subsp. *purpurascens*. The diagnostic characters for each species are photographed on a black background to highlight coloration, textures, prickles and hairs, and shapes. All the photos were carefully edited and are sharp. These are a delight to scan through. Scale bars are included for parts, along with labeled parts and pointers to diagnostic traits. Cindy Roché was one of the main illustrators of grasses for FNA vol. 24 & 25, which shows through in attention to key characteristics in the photos. Such high-quality photos help to capture the feel for each grass



A page plate featuring *Poa chambersii* Soreng from the *Field Guide to the Grasses of Oregon and Washington*.



Field Guide to the Grasses of Oregon and Washington (Oregon State University Press) by C.T. Roché, R.F. Brainerd, B.L. Wilson, N. Otting and R.C. Korfhage (2019).

species and bring them to life. Photographing all species in the field took a lot of care and time, with many road and trail miles. Photographing grasses is not easy work, as anyone who's tried it knows, as I have for over 40 years with variable success. I highly recommend this guide for learning and identifying grasses in the Pacific Northwest.

List of Cited Field Guides

Allred, K.W. 1993. *A Field Guide to the Grasses of New Mexico*. Department of Agricultural Communications, New Mexico State University, Las Cruces. **Notes:** 1-259 pp. keys, and illustrations (genera and some species) line drawings mostly from *Manual of Grasses of the United States*, and county dot maps, comprehensive. No ISBN, Spiral bound.

Anderton, L.K. and M.E. Barkworth. 2009. *Grasses of the Intermountain Region*. Intermountain Herbarium, Logan, UT. **Notes:** xi + [1]—559 (and inside covers), fully illustrated with excellent line drawings by C.T. Roché et al. (from FNA vol. 24 & 25), all accounts extracted from FNA (reformatted with abbreviations added), with keys to genera and species, and descriptions, comprehensive, unfortunately the

organization of genera is as chaotic (particularly so in tribe Poeae) as in FNA, and species are arranged in infrageneric groups, not very helpful for a field guide, the illustrations are all in the back in the same order. ISBN 978-0-87421-7773, Spiral bound.

Herrera Arrieta, Y. and P.M. Peterson. 2018. *Grasses of Chihuahua, Mexico*. *Smithsonian Contr. Bot.* 107: i–ix, 1–380. **Notes:** specimens cited (no maps), keys to genera and species, comprehensive, many species illustrated by line drawings (mainly from FNA vol. 24 & 25, M.E. Barkworth et al., eds.), pdf open access (<https://dx.doi.org/10.5479/si.1938-2812.107>), paperback.

Hitchcock, C.L. and A.J. Cronquist. 2018. *Flora of the Pacific Northwest, 2nd ed.* Burke Museum Herbarium & University of Washington Press, Seattle. **Notes:** 2nd edition. D.E. Giblin, B.S. Legler, P.F. Zika, R.G. Olmstead (eds.). Illustrated originally by J.R. Janish, J.H. Rumley, with additions by C. Shin, N. Porcino. Taxonomy and illustrated keys updated, comprehensive. ISBN-13: 978-0-29574-288-5, hardcover. ISBN 10: 978-0-29574-288-7, paperback, and electronic Kindle versions.

Judziewicz, E.J., R. Freckmann, L. Clark and M. Black. 2014. *Field Guide to Wisconsin Grasses*. University of Wisconsin Press, Madison. **Notes:** ix + [1]-346, county maps, lists of species by habitats, fully illustrated by line drawings and photos, illustrated key to genera and keys to species, comprehensive. ISBN 978-0-299-30134-7, paperback, and ISBN 978-0-299-30133-0, e-book.

Perryman, B.L. and Q.D. Skinner. 2007. *A Field Guide to Nevada Grasses*. Indigenous Rangeland Management Press, Lander, WY. **Notes:** 256 pp., fully illustrated with photos. ISBN 0-940936-99-2, paperback.

Roché, C.T., R.F. Brainerd, B.L. Wilson, N. Otting and R.C. Korfhage. 2019. *Field Guide to the Grasses of Oregon and Washington*. Oregon State University Press, Corvallis. **Notes:** ix[x] + 1-460, specimen dots on topographically colored maps, fully illustrated with photos, keys, comprehensive. ISBN 978-0-87071-959-2, paperback. 2.2 lb.

Shaw, R.B. 2008. *Grasses of Colorado*. University of Colorado, Boulder. **Notes:** xi +

1-650, fully illustrated with line drawings from Vascular Plants of the Pacific Northwest, pt. 1 (C.L. Hitchcock et al., 1969), and FNA vol. 24 & 25, (M.E. Barkworth et al., eds.), county maps, keys, comprehensive. ISBN 987-0-87081-883-7, hardcover.

Shaw, R.B. 2012. *Guide to Texas Grasses*. Texas A&M University Press, College Station. **Notes:** xi, 1-1080, keys, mixture of line drawings (mostly from FNA) and photos (for most), county dot maps, habitat maps and discussions, genera and species alphabetical (tribes noted), comprehensive. ISBN 13: 978-1-60344-186-5, Softbound (flexibound), 6.5 lbs., and ISBN 978-1-60344-674-7, e-book version.

Skinner, Q.D. 2010. *A Field Guide to Wyoming Grasses*. Education Resources Publishing, Cumming, Georgia. **Notes:** xii + 1-596, full dot maps, fully illustrated with photos, keys, comprehensive, genera arranged by tribes, dated. ISBN 978-0-615-38762-8, paperback.

Skinner, Q.D., S. Wright, R. Henszey, J. Henszey and S.K. Wyman. 2012. *A Field Guide to Alaska Grasses*. Education Resources Publishing, Cumming, Georgia. **Notes:** xix + [1]-380 pp., distributed by Alaska Dept. of Natural Resources, Palmer, AK fully illustrated with photos, specimen dots on topographically colored map, keys, genera arranged by current tribes (easy for Alaska), comprehensive. ISBN 978-0-615-64886-6, paperback.

Smith, Jr., J.P. 2014. *Field Guide to Grasses of California*. University of California Press, Oakland. **Notes:** x + 1-438 pp., K. Simpson (illustrator for introduction), photos (of mixed quality) of selected genera and species, keys to genera and to selected species, and generic concepts variously outdated. ISBN 13: 978-0-520-27567-6, hardcover, ISBN 10: 978-0-520-27568-3, paperback and electronic Kindle version.

Valdés-Reyna, J. 2015. *Gramineas de Coahuila*. CONABIO, Talapan, Mexico. **Notes:** 1–556 pp., specimens dots on municipio maps, keys to genera and species, comprehensive, fully illustrated by line drawings (mainly from FNA vol. 24 & 25, M.E. Barkworth et al., eds.), ISBN 978-607-8328-16-1, paperback.

A look into the Budapest Herbarium

On a recent trip Julia Beros, Botany contactor, accompanied by her sister, visited the Budapest Herbarium. Inspired by the similarities and differences between the herbarium in Budapest and the U.S. National Herbarium she recounts some of the tour's highlights.

On the corner block of Könyves Kálmán körút is a massive white stucco castle. A relic of Art Nouveau, the "Fairy Palace" at one time housed one of the Royal secondary schools of Hungary, and after a series of various uses it now safeguards the botanical department of the Hungarian Natural History Museum. Zoltán Barina, one of four permanent collections staff in Budapest, gave us a tour of the collections.

The sun radiates in the stillness of the valley, wafting through shallow fields of grass, reflecting off the architectural vestiges of the past, the Baroque facades, the Maria-Theresa yellows, deflecting back over the hills of Buda. A city divided by its own river, here in Pest the herbarium too is split, into the Carpathian and General collections. The Natural History Museum was created in 1802 and the department of Botany in 1870 (around the time the U.S.

National Herbarium was formed, 1848). The collections, now surpassing 2 million (with some housed at an offsite extension location), began with a vast deposit from renowned botanist Pál Kitaibel. Frequently referred to as the "Linnaeus of Hungary" for having been the first official collector in the Carpathian basin, and having more than 1,000 names described from his collections.

The herbarium is growing rapidly, having received roughly 150,000 new specimens within the past 15 years from nearby institutions. Though the building underwent renovations in the 1920s it lacks an industrial freezer, making the challenges of running an herbarium more pronounced. Often relying on various chemicals for fumigation, they are still looking for the best way to manage pests in a less than ideal situation. As Barina notes, there are burns from fluoridic acid (no longer in use) on many older sheets. Likewise at the U.S. National Herbarium many older specimens cured with mercury show dark stains, and controlling the spread is a continual chore. One recent acquisition is a collection of around 40,000 specimens from Szeged University of never before fumigated miscellanea.

Although some sheets show visible damage many are untouched, which gave researchers a unique opportunity to study natural pest resistance in certain species (or learn which are the tastiest treat for an herbarium stowaway).

The hallways are lined with windows reaching up to the great height of the ceiling, and each sill festooned with live plants, vibrantly thriving in the archives of their relatives, their foliage shrouding a towering red cabinet. Removing a drawer Barina reveals a stack of spe-



Curator Zoltan Barina and Julia Beros in the Budapest herbarium. (photo by Kathryn Beros)

cimens made by Lajos Kossuth. Most recognized as a politician, Kossuth had a great fascination in botany and decided in his downtime from political life to start collecting. Further in is the library where resides a hand-painted edition of Vera Csapody's *Iconographia florae hungaricae* (a copy of which is viewable in the Smithsonian's Botany Library). A tome of colored plates, this paradigm of Hungarian botanical research is dedicated to the foundational work of Kitaibel.

Within the collections are housed approximately 100,000 lichen and 260,000 Bryophytes, comprising around 20% of the collections (whereas the U.S. National Herbarium bryological collections, currently undergoing a mass reorganization, only comprise about 125,000 of the 5 million total specimens). Ádám Boros and László Vajda were prominent bryologists in the region, their notetaking so supremely detailed they can still be followed step by step to reach the exact stone from which they had plucked a moss.

Currently unimaged these historic collections are only viewable in person, though barcoding is underway to database all the material. As bryologist Beáta Papp elaborates, they are also quite active within Europe exchanging material and inviting research exchange. The "Synthesys" program, commissioned by the EU, allows researchers to request funds to go on exchange to other institutions, encouraging multi-national collaboration and active



Two quasi-books, known as Holz Bücher, camouflaged by their binding made of tree material, act as plant records for various tree collections. Ranging in age some are 130 years old. (photo by Julia Beros)

use of natural history collections.

Returning home and returning to work at the Smithsonian, I resumed my duties in the digitization team. We have imaged over 2.5 million specimens to this day, and I still ruminate on the beautiful collections of Budapest. For such diverse collections in different cultures and societies, I see many of the same challenges that Barina was pointing out in Budapest. Constantly lacking enough space, enough funding, enough staffing and general resources to keep up with the ever changing and modernizing standards underpins the importance for natural history institutions to find support amongst each other; as an international community we must continue to encourage partnerships and exchange in the effort to preserve our diverse natural history and as a means to inform our present.

I would like to thank Zoltán Barina and his colleagues for so warmly guiding me through their collections, and hope our institutions have the chance for collaboration soon.

ForestGEO awards research grants to 7 forest scientists

Since 2002, ForestGEO has supported the work of forest researchers through its annual Research Grants Program. Proposals were required to use data from at least one of ForestGEO's 67 long-term, large-scale research sites and could be put towards a research project ranging from 3 months to 2 years. A panel of reviewers met to assess the merit of 30 proposals in early September and granted over \$60,000 among seven researchers. These scholars come from five countries and will cumulatively work in up to 14 ForestGEO research sites.

The grant funds will facilitate research in a host of topics pertaining to forest dynamics, including wood decomposition, mycorrhizal fungi, functional trait diversity, nutrient cycling, and habitat associations. Building global scientific capacity requires support throughout the progression of a scientist's career, and ForestGEO is pleased to have been able to award funding to four Ph.D. students, two postdocs, and one professor.

Conveyor belt project hits 2.5 million images

In coincidence with its four-year anniversary, the Department of Botany digitization belt project has hit 2.5 million images, a huge milestone for the department. The number of catalog records in the US Herbarium has reached 3.5 million and is growing quickly. Soon we will see a digital record for almost all of the dicots

and monocots of pressed specimens, with the exception of the Poaceae (grasses). With available funding, Poaceae will be next on our agenda. See <https://collections.nmnh.si.edu/search/botany/> for all records in our catalog, and enjoy the high-resolution images created with care by the botany digitization team.



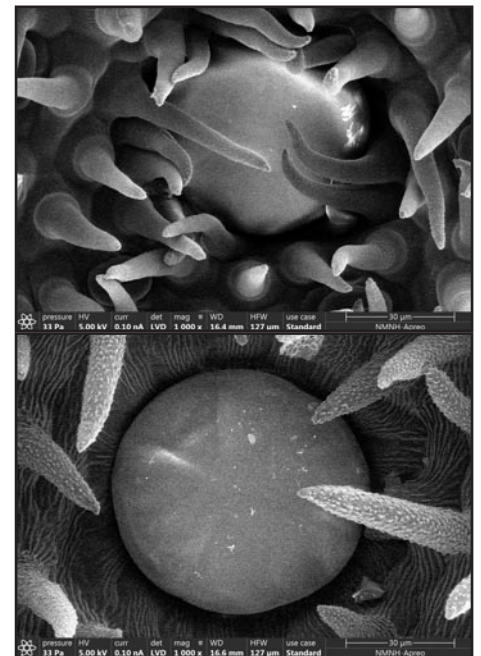
Q?rius botany class: Summer 2019

On July 24 and 31, a cohort of scientists from the National Museum of Natural History, **Liz Zimmer**, **W. Carl Taylor**, Steven Canty, **Julia Steier**, **Erika Gardner**, **Shruti Dube**, and **Gabriel Johnson** led classes of local high school students who were working at the museum this summer as Q?rius teen ambassadors and YES! interns. Here, groups of 2 or 3 students were paired with a botanist-mentor and then visited the museum's pollinator and bird gardens to learn to properly collect voucher specimens, log their observations in a field notebook, and use a dichotomous key to determine species identification. Each student was tasked with collecting a different species in the Lamiaceae. Once they returned to the Q?rius lab, the students pressed their collected materials and then mounted pre-pressed specimens on herbarium sheets and completed a herbarium sheet label.

The students made observations of glandular trichomes and floral organs under the dissecting microscopes and compared them to SEM images prepared for the same plants by microscopy educator Juan Pablo Hurtado Padilla (Note, these SEM specimens were prepared using the methanol fixation method described by Talbot & White (2013) *Plant Methods* 9(36): 1-7 and it is highly recommended). By comparing trichome and pollen ultrastructure, they could begin to understand the range of morphological variation in the microanatomy of plants within the same family. This concept of taxonomic relatedness was explored further by mapping morphological features onto a phylogenetic tree of the mint family. On this phylogeny, the students identified several common herbs in the mint family such as basil, oregano, sage, thyme, spearmint, savory, rosemary, and lavender. Here we dis-

cussed what the "officinalis" species epithet means in the context of classical medicine, and students could compare their specimens with renderings printed in herbals by William Turner and Leonhart Fuchs and an Anglo-Saxon codex. The student groups were then given sets of numbered vials containing essential oils from these plants and they were asked to assign the correct name to the different oils based on their smell.

Many of these students will continue to volunteer as members of the Q-Crew and serve as teen ambassadors to museum visitors. It is our hope that this brief introduction to botany will enable them to better orient visitors exploring the various herbarium sheets and plant curiosities on display in Q?rius.



SEM images of *Monarda fistulosa* (top) and *Pycnanthemum muticum* (Lamiaceae) (bottom) taken by Juan Pablo Hurtado Padilla for the summer botany class.

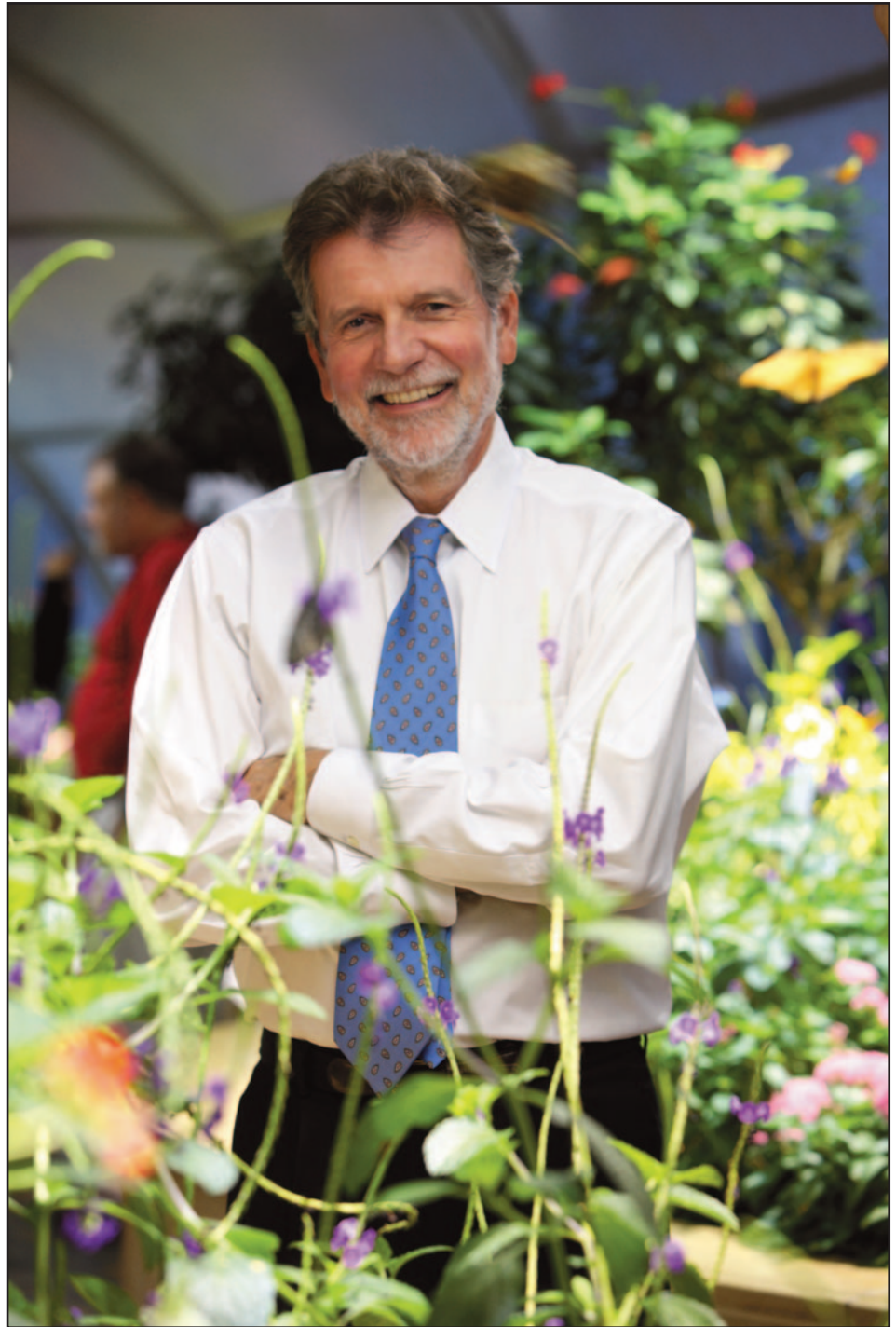
Retirements

W. John Kress retired on 31 July 2019 after 31 years of service at the Smithsonian Institution. He joined the Department of Botany at the Smithsonian's National Museum of Natural History in 1988 first as an Associate Curator and then promoted to Curator. Kress was appointed Chair of Botany in 1997, and he served in that role for nearly nine years. In 2010, Kress was named the Director of the Consortium for Understanding and Sustaining a Biodiverse Planet in the Office of the Under Secretary for Science at the Smithsonian. From 2014 to 2016, he served the Smithsonian as interim Under Secretary for Science.

A major focus of Kress' research has been on the order Zingiberales. He has examined reproductive biology, allozyme and molecular variation, and phylogenetic relationships in the group and has been especially interested in the classification, evolution, and pollination biology of the Heliconiaceae. Additionally, Kress has produced a significant body of work on orchids, bromeliads, and other epiphytes. He is the author or co-author on over 300 scientific papers, books, and book chapters.

Kress' research has led him to explore the Amazon, the Andes, Costa Rica, the West Indies, Madagascar, the South Pacific, tropical Indonesia, Malaysia, Papua New Guinea, and Myanmar. He has authored or co-authored about 46 plant taxa and proposed about 150 new combinations. Kress authored *The Weeping Goldsmith: Discoveries in the Secret Land of Myanmar*, a first-person narrative of his scientific surveys in Myanmar's teak forests, bamboo thickets, timber plantations, rivers, and mangroves. Kress is also the co-author of *A Checklist of Trees, Shrubs, Herbs, and Climbers of Myanmar* (*Contr. US Natl. Herb.* 45: 1-590; 2003), a work that updates four previous editions going back to 1912.

During his expeditions abroad, Kress often collected living plants in the field and brought them back to the Botany Research Greenhouses for further study. Over time, Kress had built one of the finest living collections of gingers and relatives housed in the greenhouses at the Museum Support Center (MSC) in Suitland, Maryland. Kress played a pivotal role in establishing the greenhouses, when in 1994 the Botany



W. John Kress. (photo by Smithsonian Institution)

Department moved the living plant collection from the east courtyard of NMNH to the larger, more modern facility at MSC.

Kress' interest in plant-pollinator interactions resulted in a paper in *Nature* about a flexible style in *Alpinia* that encourages outcrossing and a *Science* cover story about intricate evolutionary partnerships among *Heliconia* species and Caribbean purple-

throated carib hummingbirds. With bat specialist Ted Fleming, Kress co-wrote the book, *The Ornaments of Life: Coevolution and Conservation in the Tropics*, which focused on tropical pollination and frugivory and probing the influences of vertebrate pollinators and seed dispersers.

His advocacy for conservation and sustainability can be seen in the co-edited

book *Plant Conservation – A Natural History Approach*, which addresses the roles that museums and botanical gardens can play in the conservation of plants, and the co-edited book *Living in the Anthropocene: Earth in the Age of Humans*, a set of essays by scientists, humanists, and artists addressing the causes and effects of a changing planet.

In the early 2000s, Kress had the vision of an electronic field guide in which users could identify plant species simply by taking a photograph of an individual plant. In 2011, his idea came to fruition with the release of Leafsnap, a mobile app that helps scientists and the public identify tree species in the field by comparing digital photo images of leaves to a database of herbarium specimens.

Kress was instrumental in the early development of DNA barcodes in flowering plants (*Proc. Natl. Acad. Sci.* 102: 8369-8374; 2005). DNA barcodes are a practical and standardized tool for plant species identification in biodiversity assessments, life history and ecological studies, and forensic analyses. His team has produced a DNA barcode library for plant species on Panama's Barro Colorado Island (*Proc. Natl. Acad. Sci.* 106: 18621-18626; 2009). His team is currently building a DNA barcode library for all medicinal plant species.

Kress' artistic endeavors include *Botanica Magnifica: Portraits of the World's Most Extraordinary Flowers and Plants*, a collaboration with Hasselblad Laureate Award photographer Jonathan Singer. *Botanica Magnifica* is an elegant art book with 250 stunning photographs of rare and exotic plants and flowers. The original edition of *Botanica Magnifica*, consisting of five lavishly hand-bound volumes, was limited to 10 copies, the first of which was donated to the Joseph F. Cullman 3rd Rare Book Library at the Smithsonian Institution.

As Chair of the Department of Botany, Kress started the annual Smithsonian Botanical Symposia as recommended in the Botany strategic plan. He also

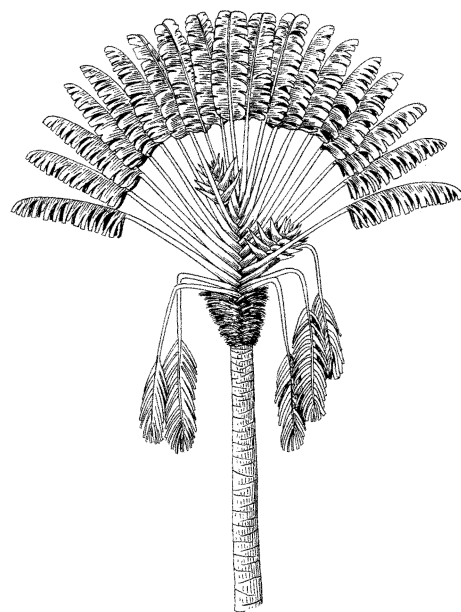
initiated the Jose Cuatrecasas Medal for Excellence in Tropical Botany, an award presented at the symposium to a botanist and scholar of international stature who has contributed significantly to advancing the field of tropical botany. He developed a memorandum of mutually beneficial understanding between the National Museum of Natural History and the U.S. Botanical Garden in Washington, D.C. He also oversaw the completion of one of the first fully imaged herbarium type collections with high-resolution digital images.

Kress has served as the Executive Director of the Association for Tropical Biology and Conservation (ATBC) and as the Chairman of the Board of the Organization for Tropical Studies (OTS). He has been serving as the Editor-in-Chief of the botanical journal, *PhytoKeys*, since its inaugural issue in 2010. He has been an Adjunct Professor at George Mason University, George Washington University, and Xishuangbanna Tropical Botanical Garden, China.

Among his awards and honors, Kress has received the Parker-Gentry Award for Biodiversity and Conservation from the Field Museum of Natural History, the Lifetime Achievement Award from *Heliconia* Society International, and the Edward O. Wilson Biodiversity Technology Pioneer

Award for co-development of Leafsnap. He is a fellow of the American Association for the Advancement of Science and an honorary fellow of the Association for Tropical Biology and Conservation.

As Research Botanist Emeritus, Kress will be working on a guide to the common trees of North America.



W. John Kress collecting plant specimens in a Costa Rican rainforest. (photo by Smithsonian Institution)

YES! Interns experience a summer of mistletoes and lichens

This past summer, the Department of Botany hosted four interns through the Youth Engagement through Science (YES!) internship program at the National Museum of Natural History. YES! is a career immersion and science communication program for youths between the ages of 14-19, who are currently enrolled in high school (grades 9-11) in the Washington D.C. region. The YES! program gives interns practical experience through a hands-on science internship with Smithsonian science staff. In addition to conducting research, the teens also had access to behind-the-scenes tours and field trips, creative studio workshops, college preparatory classes, and the opportunity to create their own TED-type talks. To protect the privacy of these minors, their last names are being withheld in this article.

Marcos Caraballo mentored two YES! interns, **Nina** and **Leah**, on a project exploring the morphological diversity and genomics of parasitic mistletoes. Both interns learned how to perform microscopy work, DNA extractions, PCR amplifications, and sequence editing, and visited the U.S. Botanic Garden to study the diversity of plants growing there. Nina focused her activities on lab work, including purification of DNA from herbarium specimens, primer design, and visualization and interpretation of agarose gel images. Leah delved into plant taxonomy, learning how



YES! interns Leah and Nina (left to right) learn laboratory techniques to study the diversity of parasitic mistletoes. (photo by Smithsonian Institution)

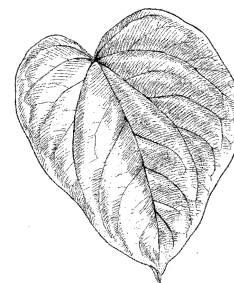
to dissect flowers and interpret their inner structures, taking high quality images using a modern dissecting scope. Both Nina and Leah presented their summer projects at the YES! program community day on August 2, where each prepared an exhibition and showed mistletoes to museum visitors.

Manuela Dal Forno worked with two YES! interns, **Sarah** and **Maria**, on the project “Lichen Diversity in the Tropics.”

The interns learned about lichens in general, especially taxonomic characters and chemical tests, and dove into a focus on identifying bacteria and fungi from different lichen cultures. They selected and photographed cultures, extracted and sequenced DNA, and generated culture guides for future comparisons. Maria and Sarah participated in two outreach programs at Q?rius, teaching museum visitors about lichens and their experience in the internship program. Sarah and Maria also worked alongside **Julia Adams**, a doctoral student from the University of California at Riverside. Adams was at the museum for 10 weeks conducting research on the systematics of the lichen *Acarospora socialis* from southwestern United States. During her time here, Adams worked on the taxonomy of 32 samples of this species complex housed at the US National Herbarium and performed lab work to acquire molecular data on these historical specimens.



YES! interns Maria and Sarah (left to right) learn laboratory techniques to study the diversity of lichens. (photo by Smithsonian Institution)



NEW FACES



Daniel Zuleta is a postdoctoral fellow working on tropical forest mortality with ForestGEO and Next-Generation Ecosystem Experiments–Tropics (NGEE–Tropics). His research has focused on understanding the spatial variation in drought-induced tree mortality and biomass dynamics, as well as assessing the interactions between the species' drought tolerances and their spatial distributions in Amazon forests. As a postdoctoral fellow, Zuleta aims to understand the mechanisms driving tropical forest mortality in order to develop mortality models that can be included in the Functionally Assembled Terrestrial Ecosystem Simulator

(FATES) model and improve predictions of forest response to environmental changes. He will use long-term forest dynamics data from ForestGEO sites along with annual mortality censuses established by Gabriel Arellano to explore tree death modes and implications on stand carbon dynamics. He will additionally collect data on plant stress attributes and the response of trees to extreme climatic events to infer the physiological mechanisms of tree death. Zuleta is based at the ForestGEO headquarters at the Smithsonian National Museum of Natural History in Washington, DC.

Betsy Collins traveled to Oaxaca and Veracruz, Mexico (8/7 – 8/29) to collect *Bursera* (Burseraceae).

Manuela Dal Forno traveled to Minneapolis, Minnesota (8/10 – 8/17) to present at the 2019 Mycological Society of America meeting.

Vicki Funk traveled to Tucson, Arizona (7/28 – 8/1) to attend the Botany 2019 meeting.

Karen Golinski traveled to Madrid, Spain (7/7 – 7/8) to attend the IUCN Red List Assessor Training Workshop for bryologists held in advance of the International Association of Bryologists meeting; she subsequently joined the IUCN Species Survival Commission Bryophyte Specialist Group.

Gabriel Johnson traveled to Summerland Key, Florida (7/2 – 7/9) to attend the Methods in Ecological Genomic Analysis workshop at the Elizabeth Moore International Center for Coral Reef Research and Restoration.

Kathryn Picard traveled to Minneapolis, Minnesota (8/10 – 8/16) to give an invited symposium talk on marine fungi at the Mycological Society of America's annual meeting; and to Duluth, Minnesota (9/5 – 9/9) to give an invited seminar on using long-read sequencing to study microbial communities to the Department of Biology at the University of Minnesota Duluth.

W. Carl Taylor traveled to Vancouver, Canada (8/6 – 8/8), South Lake Tahoe, California (8/8), and Reno, Nevada (8/9 – 8/11) to collect field specimens for a collaborative project with **Liz Zimmer**.

Warren Wagner traveled to Tucson, Arizona (7/28 – 8/1) to attend the Botany 2019 meeting.

Jun Wen traveled to Brunei (6/29 – 7/16) to give the opening keynote speech at the 11th Flora Malesiana Symposium on "Plant Systematics: A Century of Progress and Outlook for its Development in SE Asia"; and to Tucson, Arizona (7/28 – 8/1) to attend the Botany 2019 meeting.

Liz Zimmer traveled to Tucson, Arizona (7/28 – 8/1) to co-author two talks at the Botany 2019 meeting and to serve as a judge of posters presented by the Genetics Section of the Botanical Society of America.



HONORS & AWARDS

Vicki Funk has been honored by the American Society of Plant Taxonomists (ASPT). Linda Watson and Lucinda McDade have spearheaded a fundraising effort to establish a new endowment to allow ASPT to make an annual graduate student research grant award in honor of Vicki Funk. Many colleagues have generously contributed so that the effort has been wildly successful and a large endowment has been secured that will allow ASPT to begin awarding an annual Vicki Funk Graduate Student Research Grant in 2020. This ASPT endowment in support of graduate student research joins other named endowed grants that ASPT awards

annually to the highest ranked proposals received from graduate student members of the organization. The Vicki A. Funk Grant joins the Rogers McVaugh, William R. Anderson, Shirley and Alan Graham, and W. Hardy Eshbaugh grants in providing up to \$1,500, and is intended to help student researchers defray the costs of doing research in any area within plant systematics.

TRAVEL

Barrett Brooks traveled to the Carrie Bow Cay Field Station, Belize (7/24 – 8/1) to lead a diving activity for annual monitoring and data collection for the Smithsonian's Caribbean Coral Reef Ecosystem Program (CCRE).

VISITORS

Santos Miguel Nino and Daniela Canelón Barraez, Universidad Nacional Experimental de los Llanos Ezequiel Zamora, Venezuela; Flora of Guaramacal (5/14-7/12).

Issac Marck, University of California Berkeley; Heliantheae Alliance (Asteraceae) (6/3-8/30).

Vidal Mansano, Rio de Janeiro Botanic Garden, Brazil; Fabaceae (7/1-7/18).

Leandro Pederneiras, Jardim Botânico do Rio de Janeiro, Brazil; *Ficus* (Moraceae) (7/3-7/12).

Genise Freire, Universidade Federal Rural do Rio de Janeiro, Brazil; *Paullinia* (Sapindaceae) (7/8-8/5).

Natalia Ruiz-Vargas, University of Illinois at Chicago; Caribbean biogeography, Bromeliaceae, and Illicium (Schisandraceae) (7/8-7/12).

Jackeline Salazar, Universidad Autónoma de Santo Domingo, Zona Universitaria, Dominican Republic; Flora of Dominican Republic and Canellaceae (7/8-8/2).

Patricia Sperotto, Universidade Federal de Feira de Santana, Brazil; Neotropical vines and lianas (7/8-8/5).

Mary McKenna and 10 students, University of Virginia Blandy Field Station; Plant conservation and herbarium tour (7/12).

Jonathan Kavalier and 15 plant humanities fellows, Dumbarton Oaks Research Library and Collection; Plant conservation and herbarium tour (7/16).

Aaron Pan, Don Harrington Discovery Center; *Anthonotha*, *Berlinia*, *Englerodendron*, *Gilbertiodendron*, *Isoberlinia*, and *Isomacrobium* (Fabaceae: Detarioideae) (7/31).

Jose Mauricio Bonifacino, Universidad de la Republica, Uruguay; Asteraceae (8/1-8/8).

Mauricio Diazgranados, Royal Botanic Gardens, Kew, United Kingdom; Asteraceae and Cuatrecasas Project (8/1-8/4).

Philipy Weber, Universidade Federal do Rio Grande do Sul, Brazil; *Rhynchospora*

(Cyperaceae) (8/5-8/9).

Iris Yellum, Harvard University; South Indian legumes, economically important crops (8/5-8/12).

Sarah Elston, Smithsonian's National Collection Program; Herbarium tour (8/9).

Piper Boudart, Colorado College; Lichens (8/12-8/16).

Colin Eagle and Kate Hagsten, Division of Resource Management Leech Lake Band of Ojibwe, Minnesota; Herbarium tour (8/14).

Peiwu Xie, Guangdong Academy of Forestry, China; Herbarium research (8/28/19-8/28/20).

Joel Calvo, Pontificia Universidad Católica de Valparaíso, Brazil; *Werneria* (Asteraceae) (9/3-9/27).

Myoung-hai Kwak, National Institute of Biological Resources, South Korea; Herbarium research (9/3/19-3/3/20).

Cassiano Welker, Universidade Federal de Uberlândia, Brazil; Andropogoneae (Poaceae) (9/4-11/4).

Tracey Parker, Independent researcher, Managua, Nicaragua; Central American plants (9/5-9/6).

Fay-Wei Li, Boyce Thompson Institute & Cornell University; Hornworts (9/9-9/13).

Jacquelyn McPeck, Whitworth University; Botanical illustration internship (9/9-12/13).

Soina Molino de Miguel, Universidad Complutense de Madrid, Spain; Ferns (9/9-9/27).

Christian Feuillet, Oregon State University; Passifloraceae and Boraginaceae (9/10-9/27).

Zhang Chunxia and Ding Yulong, Nanjing Forestry University, China; Bambusoideae (Poaceae) (9/16-9/19).

Josimar Kulkamp, Jardim Botânico, Brazil; Euphorbiaceae (9/18-10/18).

Patrica Barbera, Missouri Botanical Garden; Poaceae (9/23-9/27).

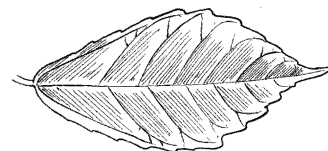
Lewis Ziska, Columbia University, and **Guy Stone** and **Martha Tomecek**, U.S. Department of Agriculture's Agricultural Re-

search Service; Phytochemistry of plant specimens (9/26-9/27).

Sandra Knapp, Natural History Museum, London, United Kingdom; Solanaceae (9/29-10/3).

Carolina Moriani Siniscalchi, University of Memphis; Asteraceae (9/30).

Ramhari Thapa, University of Memphis; Asteraceae (9/30).



PUBLICATIONS

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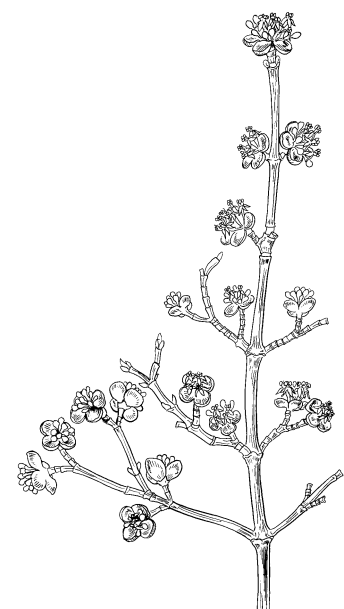
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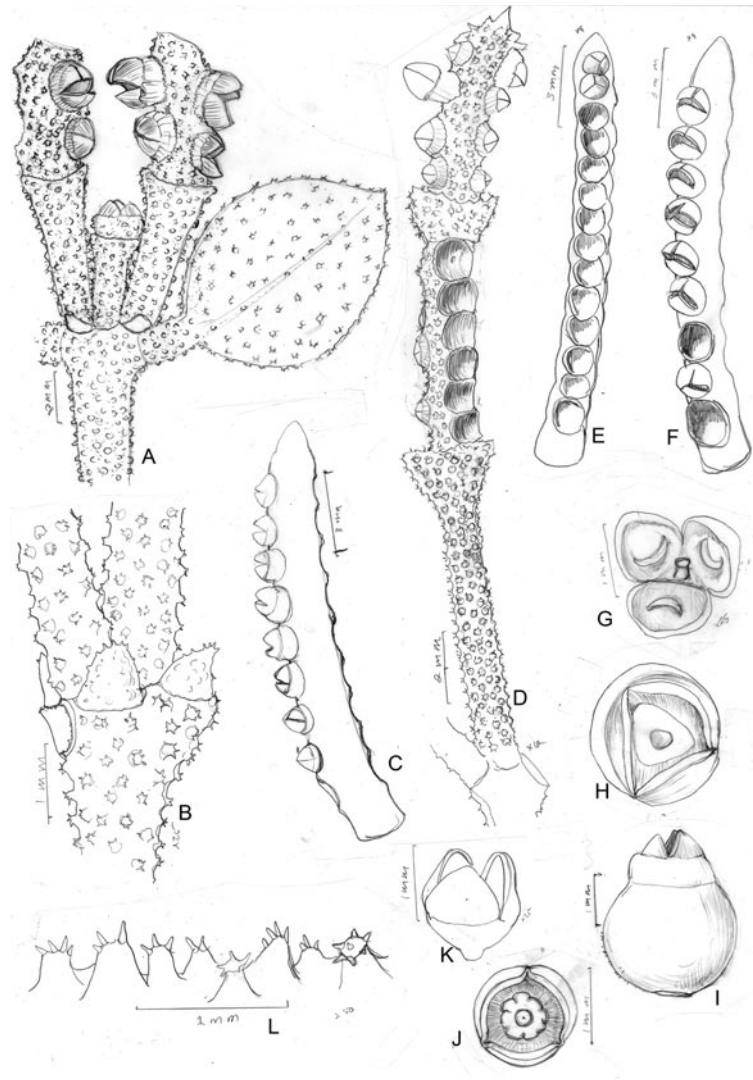
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ART BY ALICE TANGERINI

Dendrophthora sp.

This new species of mistletoe (*Dendrophthora* sp.; Loranthaceae) is a preliminary sketch from collections made by Larry Dorr (US) and Basil Stergios (formerly PORT) for the Flora of Guaramacal project, which focuses on the vascular plants of a national park in the Venezuelan Andes. Daniela Canelón, Curator of Herbario PORT, is especially interested in parasitic epiphytes and with the assistance of Miguel Niño, Botany Research Collaborator, and Marcos Caraballo, Peter Buck Fellow, they have determined that the material represents a new, as yet undescribed species. The collections provide a challenge to illustrate in that as they dry the plant color darkens to almost black. Rehydration in a wetting solution is required for dissecting and illustrating the tiny flowers and fruits. Caraballo has been generous in lending Tangerini his books and papers on the genus so that typical views by other illustrators can be studied to show how this particular collection differs from similar species.



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