Department of Botany & the U.S. National Herbarium

The Plant Press

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Botany Profile

Humming to the Tune of Coevolution

By W. John Kress and Ethan J. Temeles

A major goal of systematic, evolutionary, and ecological studies is to understand the processes that shape adaptations of organisms to their environment. One approach towards this goal is to use patterns of morphological variation among closely related species to make inferences about the kinds of ecological processes, such as competition, predation, parasitism, or mutualism, through which these characteristics have evolved. This type of study traces back to Charles Darwin and his classic observations in the Galapagos Islands of beak variation and food types among species of ground finches in the genus *Geospiza*.

Since Darwin's time, interactions between flowering plants and their pollinators have provided model examples of hypothesized feeding adaptations, species specialization, and coevolution. However, some investigations suggest that such interspecific interactions are seldom constant throughout a species' range and that populations differ in the traits shaped by the interaction. These observations have resulted in the John Thompson's proposed "Geographic Mosaic Theory of Coevolution." Accordingly, studies of co-adaptation between species require an analysis of populations across the broad geographic distribution of the species. Some populations across this geographic landscape are hotspots of reciprocal selection and others are coldspots with little coevolution.

We have recently described an interaction between a plant and its hummingbird pollinator found in the Eastern Caribbean that provides an ideal tropical system to test Thompson's theory. Both the pollinators and the plants exhibit character polymorphisms, which can be readily linked to fitness measures, throughout their ranges. Over the last several years and probably for a number of years to come we plan to study co-adaptations in this plant-hummingbird association through extensive observations of both floral and sexual dimorphisms across the island archipelago in the Eastern Caribbean.

The focal system of this research involves the purple-throated carib hummingbird, *Eulampis jugularis*, and its *Heliconia* food plants, considered one of the strongest examples of ecological causation of sexual dimorphism to date and a well-documented plant-pollinator mutualism. Many biology textbooks note that flowers pollinated by hummingbirds have long, tubular corollas matching the size and shape of the birds' beaks. Darwin himself stated that bills of hummingbirds are specially adapted to the various kinds of flowers they visit.

Our work has provided evidence for co-adaptation by demonstrating that the purple-throated carib hummingbird is the primary pollinator of *H. caribaea* and *H. bihai*, with flowers of the former corresponding to the short, straight bills of males (the larger sex) and flowers of the latter to the longer, curved bills of females. Further evidence for co-adaptation comes from a reversal in the floral dimorphism of the *Heliconia* food plants on two islands: on St. Lucia, the female-pollinated *H. bihai* develops a second morph with shorter, straighter flowers matching the bills of males, whereas on Dominica the male-pollinated *H. caribaea* develops a second morph with longer, curved flowers matching the bills of females. The nectar rewards of all *Heliconia* morphs on both islands are consistent with each sex's choice for the morph corresponding to its bill morphology and energy requirements, supporting the hypotheses of ecological causation of sexual dimorphism and co-adaptation.

Our work started nearly a decade ago when Ethan Temeles initiated studies of the purple-throated carib hummingbird, *Eulampis jugularis*, on the island of St. Lucia. The males and females are identical in plumage, but display some of the most extreme sexual dimorphisms of any hummingbird species. First, bills of males average 24.8 mm in length, whereas bills of females average 29 mm in length, a difference of 15 percent. Moreover, bills of males are relatively straight, curving downwards at a 15 degree angle, whereas bills of females are highly curved, curving downwards at a 30 degree angle.

These differences in bill morphology were associated with differences in the use of the two *Heliconia* species on the island. Males were associated with a red-bracted morph of *H. caribaea,* which they defended against other males and females. In contrast, females intruded onto male territories to feed and also fed at undefended patches of *H. caribaea*, but more importantly they were the predominant visitor to the other *Heliconia*, a green-bracted morph of *H. bihai*.

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Travel

Pedro Acevedo traveled to Bronx, New York (12/9) to attend a meeting of the Caribbean Flora initiative sponsored by the New York Botanic Garden.

Walter Adey traveled to Philadelphia, Pennsylvania (10/10) to give a technical presentation of the Algal Turf Scrubber (ATS) Energy Project at the Region 3 EPA; to Kennett Square, Pennsylvania (12/2 – 12/4) to give a technical presentation to Exelon officials; to Blacksburg, Virginia (12/5 – 12/7) to give an invited presentation at Virginia Tech; and to Conowingo Dam, Maryland (12/12) to review test plans with engineers and officials and to make a presentation to the University of Maryland, Department of Natural Resources.

Laurence Dorr traveled to Cambridge, Massachusetts (11/1 – 11/5) to present a talk to the New England Botanical Club on Malagasy plants that have been introduced into cultivation, and to examine Malvaceae in the Harvard University herbaria.

Robert Faden traveled to St. Louis, Missouri (12/2 – 12/5) to attend a meeting on a proposed Cultivated Flora of North America at the Missouri Botanical Garden, and to conduct herbarium work on African Commelinaceae.

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Web site: http://www.nmnh.si.edu/botany

Vicki Funk traveled to Philadelphia, Pennsylvania (12/13) to serve on the search committee for a new Curator of Botany at the Academy of Natural Sciences of Philadelphia.

Carol Kelloff traveled to Georgetown, Guyana (10/8 – 10/19) with **Karen Redden** (George Washington University postdoctoral fellow) to meet with staff at the University of Guyana and the Centre for the Study of Biological Diversity.

W. John Kress traveled to Cambridge, Massachusetts (10/4 – 10/10) to attend the Island Biogeography Symposium at Harvard University and to work with Ted Fleming on their vertebrate pollination and dispersal book; to Millersville, Pennsylvania (11/7) to give a lecture on tropical pollination systems at Millersville University; and to Panama City, Panama (12/4 – 12/7) with post-doc **David Erickson** to meet with STRI Director Biff Bermingham and Oris Sanjur for discussions on DNA barcoding the woody plants in the Forest Dynamics Plot on Barro Colorado Island.

Mark and **Diane Littler** traveled to South Florida (12/25 – 2/15) to conduct field research on marine algae and seagrasses based at the Smithsonian Marine Station, Ft. Pierce.

Rusty Russell traveled to Panama City, Panama (10/22 – 10/26) to take part in a meeting of the Mellon-funded Latin American Plants Initiative at STRI; and to Princeton, New Jersey (11/20) with **Christine Allocca** to meet with Aluka, a non-profit organization that is web-hosting the Latin American Plants Initiative.

Alain Touwaide and **Emanuela Appetiti** traveled to Italy (10/2 – 10/7) to participate in the meeting of the International Association for the History of Nephrology in Palermo, to work at the National Library in Rome, to present three seminars in Naples, and to present a paper at the Meeting of the International Society for the History of Medicine in Figline Valdarno; to Siena, Italy (10/12 – 10/29) to attend the 100th Conference of the Italian Society for the History of Medicine; and to deliver a paper at an international conference organized on the occasion of the 750th anniversary of Pietro D'Abano's birthday in Abano Terme; and to Venice, Italy (11/28 – 12/9), to work at the Marciana National Library.

Warren Wagner traveled to St. Louis, Missouri (10/06 – 10/15) to attend the board meeting of the National Tropical Botanical Garden, gave a presentation on the McBryde Pacific Botany Program, and attended the annual Systematics Symposium of the Missouri Botanical Garden; and to St. Louis, Missouri (10/30 – 11/2) to attend the first working group of the Encyclopedia of Life and contribute to the species web pages for plants at the Missouri Botanical Garden.

Kenneth Wurdack traveled to Cambridge, Massachusetts (12/14 – 12/17) to conduct research at Harvard University.

Visitors

Ki-Oug Yoo, Kangwon National University, Chuncheon, South Korea; Coryloideae and Vitaceae (12/12/06-12/11/07).

Lei Xie, Chinese Academy of Sciences; *Clematis* (Ranunculaceae), *Circaea* and *Fuchsia* (Onagraceae) (1/1/07-12/31/08).

Tieyao Tu, Kunming Institute of Botany, China; *Nolana* (Solanaceae) (1/18/07-1/17/08).

Ling Zhang, Xishuangbanna Tropical Botanic Garden, Chinese Academy of Sciences; Instant Identification System (1/22/07-1/21/08).

Mauricio Bonifacino, Universidad de la Republica, Montevideo, Uruguay; Compositae (2/1/07-6/1/08).

Hongli Tian, Beijing Institute of Botany, China; *Nelumbo* (Nelumbonaceae) (4/25-10/24).

Yunjuan Zuo, Beijing Institute of Botany, China; *Panax* (Araliaceae) (5/7/07-5/6/08).

Melissa Luckow, Cornell University; Leguminosae (7/16/07-6/30/08).

Tracey Parker, Independent researcher, Managua, Nicaragua; Central American plants (9/18-10/2).

Theodore Fleming, University of Miami; Pollination systems (9/24-11/30).

John Clark, University of Alabama; Gesneriaceae (9/30-10/7).

A Mutual Influence

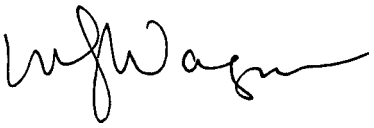
Species continually interact in an astounding diversity of ways, such as parasitism, predator-prey relationships, and obligate, facultative, and symbiotic mutualism. Mutualism is any interaction where both species derive benefits from the interaction. It has been studied to a lesser degree than other types of interaction, such parasitism, but it is a major force in the evolution of a significant array of global biological diversity, and plays a major role in the coevolution of flowering plants and their pollinators.

The most common type of mutualism is a resource-resource interaction, in which one type of resource is traded for a different resource. An example of this is the mycorrhizal association between plant roots and fungi, in which the plant provides carbohydrates to the fungus in return for nitrogenous compounds. Another common type is a service-resource relationship, where, for example, plants trade nectar or pollen (food) for pollen dispersal (service), or ants provide protection for aphids in return for sugar-rich honeydew. Evolution in a one-on-one interaction, such as in many examples of mutualism, predation, or parasitism, represents relatively clear-cut cases of coevolution. However, many situations of coevolution are much more complex, with species responding and evolving due to a number of different species.

Coevolution has been one of the significant areas of study since Charles Darwin studied the Galapagos finches. Studying interacting species and their abiotic environment, however, is complex and it has been difficult to make real progress beyond observational breakthroughs. Since the 1990s, coevolutionary studies have taken increasingly rigorous approaches to examine the structure and the dynamics of the evolutionary processes. Tools that allow researchers to examine in detail the structure of species' genetic, geographical, and ecological situation in a phylogenetic context are providing major advances in study of coevolution.

A striking example involving coevolution of the genus *Heliconia* and hummingbirds in the Caribbean is discussed on the cover of this issue by W. John Kress and Ethan J. Temeles. Their intensive study of this system shows that a geographic approach can identify populations of plant-pollinator specialization and generalization where certain highly-specialized populations may represent hotspots of reciprocal evolution.

It is an exciting time to examine the recent progress made in the study of coevolution. On April 26, the Smithsonian Botanical Symposium, co-hosted by the Departments of Botany, Entomology, and Paleobiology, will address the various ecological interactions, evolutionary adaptations, and co-radiations of plants and animals in habitats across the planet, and will explore the processes of coevolution. The speakers represent an array of leading investigators who will examine recent advances in the field in general, coevolution in deep time, and case studies of speciation and adaptation – the pollinators in *Aquilegia*, the yuccas and yucca moth, and the fungus-growing ants, their fungal cultivars, and their microbial symbionts. Several of the speakers will also examine the question of how human alteration of environments is affecting the coevolutionary process. The Symposium highlights the new hall of coevolution, entitled "Butterflies and Plants: Partners in Evolution," which will open at the National Museum of Natural History on February 15. We hope to see you at the Symposium on April 26.



Chair With A View — Warren L. Wagner

Kristian Baird, George Mason University; Compositae (10/2).

Diana Pierce, University of British Columbia, Vancouver, Canada; Pacific Science Network (10/2-10/3).

Elizabeth Wells, George Washington University; Saxifragaceae (10/4-10/9; 11/6).

Chelsea Specht, University of California at Berkeley; Monocots (10/4-10/6).

Jim Estes, University of Oklahoma; Flora of Oklahoma (10/5).

R.J. Tryl, Oklahoma State University; Flora of Oklahoma (10/5).

Khwanruan Papong, Field Museum; Thai lichens (10/8-10/16).

Summit Country Day School, Cincinnati, Ohio; Herbarium tour (10/10).

Susan Verhoek, **Stephen Williams** and **Wendy Zomlefer**, Lebanon Valley College; *Dionae* (Droseraceae) (10/15).

Wendy Zomlefer, University of Georgia; *Callisia* (Commelinaceae) (10/16).

Blanca Leon, Universidad Nacional Mayor de San Marcos, Lima, Peru; Peruvian *Tillandsia* (Bromeliaceae) (10/18).

Robynn Shannon, Ramapo College, New Jersey; Commelinaceae (10/19).

Mark Simmons, Colorado State University; Celastraceae, Hippocrateaceae and Brassicaceae (10/19).

Neil Snow, University of Northern Colorado; Poaceae (10/19).

Khoon Meng Wong, University of Malaya, Kuala Lumpur; Philippine *Gardenia* (Rubiaceae) (10/23-10/25).

Fabian Michelangeli, New York Botanical Garden; Melastomataceae (10/24-10/26).

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Staff Research & Activities

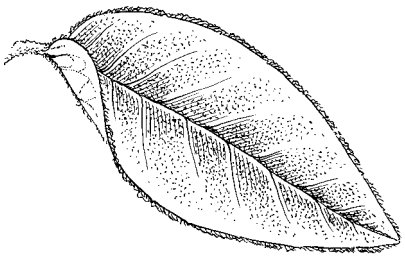
Laurence J. Dorr was the invited speaker on 1 November for the 1,030th meeting of the New England Botanical Club. The talk presented at Harvard University was entitled "Ny Hasina: Madagascar's Contribution to Horticulture."

Robert Faden attended a meeting at the Missouri Botanical Garden in St. Louis, on 3-4 December on a proposed Cultivated Flora of North America. Approximately 20 people representing 15 institutions from 10 states and the District of Colombia and one retail nursery were present. Although little was decided per se, there was a great deal of enthusiasm expressed for the project, which would be an on-line resource that could have many different kinds of users. A steering committee of seven was self selected and was planning to meet in Washington, DC early in 2008. A larger meeting that would include more representatives from the Green Industry will likely take place after that.

Mark and **Diane Littler** traveled to South Florida for two months this winter to conduct field research on their SMN-funded project "Functional Form, Biosystematics, and Comparative Ecology of South Florida Marine Algae and Seagrasses"—based at the Smithsonian Marine Station, Ft. Pierce. They presented an Ocean Sciences Lecture Series seminar at the Harbor Branch Oceanographic Institute (HBOI) at Florida Atlantic University, entitled "Submersed Plants of the Indian River Lagoon: a Floristic Inventory and Field Guide" highlighting the 2008 arrival of thei new treatise co-authored with M. Dennis Hanisak. This 6-year effort (distributed by HBOI) treats 234 marine plants (127 new records) from 8 phyla, with 565 underwater color images, 492 photomicrographs, and 305 anatomical line drawings.

During September and October, **Paul Peterson** traveled throughout Mexico (Aguascalientes, Coahuila, Durango, Nuevo Leon, Mexico, Puebla, Sinaloa, Tamaulipas, and Zacatecas) with Jeffery M. Saarela (Canadian Museum of Nature, and former Smithsonian Research Training Program intern) to collect grasses. Peterson presented an illustrated lecture (coauthored with Saarela) at the XVII Congreso Mexicano de Botánica held in Zacatecas, entitled "Una filogenia de *Calamagrostis* (Poaceae: Agrostidinae) y los géneros relativos basados en secuencias de ADN plastidial y nuclear" (A phylogeny of *Calamagrostis* (Poaceae: Agrostidinae) and related genera based on plastid and nuclear DNA sequences).

In November, **Alain Touwaide** and **Emanuela Appetiti** attended the annual meeting of the History of Science Society, held in Arlington, Virginia, where Touwaide delivered the paper "Global Science and International Language: The Case of the Medieval Mediterranean," and Appetiti attended the meeting of the editorial board of the *Isis*'s *Current Bibliography* (special annual issue of the Society's journal). Touwaide and Appetiti where also invited to deliver seminars to the Biology Department of Salisbury University, Salisbury, Maryland. Touwaide delivered "Medicinal Uses of Plants in the Ancient Mediterranean," and Appetiti delivered 'Traditional Medicine and Cultural Beliefs in Aboriginal Australia."



Awards & Grants

Laurence J. Dorr was appointed to the Advisory Board (Comité Asesor) of the *Flora del Paraguay*, a collaborative project between the Conservatoire et Jardins botaniques de la ville de Genève and the Missouri Botanical Garden.

Jun Wen received a 3-year grant from the National Science Foundation on her phylogenetic and biogeographic studies of the grape family, "Evolution via the grapevine: Phylogeny and biogeographic history of the Vitaceae." This project is a collaboration among Wen, Steve Manchester (University of Florida in Gainesville), and Jean Gerrath (University of Northern Iowa).

A Tribute to Carl Linnaeus: 1707-1778

To celebrate the birth of Swedish naturalist Carl Linnaeus, the National Museum of Natural History hosted a two-day exhibit, "A Tribute to Carl Linnaeus, 1701-1778" in partnership with the Embassy of Sweden on November 13 and 14. Accompanying the exhibit, **W. John Kress** co-organized a symposium with Jim Edwards (Encyclopedia of Life) and Hans Sues (Associate Director for Research and Collections). "Three Hundred Years of Linnaean Taxonomy" featured an overview of Linnaeus's life and times by Gunnar Broberg (Lund University) and talks on current issues of systematic biology by leading international experts.

Linnaeus transformed the classification of life by creating the binominal method for naming species. Because this system was easier to use than its cumbersome predecessors and ensured a considerable measure of consistency, it was quickly widely adopted by biologists for sharing research information. Linnaeus's system is still used today. This year marks the three hundredth anniversary of Linnaeus' birth. On exhibit at the museum was Linnaeus' own copy of the first edition of his *Systema Naturae* (courtesy of the Swedish Embassy).

Recipients of the José Cuatrecasas Award Visit NMNH

Maria Beatriz Rossi Caruzo, is a PhD student at Universidade de São Paulo (USP) under the direction of Inês Cordeiro, a specialist in Euphorbiaceae from Instituto de Botânica de São Paulo (IBt), Brazil. She is conducting research on the systematic and biogeography of *Croton*, the second largest genus of the family Euphorbiaceae and one of the most important genus in the Neotropics, with around 350 species only in Brazil. The subject of her PhD thesis is **"**Systematics and Biogeoraphy of *Croton* section *Cleodora* (Klotzsch) Baill." Her visit to the U.S. National Herbarium focused on Neotropical *Croton*, reviewing and identifying collections of *Croton* sect. *Cleodora*, and other Brazilian species. She also studied

Maria Beatriz Rossi Caruzo

type collections of Neotropical species of *Croton*, improving her knowledge about the genus in this region. The visit helped her increase her current data and improve her knowledge about the genus, helping her to answer questions concerning the identity and circumscription of the species within the section.

María Camila Gómez G. and **Camilo J. Londoño A.**, from Universidad de los Andes, Bogotá, Colombia, are constructing a "Biological Information System of the Flora of the Colombian Paramos" from specimen data of the type and general collections, to be incorporated into a Geographical Information System in order to obtain biodiversity indexes such as endemic species vs. area curves, and global warming modeling. This information system will constitute a key tool for the knowledge, monitoring and establishment of the conservation criteria needed for this highly unique flora, from the basis of the richness and rarity of some of the most representative genera. Gómez and Londoño visited the U.S. National Herbarium between December 13, 2007 and January 17, 2008. They took 11,370 pictures of specimens belonging to 61 genera from 36 families that will be digitalized in the Botanic and Systematic Lab of the Universidad de los Andes.

María Camila Gómez G.

Mónica Ponce, from the Instituto de Botánica Darwinion (San Isidro, Argentina), studied at the U.S. National Herbarium between August 28 and October 2, 2007. Her project was the study of specimens of *Cheilanthes* (Pteridaceae, Pteridophyta). Her visit resulted in a remarkable increase of information about the species and its synonyms. Material of *Cheilanthes* of the Antilles, Central and South America was reviewed. She examined roughly 700 specimens using the dissection scope to confirm their taxonomic identification and to record their morphology. She found that in general, she agreed with the current determination though in a few cases it was necessary to provide another name and taxonomical rearrangement. In addition, the collection data for each specimen were transcribed directly to the manuscript text of the synopsis of *Cheilanthes* or in the cases of very abundant material the labels were photographed to later transcribe them to the text. The morphological attributes of each taxon were entered in a characters data matrix for a total of 40 species, with the purpose of performing a cladistic analysis. For the future illustration of taxa, images of the general aspect of plants and details of fertile lamina and indument were taken for around 30 species. A fundamental part of the work was the revision of the type specimens of *Cheilanthes* and allied genera such as *Adiantopsis*, *Notholaena* and *Pellaea*. A first record in South America for *Cheilanthes cuneata* Kaulf. ex Link was registered, several new synonyms were added and the validity of various names was verified.

Rachel Schmidt Jabaily, from the University of Wisconsin, is a PhD student studying the systematics of *Puya* (Bromeliaceae). This project requires a lot of fieldwork in the Andes and plant localities and documentation are of utmost importance. While on a Cuatrecasas Travel Award this past summer she photographed the *Puya* collection of the U.S. National Herbarium and noted localities of species, especially those found in Colombia and Peru. She added these photographs to her computer database of specimens from herbaria throughout the US and

Camilo J. Londoño A.

South America. The US *Puya* collection is organized after the key of L.B. Smith in Flora Neotropica and working through the collection allowed her to learn a lot about Smith's thought process and she now has a better appreciation for the characters he emphasized. She also had the opportunity to meet Mauricio Diazgranados, another recipient of the same award, and together they planned a trip through Colombia. Schmidt Jabaily used the information she gathered during her visit in her December trip through Colombia and she reported from the field that the digital images of the plants helped enormously with plant identification. She is now planning her trip to Peru for March and April of 2008.

Rachel Schmidt Jabaily

Collecting Reed-Grasses (*Calamagrostis*) in Appalachia

By Jeffery M. Saarela,
Canadian Museum of Nature

Paul Peterson and I are engaged in a study of the taxonomy and phylogenetics of the large reed-grass grass genus *Calamagrostis* (~250 spp.) and its close generic relatives. There are many problems with the taxonomy of the group at various hierarchical levels that we are addressing with morphological and molecular data. Over the last several years we have been conducting field work throughout North and South America to study *Calamagrostis* species in their natural environments, to collect fresh material for morphological and genetic studies, and to document the distribution of the species through time and space, an endeavour that is particularly important during this critical time of global change. In August 2007, we spent two weeks searching for several *Calamagrostis* species that occur in the eastern United States. Here I present a general account of that trip.

The narrowly distributed *Calamagrostis cainii* Hitchc. is known only from Mt. Le Conte in the Great Smoky Mountains National Park, Tennessee, and from two small areas about 100 miles eastward in North Carolina. Upon arriving at Great Smoky Mountains National Park, we picked up our pre-arranged research permit from the park office, and prepared for an overnight hike up and down Mt. Le Conte. With enthusiasm and heavy backpacks filled with collecting and sleeping gear, we eventually came across *C. cainii*, and with a bit of treacherous climbing on the steep and slippery rock face—extreme botany—we were able to take photographs and collect good specimens. In many places along the trail *C. cainii* is the dominant grass and even the dominant vascular plant species, with hundreds of clumps in some places representing what could well be the largest population of the species in the world.

The top of Mt. Le Conte is a five mile hike that ascends about 1000 m. Unlike many mountain summits in the backcountry, atop Mt. Le Conte sits a rustic lodge that provides all the amenities of home. We were lucky to secure two spots in the far less civilized lean-to camping shelter just down the trail from the lodge, only to find that it was overbooked. Resigning to sleep on the ground, we prepared a camp stove dinner with our days grass collections laid out, and a friendly backpacker asked us if we were "some kind of vegetarians"— evidently he thought we were eating our grass collections.

Before leaving the summit in the morning haze, we headed back to the lodge grounds to collect the introduced grasses growing there. Before long a small crowd had gathered, asking what we were doing, and Peterson and I were giving an impromptu biology lesson about the biological richness of the Great Smoky Mountains, the endemic *C. cainii* that brought us all the way to the top of this mountain, and the general biodiversity of grasses. One woman remarked surprisingly to her husband about Peterson, "Can you believe he's been studying grasses for 28 years!"

The mostly-downhill eight mile hike from the Mt. Le Conte lodge across the ridge winds along narrow rocky ridges and through cool Fraser fir [*Abies fraseri* (Pursh) Poiret] forest, peppered with scenic overlooks. Five hours after leaving the shelter, we reached the parking lot and trailhead, several miles from where we parked our truck the day before. Within a few minutes on the roadside, we were graciously given a ride to our vehicle, content that we had successfully found the first of the *Calamagrostis* species that we were searching for.

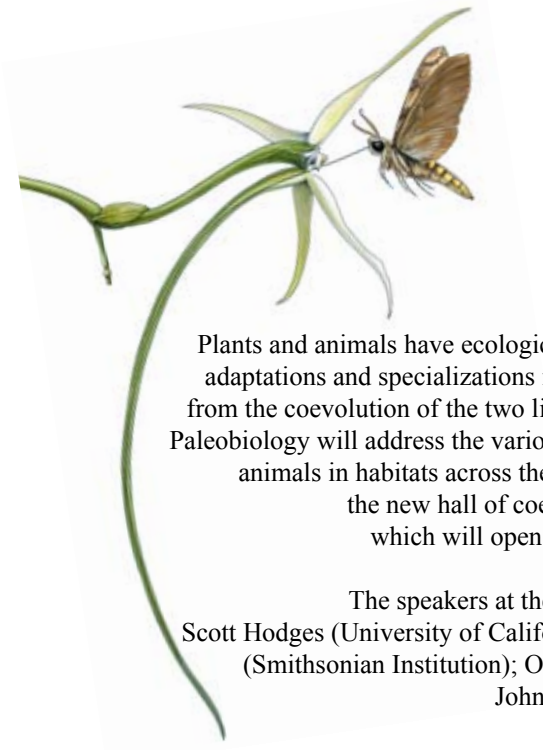
Later that day, park staff informed us that 25 individuals of *Calamagrostis cinnoides* (Muhl.) W.P.C. Barton, another eastern species, had been observed in the park 15 years earlier, in an area that used to receive some water outflow from a pump house that has since been removed. We relocated the area easily, and after about 30 minutes of searching in the moist shaded woods we had found and collected several grass species, but had not found *C. cinnoides*. At one point I thought Peterson had found the plant when I heard him screaming from only a few yards away, but in fact he had been swiftly attacked by a swarm of yellowjacket wasps after he inadvertently stepped on their nest. Peterson finally encountered a few scattered plants that we positively identified as *C. cinnoides*, content with our perseverance. Remarkably, the number of individuals we observed was no greater than the previous observations 15 years earlier. The next morning was consumed with processing all of our collections from the past two days, and by afternoon we were heading northwards.

Six hours later we were the lone campers in a small campground in George Washington National Forest. Peterson

Calamagrostis cainii **along the trail up Mt. Le Conte in the Great Smoky Mountains National Park. (Photo by Jeff Saarela)**

26 April 2008
National Museum of Natural History

Smithsonian
Botanical Symposium



"Partners in Evolution: Interactions, Adaptations, and Speciation"

In collaboration with the United States Botanic Garden and the National Tropical Botanical Garden

Plants and animals have ecologically interacted for hundreds of millions of years. These interactions have resulted in adaptations and specializations in both the plants and the animals. In some cases these adaptations have resulted from the coevolution of the two lineages. This Symposium, hosted by the Departments of Botany, Entomology, and Paleobiology will address the various ecological interactions, evolutionary adaptations, and co-radiations of plants and animals in habitats across the planet and explore the processes of coevolution. The Symposium highlights the new hall of coevolution, entitled "Partners in Evolution – Butterflies and Plants," which will open at the National Museum of Natural History in February of 2008.

The speakers at the Symposium will be Judith L. Bronstein (The University of Arizona); Scott Hodges (University of California Santa Barbara); W. John Kress (Smithsonian Institution); Conrad Labandeira (Smithsonian Institution); Olle Pellmyr (University of Idaho); Ted Schultz (Smithsonian Institution); and John N. Thompson (University of California Santa Cruz).

The hawk moth (*Xanthopan morganii* Walk. ssp. *praedicta* R. & J.) visiting the Madagascar Star Orchid (*Angraecum sesquipedale* Thou.). (Illustration by Emily Damstra for the Smithsonian Institution)

Information and registration at: http://persoon.si.edu/sbs/
Fax: 202-786-2563 – e-mail: sbs@si.edu

knew that we could easily find and collect Porter's reedgrass (*Calamagrostis porteri* A. Gray) here, where it occurs in dry oak forests on rocky ridge tops. Waking at first light the next morning, we broke camp, packed breakfast, and began the short climb up to the ridge, which straddles the Virginia/West Virginia state line. We immediately encountered the inspiration of our morning hike growing in dense patches along the edge of the woods. Research published in the early 1980s indicated that *C. porteri* is a sexually reproducing species that rarely flowers. Our observations were fully consistent with this—we saw many clumps of vegetative plants along the 2.1 mile stretch of the trail that we walked, and only three small patches with flowering individuals, each in areas with little to no canopy cover. Nonetheless, there was ample flowering material to make good collections. Not bad for a Thursday morning—before noon we had walked about four miles, and ticked another species off our '*Calamagrostis* life lists.' Leaving the general area, we stopped for a quick cool-off and clean-up in Little Stony Creek—a much needed break after all the hiking we had been doing.

Pickering's reed grass (*Calamagrostis pickeringii* A. Gray) occurs from Newfoundland to New York. In the Adirondack Mountains in New York we stopped at a beautiful roadside bog, and with minimal searching we found the species growing among classic bog vegetation. At this location, the species appeared to have flowered earlier in the season, but the brown and withered plant remnants were sufficient to allow us to conclusively determine the identity of the species. In New Hampshire, the best collection information we had was "Lakes of the Clouds, Mt. Washington" based on a 1901 collection. Our first day in White Mountains National Forest, we drove to the alpine summit of Mt. Washington (6288 ft) via the privately-owned eight mile long Mount Washington Auto Road. Despite a thorough search of the *Carex*-dominated alpine meadows, we did not find *Calamagrostis pickeringii*. Looking down from the Mt. Washington summit we could see the small Lakes of the Clouds, but time that day did not permit us to walk down and search the area.

The next morning after processing our collections, we prepared to hike up to the Lakes of the Clouds from the opposite side of Mt. Washington. The 3-mile long Ammonoosuc Ravine Trail—decidedly not suitable for those interested in a leisurely walk—ascends almost a kilometre. It starts in rich, mesic woods carpeted with mosses and lush vegetation, and eventually passes through a dwarf, subalpine forest dominated by krumholtz vegetation. Atop the trail, amidst signage indicating the fragility of the alpine environment, sits a welcoming hikers' shelter along the Appalachian Trail overlooking two small alpine lakes. After searching almost the entire general area around the lakes, and about to give up in disappointment, I elatedly stumbled across a large population of *C. pickeringii* species growing along one side of the lakes among the rocks. This grass was clearly locally abundant in this spot, but curiously it does not occur in other areas around the lakes. We made several collections, while at the same time confirming that this beautiful native species has persisted alongside the well-

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Reed-Grasses

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travelled Appalachian Trail and below the heavily-visited summit of Mt. Washington. It can only be hoped that the species will continue to persist in this fragile environment, under continued pressures from humans in the immediate area, as well as larger forces such as climate change. Our detailed collection information should allow researchers 100 years from now to locate our exact collection spot with ease.

By the end of our two-week trip we had travelled a substantial portion of the eastern United States along the Appalachian Mountain chain. We learned a lot about the *Calamagrostis* species that we were able to study in the field, and look forward to the insights that we will gain through detailed study of their morphology and DNA. Already, our preliminary data are yielding new insights into the evolution of this group, and it is becoming clear that we need increased sampling within *Calamagrostis* and among its relatives from around the world. This means that more field trips will eventually be necessary to collect the requisite genetic material in our effort to understand the evolutionary history of this group of grasses.

Botany Volunteer Awarded High Honor

For the second time in three years, a Botany volunteer has been awarded the Museum's highest volunteer honor. At the recent Peer Recognition Awards Ceremony in December, **Jim Harle** received the Outstanding Volunteer Award from Acting Director Paul Risser. Four years ago, at the invitation of Collections Manager **Rusty Russell**, Harle began a project to catalog the collection of maps that had been assembled by Botany staff for almost 100 years. It was a task that began nearly from scratch because these maps had been virtually ignored for decades, and the sense of organization that may have existed previously was now non-existent. With guidance from Suzanne Pilsk in the Smithsonian Libraries regarding map standards, and with his own expert knowledge of data programming, Harle designed and built a map cataloging system that currently consists of more than 5,000 records covering almost 7,000 map sheets and 4,000 subjects.

To begin with, Harle needed to get an idea of the scope of the problem. More than 20 five-drawer map cases existed in the herbarium and the basement, and hundreds more maps turned up in various offices and labs in the Department. The geographic coverage of all the maps needed to be determined and a physical arrangement of the maps by region was begun. Many maps required physical conservation and were isolated from the others. Overcrowding was a serious issue and, with help from Linda Hollenberg, additional map storage was provided and duplicates were culled from the collection.

For each map, scores of data fields are filled in, including physical map information, subject data, and the all-important latitude and longitude of the four corners of the map. Harle developed a feature that allows a user to enter a global coordinate into the search field and the program uses these corner points to fetch all existing maps that contain that fixed coordinate. Map records are then presented to the user beginning with the most highly resolved. Another search feature employs clickable maps of continents to guide users to map records. In addition to the map data, high quality digital images of many of the maps have been produced. The entire application is currently available on the Department intranet and is available throughout the Museum. Eventually, this resource will be made publicly available.

Harle has never worked in isolation. He consistently seeks out opinions, new information, and, of course, maps. He has supervised many high school and college interns who have come to the Museum during school breaks specifically to work with him. The Division of Reptiles and Amphibians (Department of Vertebrate Zoology) and the Department of Invertebrate Zoology have recently enlisted Harle's assistance in getting a handle on their respective map collections. In addition, because of the high profile Harle has given to maps, the Museum has just created a working group to look into how the National Museum of Natural History, in concert with the Smithsonian Institution Libraries (SIL), should handle, inventory, and make available its vast map resource. The final chapter on this story has not been written, so we hope Harle remains a valuable member of the Botany (and the Museum) community. Congratulations, Jim.

New *Cyrtandra* Named for Wagner

A new species, *Cyrtandra wagneri* Lorence & Perlman, is named for **Warren L. Wagner** because of the extensive work he has done on the systematics of Hawaiian *Cyrtandra* and in general on the study of the Hawaiian flora (*Novon* 17: 357-361; 2007). *Cyrtandra* in the Hawaiian Islands is extremely complex and nearly 500 species have been described.

Wagner's work has lead to a new understanding that there are only about 55 species of Hawaiian *Cyrtandra* and many hybrids in up to 90+ different combinations of species. Wagner is currently working with a graduate student John R. Clark and his major professor Eric Roalson (former Smithsonian post-doc) at Washington State University using molecular analyses to examine the pattern of hybridization and the question of how species remain distinct in the face of abundant hybridization among them.

Visitors

Continued from page 3

Kathleen Pryer and **Michael Windham**, Duke University; Ferns (10/25).

Carl Taylor, National Science Foundation; North American *Dryopteris* (Dryopteridaceae) (10/25).

George Yatskievych, Missouri Botanical Garden; Missouri flora (10/25).

Raymund Chan, University of Singapore; Compositae (10/29-11/17).

Dennis Kearns, Bureau of Land Management; Cucurbitaceae (10/29-10/30).

Daniel Layton, College of William and Mary; Commelinaceae (11/2).

Andrew Schnabel, University of Indiana South Bend; Commelinaceae (11/2).

Melanie Schori, Ohio University; Philippine Plant Inventory, Icacinaceae (11/13-11/14).

Nina Owczarek, Smithsonian's National Museum of African Art; Wood study (11/15-11/18).

Yongqing Zhu, East China Normal University, Shanghai; Bryophytes (11/15).

Jerry Davis, Cornell University; Poaceae (11/16).

Michael Dix, Universidad del Valle de Guatemala, Guatemala City; Guatemalan Bromeliaceae and Orchidaceae (11/19-11/21).

Chelsea Clifford, Carleton College; United States Exploring Expedition (11/26-12/21).

Roger Troutman, Independent researcher; *Liatris* (Asteraceae) (11/26-12/2).

Michael Fratz, Independent researcher; Herbarium tour (11/28).

Doreen Bolnick, Independent researcher; Library studies (11/30).

Beata Paszko, W. Szafer Institute of Botany, Polish Academy of Sciences, Krakow; Calamagrostis (Poaceae) (12/2/07-3/2/08).

Beatriz Caruzo, Universidad de Sao Paulo, Brazil; Euphorbiaceae (12/3-12/14).

Bill Dahl, Botanical Society of America; Meeting (12/4).

Ben Torke, Academy of Natural Sciences, Philadelphia; *Swartzia* (Fabaceae) (12/4-12/6).

Yusheng Liu, East Tennessee State University; *Quercus* (Fagaceae) (12/6).

Silvia Lobo, Herbario Museo Nacional de Costa Rica, San Jose; Muhlenbergiinae (12/8-12/21).

Silvia Lobo Caberas, Museo Nacional de Costa Rica, Heredia; Costa Rican Poaceae (12/10-12/18).

Emily Gillespie, Wake Forest University; Ericaceae (12/11).

Margaret Dix, Universidad del Valle de Guatemala, Guatemala City; Central American Bromeliaceae and Orchidaceae (12/12-12/19).

Abby Kula, University of Maryland; *Silene* (Caryophyllaceae), plant conservation (12/13).

Maria Camila Gómez and **Camilo Londoño A.**, Universidad de Los Andes, Merida, Venezuela; Flora of the Colombian Paramos (12/14).

Beatriz Baker, University of Missouri; *Chamaecrista desvauxii* (Caesalpinioideae) (12/19-1/3/08).

A. J. Harris, University of Alberta, Edmonton, Canada; Mastixioideae (Cornaceae) (12/19-12/21).

Joe Kirkbride, Beltsville Agricultural Research Center, United States Department of Agriculture; Rubiaceae (12/21-1/10/08).

Baird Kris, George Mason University; Asteraceae (12/21).

Ed Schilling, University of Tennessee; Asteraceae (12/21).

Matt Sewall, New York Botanical Garden; *Ilex* (12/21).

Profile

Continued from page 1

The morphology of the flowers of the two heliconias reflected this sexual preference by the hummingbirds. Flowers of *H. caribaea* were short and straight, measuring 38 mm in length and 20 degrees in curvature, which approximates the short, straight bills of male purple-throats, their primary pollinator.

In contrast, flowers of the green-bracted *H. bihai* were long and curved, measuring nearly 44 mm in length and 31 degree in curvature, which is almost identical to the 30 degree curvature of female bills. The close correspondence between bills of male and female purple-throats and the sizes and shapes of the *Heliconia* flowers they visit argues strongly for reciprocal adaptation. This hypothesis receives additional support from our discovery of a second, red-green morph of *H. bihai* on the island. This red-green morph acts as a geographic replacement of *H. caribaea* and is defended and visited primarily by male purple-throated caribs. Its flowers are both significantly shorter and straighter than flowers of the green-bracted morph visited by females, which is what you would expect given its visitation by males.

We then extended our investigations of this plant-pollinator system to the island of Dominica, located 100 miles north of St. Lucia. Bills of both sexes of purple-throated caribs on this island are slightly longer and slightly less curved than on St. Lucia. As on St. Lucia, however, the primary food plants of these birds are *H. caribaea* and *H. bihai*. But in contrast to St. Lucia which has two morphs of *H.*

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***Heliconia caribaea* and the Purple-throated Carib Hummingbird is distributed throughout the Eastern Antilles. (Photo by W. John Kress)**

Profile

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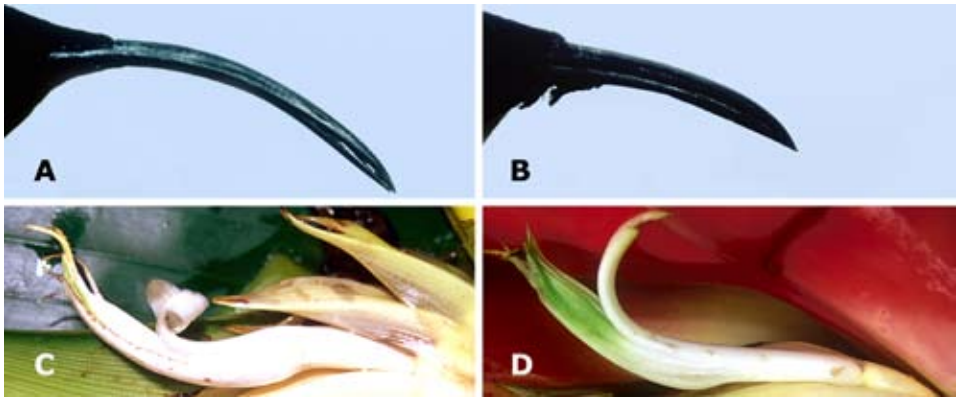
bihai, green and red-green, on Dominica there is only one morph of *H. bihai* which is red with a yellow stripe. Similarly, whereas there was only a single, red color morph of *H. caribaea* on St. Lucia, on Dominica there are now two: a red morph and a yellow morph.

As on St. Lucia, males associate primarily with *H. caribaea*. Females also visit *H. caribaea* and are the sole pollinator of *H. bihai*. Once again, flowers of the two heliconias correspond closely to the bills of their primary hummingbird visitor. Flowers of *H. caribaea* are short and straight, measuring 36 mm in length and 20 degrees in curvature, which roughly corresponds to the 15-degree bill curvature of males. In contrast, flowers of *H. bihai* measure 48 mm in length and 30 degrees in curvature, a perfect match for the 30 degree bill curvature of females. The flowers of *H. bihai* are 4 mm longer than on St. Lucia which we interpret as a coevolutionary response to the exclusive visitation by female purple-throats with their long bills.

Vinita Gowda, a graduate student at George Washington University working with us on this project, has provided an important temporal component to our observations. As part of her dissertation, she monitored the flowering times of the heliconias and the visitation rates of the hummingbirds on three islands: Dominica, St. Kitts to the north, and St. Vincent to the south. On Dominica flowering patterns of *H. bihai* and *H. caribaea* were significantly different: *H. bihai* flowers throughout the year but has a distinct peak flowering season in April, whereas *H. caribaea* has a distinct flowering season from March until September (with a peak in May) and does not produce any flowers the rest of the year. The peak flowering season of the two species did not overlap.

With respect to pollinator visitation patterns *H. bihai* shows a clear female dominated interaction throughout the flowering season while *H. caribaea* inflorescences are always strictly defended as territories by males with females often allowed to enter the territories to feed on the flowers during the mating season. Other pollinators that were rarely observed on *H. caribaea* are Green throated Carib Hummingbirds (*Eulampis holosericeus*) and Antillean Crested Hummingbirds



Polymorphisms in bills of purple-throated caribs and in flowers of *Heliconia* species. A) Female bill; B) Male bill; C) *H. bihai*, flower; D) *H. caribaea*, flower. (Photos by W. John Kress and Ethan Temeles)

(*Orthorhyncus cristatus*). Both of these visitors are aggressively chased away by territorial males.

As our studies and observations have spread throughout the archipelago we have tracked the long-distance transition between generalized and specialized plant-pollinator interactions in this heliconia-hummingbird system. What we have found is that one species of plant, *H. bihai*, changes from a generalist strategy in the southern range of the island chain (Trinidad) where its flowers are pollinated by many hummingbird species to a highly specialized pollination strategy in the core of the archipelago (St. Lucia and Dominica) where its flowers are pollinated by one sex of one hummingbird species.

We are only now beginning to understand the floral and pollinator traits associated with the transition from generalization to specialization. Where *H. bihai* is pollinated by many hummingbird species with bills of many different lengths, the flowers are 30% shorter in length than on the islands where the flowers are only visited by female purple throated Carib hummingbirds with long-curved bills. We hypothesize that this transition across 300 miles in the Caribbean archipelago results from character release associated with a decrease in the number of species on islands as one moves north farther and farther from the mainland. The number of endemic *Heliconia* species decreases from five on Trinidad to two on St. Lucia and Dominica, whereas the number of hummingbird species decreases from twelve on Trinidad to three on St. Lucia and four on Dominica. This reduction in species diversity may permit *H. bihai* and *H. caribaea* to undergo character displacement where the two heliconias overlap. Similarly, a reduction in competing hummingbird species combined with two abundant and rewarding *Heliconia* food plants may drive the evolution of sexual dimorphism within purple-throated caribs. Our available evidence supports this hypothesis.

These results indicate that a geographic approach can identify populations of plant-pollinator specialization and generalization. Highly-specialized populations may represent hotspots of reciprocal evolution. In this regard, it is significant that the longest flowers of *H. bihai* and the longest bills of female purple-throated caribs occur where it is pollinated exclusively by females. Whether such associations represent coevolutionary arms races requires future study.

We have much more to understand about the mosaic of interactions between the species of heliconia and their hummingbirds pollinators in the Lesser Antilles. Through a grant from the National Science Foundation we have funding support to continue our investigations in the Eastern Caribbean for several more years. Like the Galapagos Islands off the coast of Ecuador, the Eastern Caribbean archipelago is an ideal natural laboratory for understanding the evolutionary processes of adaptation and coevolution.

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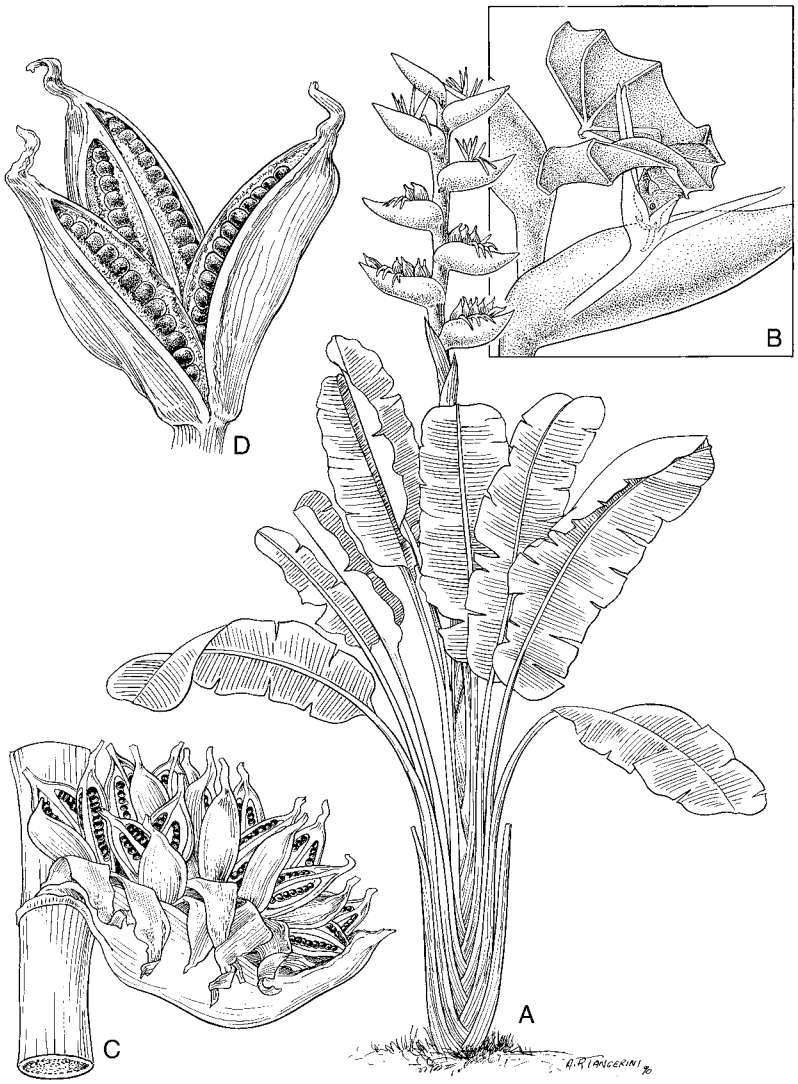
Art by Alice Tangerini

Phenakospermum guyannense (L.C. Rich.) Endl. ex Miq.

Phenakospermum guyannense, a monotypic genus in the Family Strelitziaceae, is pollinated by nocturnally foraging phyllostomid bats in the Amazon Basin of South America (Kress & Stone, 1993, *Biotropica* 25: 290-300). This genus has similar bracteate inflorescences to those found in *Heliconia*, another member of the Order Zingiberales, distributed throughout the Neotropics. In contrast to the bat-pollinated *Phenakospermum*, species of *Heliconia* are pollinated by hummingbirds with very specialized ecological and evolutionary interactions as described in the cover article of this issue of *The Plant Press*.



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