The Arizona Native Plant Society

The Plant Press

THE ARIZONA NATIVE PLANT SOCIETY

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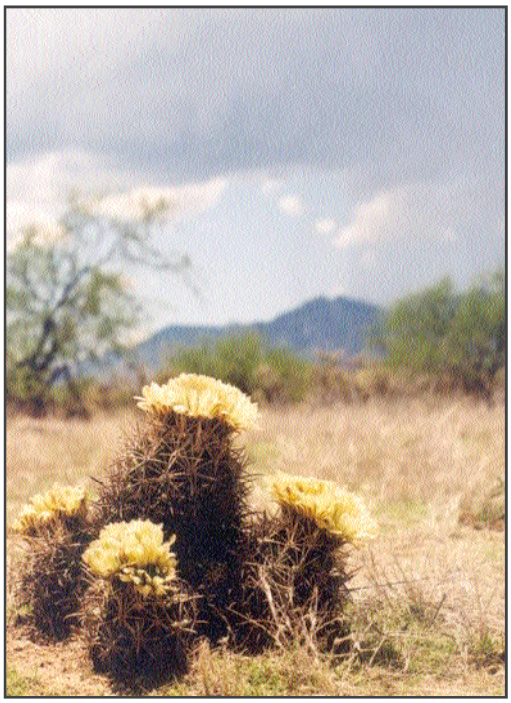
Pollinators!

& Our Regular Features:

Special thanks go to Barb Phillips for pulling this all together and to all who contributed time and effort: Judith Bronstein, Stephen Buchmann, Jessa Fisher, Carianne Funicelli, Douglas Green, Max Licher, Christopher McDonald, Lawrence Stevens.

Pima Pineapple Cactus: A Unique Cactus Hiding in Plain Sight

by Christopher McDonald[1]



Pima pineapple cactus looks seemingly like any other small cactus with an inconspicuous cloak of spines, but looks can be quite deceiving. Although taxonomy is usually less-than-exciting, the taxonomy of this plant is interesting since the plant has undergone at least nine name changes within six different genera, currently resting with *Coryphantha robustispina* ssp. *robustispina*. The biology of this cactus is even more spectacular.

This cactus adds new meaning to the word rare. Imagine trying to find a softball randomly placed in a football field of semi-arid desert. This site would contain one Pima pineapple cactus plant per hectare (2.47 acres), yet many Pima pineapple cactus populations consist of one plant/10 ha (1 plant / 25acres). Pima pineapple cactus is found between the Arizona uplands and semi-arid grassland communities in the Altar and Santa Cruz valleys of southern Arizona, near Tucson. Arizona uplands are the 'postcard' plant community of Tucson with saguaro (*Carnegia gigantea*), palo verde (*Parkinsonia microphyllum*) and mesquite (*Prosopis velutina*) dominating. In contrast, native grasses (*Aristida, Bouteloua, Digitaria*), and non-native grasses (Lehmann's lovegrass, *Eragrostis lehmanniana*) dominate the semi-arid grasslands intermixed with scattered shrubs, cacti and mesquite.

Pima pineapple cactus is usually found on gently sloping alluvial fans, the foothills of mountains, and valley floors, which are the places threatened most often by suburban and exurban development. The cactus is federally listed as endangered due to several human activities including development and nonnative species introductions.

Pima pineapple cactus is a short — on average between 10-30 cm (4-12 in) tall — hemispherical-to-cylindrical cactus, sometimes surrounded by dozens of ramets (also called branches, buds, clones, offsets, or pups). Each group of straw-colored spines sits at the tip of a

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President's Note

by Barbara G. Phillips **bgphillips@fs.fed.us**
Coconino, Kaibab and Prescott National Forests, Flagstaff

Some of my earliest childhood memories are of pollinators —the busy non-native honeybees in my family's orchards of apples, peaches, pears and cherries in Western New York. We had lots of hives of the bees and my father managed them as a true beekeeper, with smoke, mask and gloves. He also put flowering bouquets of branches in barrels at strategic places in the orchards for those varieties that required cross-pollination. We ate really dark brown honey gleaned from the honeycombs. Other memories are of being stung by insects in the grass while running barefoot through the yards and orchards. Some of those stings came from native bees, bumblebees and wasps because we had a 15-acre woods, creek with native streamside vegetation, hedgerows and brush piles. Our farm was not as manicured and filled with non-native plants as corporate farms today and native species of pollinators also found homes and food aplenty.

Now both native pollinators and the introduced honeybees are in peril as I am sure you have heard on the news. This issue of *The Plant Press* is devoted to pollinators of our Arizona native plants. Pima Pineapple Cactus, our featured plant in this issue, is going to retain its endangered species protection, as announced by the U.S. Fish & Wildlife Service (**www.fws.gov/southwest/es/arizona**). I know you will be fascinated by the complex interrelationship of this rare cactus with its pollinator as well as its biology and life history. Other articles take us from the top of the San Francisco Peaks to your own backyard following the diligent research by Arizona botanists and biologists on native plants and their pollinators.

I hope that these articles and the shorter regular columns will bring you fresh perspectives about pollinators and their problems. Take time to look up the websites and books mentioned by the authors. There is a wealth of information available on the internet and at websites of other organizations such as the Arizona-Sonoran Desert Museum. Steve Buchmann suggests several ways you can help pollinators in your own gardens. Please note that the Conservation Committee of AZNPS is actively seeking your input on how AZNPS members can educate their neighbors and homeowners associations about the value of Arizona plant pollinators within our communities.

I want to thank the Board and members of AZNPS, especially Wendy Hodgson, Les Landrum and Andrew Salywon of the Organizing Committee, who worked so diligently to put on another outstanding Arizona Botanists/Arizona Native Plant Society Annual Meeting at the Desert Botanical Garden in February. Thanks also to Nancy Zierenberg, Rod Mondt and Doug Green for manning AZNPS tables at the event and organizing correlative short and long fieldtrips. The topic of "Ethnobotany and Inherited Landscapes" was very well received by over 150 attendees. A future issue of *The Plant Press* will focus on this theme.

Coryphantha robustispina ssp. robustispina

Pima pineapple cactus *continued*

tubercle (a finger-like projection) on which rests the areole (the spine-producing structure). Each tubercle has 10-15 radial spines and one central spine, which can be slightly curved at the tip. The spines are quite strong, hence the species name. Each tubercle has a cleft on the top-side easily distinguishing this cactus from small barrel (*Ferocactus*) or pincushion (*Mammillaria*) cacti.

This cactus is unusual in that it can asexually produce many ramets that grow near the base of the 'parent' plant. The number of ramets each Pima pineapple cactus produces varies from none to over 100 (rarely), but usually each plant has 3-5 ramets. Some scientists see this variation as alternatives in a survival strategy — when many ramets are produced that can outlive the parent plant, there is a greater chance of leaving offspring in the long-term. However, when fewer ramets are produced, the more energy the parent plant can invest in reproduction, increasing its chance of producing offspring in the short-term. Scientists have yet to understand the natural economics of Pima pineapple cactus.

The flowers of this species are relatively large — 6-10 cm (2-4 in) across — and are showy with bright yellow petal-like tepals. Flower color can be stunningly variable from pale-yellow, to yellow with red streaks, to salmon. Reproduction is highly variable between individuals. Large adult plants produce about ten flowers and fruits a year; however plants with many ramets can produce 20-30 fruits in a year, as the many smaller plants each produce a few fruit. Each fruit contains about 80 seeds.

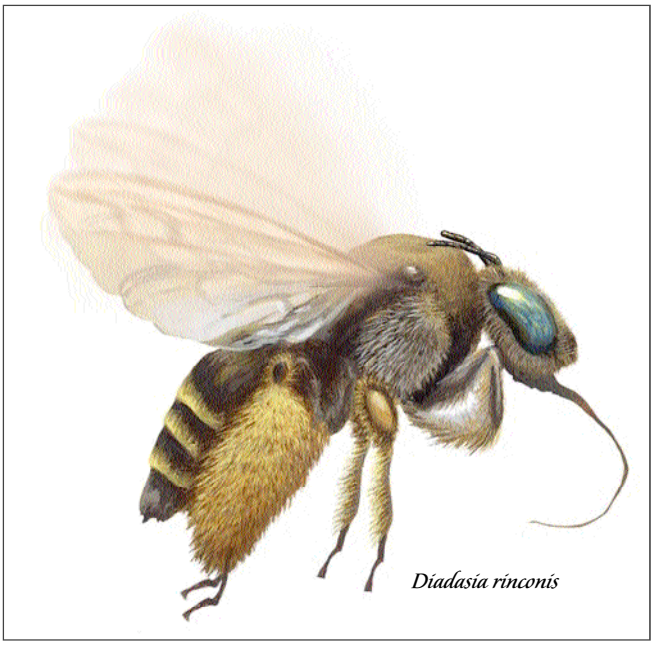
The fruits are about 3 inches long and, after September, turn from dark green to light green as they ripen. When mature, the fruits extend beyond the central spines where they are eaten and dispersed by a variety of small- to medium-sized animals, including rabbits, squirrels, birds, and even ants. Scientists do not know how successful these animals are at dispersing the seeds.

Part of the uniqueness of this cactus stems from its relationship with its pollinator *Diadasia rinconis*. The cactus owes much of its livelihood to this medium-sized, furry bee. Unlike the common European honeybee (*Apis mellifera*) *Diadasia* females are solitary, dig their nests underground, and each female provisions her own offspring. Many females live in aggregations similar to 'bee suburbs,' as the female's nests are close together but each nest is independent. Some of the largest known aggregations can house ten thousand bees in only several hundred square feet of space. The habitat that most Pima pineapple cacti occupy is the also habitat that *Diadasia* bees prefer — gently sloping alluvial fans.

About the same size as the European honeybee, *Diadasia* bees are quite fuzzy, tan-brown in color with yellow and brown bands on their abdomens, and have dark green eyes. They are cactus specialists: the females visit plants within the cactus family to collect pollen and nectar for their young. The bees sparingly use other kinds of plant pollen and nectar. Research has shown that many *Diadasia* females will not begin provisioning their nest unless they have access to cactus pollen.

The female bee collects cactus pollen and nectar and, after a dozen trips visiting possibly hundreds of flowers, she lays one egg on the large (~1 cm, 0.4 inch) mass of nectar and pollen. She seals the chamber, builds another mass in a separate

Photos
cover Monsoon & Pima pineapple cactus.
PAGE 3 *Diadasia* in Pima pineapple cactus.
PAGE 4 Pima pineapple cactus flowers and pups.



Diadasia rinconis

chamber, seals the entrance to the entire nest, and digs a new hole after she provisions about a dozen eggs. She does this without the help of male *Diadasia* bees, who are apparently too busy finding other mates to be bothered with these tasks.

Mating is very important to male *Diadasia* bees. The males emerge from their underground nests before the females and wait for them to emerge. When a female emerges the males fight each other to get access to her. Sometimes this results in a ball of males surrounding the female, with all the males pushing and shoving trying to mate. During copulation, which lasts several minutes, the pair produces brief buzzing sounds. If a male *Diadasia* finds a female that has already mated, she is generally left alone. Some vigorous *Diadasia* males have been seen attempting to mate with other species of bees.

Diadasia bees are quite harmless unless harassed, which is common with the vast majority of Sonoran Desert bees. Sometimes a nesting aggregation may be near a home without anyone noticing, since the presence of humans does not seem to bother the bees. *Diadasia* females nest in bare patches of soil. Scientists do not know why some sites are chosen to start an aggregation and others of seemingly equal quality are left unoccupied.

When pollinating a cactus flower, the behavior of *Diadasia* females is quite distinctive. A female will land on the stigma of larger flowered cacti — cholla, prickly pear, barrel, hedgehog, saguaro and beehive cacti (*Opuntia*, *Ferocactus*, *Echinocereus*, *Carnegia*, and other *Coryphantha*) among others. She then climbs down the style to the bottom of the flower, drinks the nectar, collects pollen, climbs back up the style, touching the numerous anthers on the way out, and flies to the next cactus flower. Sometimes she will run a few laps on top of the anthers collecting pollen before she leaves.

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In the air she grooms some of the pollen off her furry body and moves it to her hind legs. However, some pollen remains on the body having escaped the bee's grooming efforts.

Because of their distinctive behavior and morphology, *Diadasia* females are quite easy to identify in the field or garden during their nesting season, April through August. Part of the reason *Diadasia* females are so successful at pollinating cacti is that on most visits the last thing their fuzzy bodies touch when leaving a flower is the pollen-laden anthers and first thing they land on is the sticky stigma ready to receive pollen.

Although *Diadasia* bees visit and use the flowers of Pima pineapple cacti, the truth is the plants are very dependent on these specific bees, much more than the bees rely on this cactus. Pima pineapple cacti grow flower buds during the driest and hottest months, May and June, and bloom during an unusual time period in the Sonoran Desert, the early summer. Most Sonoran Desert plants bloom with the spring rains or towards the end of the summer with the 'monsoons.' However, since very few other cacti are flowering at this time Pima pineapple cacti have the nearly undivided attention of *Diadasia* females. Scientists are now learning that many pollinator specialists have similar asymmetric relationships with their partners.

Another unusual characteristic of this plant is that the flowers open in response to summer rainfall. The flowers bloom 5 to 7 days after a significant monsoon storm and many plants will flower on the same day in a synchronous flowering event. More surprisingly is that the flowers only last one day. These synchronous flowering events happen about four times a year spanning June through September. Researchers have found that the flowers pollinated in June and July are more successful than those that bloom later in the year.

Because of the dependency of Pima pineapple cactus on this pollinator, land managers and conservation professionals need to consider much more than this single plant when managing this species. Recent research has shown that *Diadasia* bees can carry the pollen of Pima pineapple cacti relatively short distances, generally less than 0.8 km (0.5 mile). This suggests that corridors are crucial to the long-term survival of this rare plant. Corridors of native vegetation with a variety of cacti species will need to be preserved so native bees can pollinate disparate populations of Pima pineapple cactus and still obtain enough resources to provision young. Many scientists agree that corridors are needed to function as pathways for birds, mammals and reptiles, such as hummingbirds, bobcats and tortoises. However, we are beginning to realize that corridors also need to function as safe havens for pollinators if we intend to protect populations of the plants they pollinate.

The home gardener is one effective and often critical link in the conservation of plants and pollinators, including Pima pineapple cactus and *Diadasia* bees. New research suggests that bee diversity in suburban areas can be as high as in surrounding natural areas. Many native bees are unnoticed in most people's backyards and will provide their pollination services at the modest cost of food and shelter. Last summer in my small Tucson garden I counted a dozen genera of bees visiting flowers, 4 different kinds of bees were building nests and I am sure I missed many more. Planting native plants and creating nesting areas for bees (see additional resources below) are easy and effective ways of creating beneficial and fun pollinator-friendly gardens.

Additional Resources:

A great reference on local pollinators, with plans to build your own pollinator garden (Editor's note: see review on page 10), in English and Spanish:

Chambers, N., Gray, Y. and S. Buchmann, *Pollinators of the Sonoran Desert, a Field Guide*. Arizona Sonora Desert Museum Press, Tucson. 2005.

The Xerces Society is dedicated to conservation of invertebrates. It has several fact sheets on building artificial bee nests in its Pollinator Conservation and Gardening sections: **www.xerces.org**

Wonderful examples of pollinator gardens for Arizona gardeners are:

The Arizona-Sonora Desert Museum (Tucson) **www.desertmuseum.org**
Desert Botanical Garden (Phoenix) **www.dbg.org**
Tucson Botanical Garden **www.tucsonbotanical.org**
The Arboretum at Flagstaff **www.thearb.org**
Tohono Chul Park (Tucson) **www.tohonochulpark.org**
Boyce Thompson Arboretum (Superior) **arboretum.ag.arizona.edu**

A great webpage containing information about solitary ground-nesting bees, including *Diadasia rinconis*, can be found at **desertdiscovery.arizona.edu/bees.html**

Plant and Pollinator Diversity in Northern Arizona

by Lawrence E. Stevens[1], Terry L. Griswold[2], Olivia Messenger[2], Warren G. Abrahamson II[3], and Tina J. Ayers[4]

Bombus morrisoni bumblebee
Elevation range: 900-2800 m

Dugaldia

Lonicera

ABOVE Bombus bumblebees are large-bodied native bees that become increasingly dominant at higher elevations. They appear to prefer blue to yellow or white flowers.

Introduction

The study of plant and pollinating insect biology and diversity in northern Arizona shows how mutualistic relationships between trophic levels vary across elevation. Over the past decade, we have been engaged in an elevation-based biological inventory of Apache, Coconino, Navajo, Mohave, and Yavapai counties in northern Arizona, compiling data on the distribution of native and non-native plant and animal taxa there. The large data sets now emerging from that work provide insight into a number of provocative ecological questions. The botanical work is nearing completion, with likely more than 90 percent of the region's plant species documented. However, the inventory is still far from complete for insects, including pollinators. Nonetheless, sufficient data have been assemble to allow us to present some preliminary analyses of plant and bee diversity across elevation in northern Arizona.

Plant Biodiversity across Elevation

With more than 2000 species, the vascular plant diversity of northern Arizona is simply enormous. Plant diversity here is strongly influenced by elevation, which ranges from 350 to 3800 m (1150 to 12,633 ft). Although elevational zonation of trees has been recognized since the 1890s through the work of C. Hart Merriam, basic elevation patterns of flowering plant diversity in northern Arizona have received relatively little attention. Important questions exist as to whether plant species other than trees are tightly organized into "life zones," and how plant diversity influences the diversity of other taxa across elevation. To address such questions, Stevens, Abrahamson and Ayers are compiling data on the elevational distribution of plants in northern Arizona from herbaria, available databases, and field transects. Thus far they have compiled elevation range data on 2,030 plant taxa in the region. Overall, these data indicate that vascular plant diversity is strongly non-linearly related to elevation, with the highest number of species occurring between 1500 and 2000 m (4900-6500 ft) elevation (Fig. 1).

Studies of biodiversity require understanding how habitat area affects species richness: larger habitats generally support larger numbers of species. To understand habitat area relationships in relation to plant species diversity, we conducted a geographic information analysis to determine how much land surface area exists within 100-m elevation belts across northern Arizona. To adjust diversity for the strength of this species-area effect, we calculated vascular plant species density/km^2 for northern Arizona. A plot of the number of plant species within each elevation belt as a function of the land surface area within that belt demonstrates (as expected) a strong positive relationship (Fig. 2).

Pollinator Diversity

Pollinating insect diversity is also remarkably large in the arid, topographically diverse habitats of northern Arizona. To date, Griswold, Messenger and Stevens have documented at least 533 species of bees (Hymenoptera: Apoidea) in six families in Apache, Navajo, Coconino, Mohave and northern Yavapai Counties. Of these, the only non-native species is the European honeybee (Apidae: *Apis mellifera*), which is extremely common and may out-compete native bees in some situations. The Mohave-Sonoran Desert is renowned for having the highest diversity of several other pollinating Hymenoptera in North America, including not only bees, but also spider wasps (Pompilidae) and velvet ants (Mutillidae). Additionally, many species of thread-waisted (Sphecidae), crabronid, and vespid wasps are found there. In addition, Stevens (unpublished data) has recorded more than 130 species of butterflies and skippers, and the diversity of pollinating flies and beetles also is large in the region, although taxonomic progress to verify their diversity has been slower.

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CONSERVATION COMMITTEE UPDATE

Is the native habitat in your yard under attack?

by Carianne Funicelli
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AZNPS Conservation Chair

The **Grow Native: *Don't Plant a Pest*** public education campaign has been a huge success — since August of 2006 we have distributed over 50,000 brochures in English and Spanish to local governments, home owner's associations, schools, nurseries, and conservation organizations throughout southern Arizona. (If you are new and not familiar with this effort, check out our website at: **www.aznps.org/invasives/GrowNative/invasives.html**.)

Even so, butterfly and hummingbird gardeners in many neighborhoods across Arizona are finding that their neighborhood rules are not necessarily supportive of native plants. For example, one management company in Marana regularly features an article in their newsletter about their position that "wildflowers are weeds." Residents are actually receiving citations for having native wildflowers in their yards, although ironically those with non-native invasives such as African sumac *(Rhus lancea)* and fountain grass *(Pennisetum setaceum)* are deemed acceptable. Clearly we have our work cut out for us in educating these entities about not only the dangers of invasive ornamentals, but the value of native plants in residential landscapes.

The conservation committee is getting very interested in finding ways (in addition to the brochure and presentations) to bring about a native plant paradigm shift. Please share your ideas and experiences with us — we would like to hear about what is happening from across the state! Email us at **conservation@aznps.org**.

Plant and Pollinator Diversity *continued*

We have assembled sufficient information on bee diversity to address a basic question of how pollinator diversity is related to plant diversity, and how that relationship varies across elevation. Using the USDA and MNA bee databases, we calculated elevation ranges of bee species for which sufficient data exist (367 of the 533 bee species). We found a strong negative relationship between bee diversity and elevation (Fig. 3).

That analysis gave us the opportunity to look at the area-adjusted ratio of bee species diversity in relation to that of vascular plants, the first time this has been done in the Grand Canyon region to our knowledge. This analysis revealed a strong negative response of bee:plant diversity across elevation (Fig. 4). Uppermost elevations are extremely limited in area, and although bee diversity drops to only one species, the species area relationship is anomalously skewed upward by that statistical artifact from 3500-3700 m elevation. Nonetheless, the overall strength of the pattern suggests that bee pollinator diversity declines with elevation relative to that of plants, and thus plant species support relatively fewer bee species at higher elevations.

Discussion

Reporting such a bold pattern in nature is an invitation for scientists to attempt to falsify that pattern and seek the most parsimonious explanation. Bee-to-plant diversity variation across elevation is likely to be attributable to numerous factors. One could hypothesize that host-plant specialization might be more common among pollinators at higher elevations, resulting in fewer pollinator species/plant species. However, that does not appear to be the case: although bee diversity naturally decreases at higher elevations as a result of the thermodynamic challenges, montane bees appear to be even broader generalists than those at lower elevations. Improved understanding of floral use specialization by bees is needed to more fully test that hypothesis.

Temperature is the most common factor affecting the distribution of ectotherms, such as pollinating insects. The alpine growing season is notoriously short: native bee diversity is bimodal in the desert, with spring and fall periods of emergence, but is restricted to a single, relatively brief mid-summer peak at high elevations. The short duration of the alpine growing season likely greatly restricts the effectiveness of bees as pollinators, and colder temperatures mean that only the hardiest bees can survive and function there. The Transition and Canadian forest meadows on the lower and middle slopes of the San Francisco Peaks support a relatively rich assemblage of bumblebees (Apidae), including *Bombus morrisoni, B. rufocinctus, B. occidentalis, B. fervidus,* and *B. huntii.* However, only *Bombus centralis* and *Colletes simulans* (Colletidae) appear to take on the extreme cold and wind above treeline. These all are relatively large-bodied bees with dense coats of hair-like spines that afford them some ability to conserve heat, a necessity in cold montane temperatures.

It is not only the severity of the weather that affects alpine pollinators, but also climatic variability. A themistor placed at the top of the San Francisco Peaks showed that air temperature there ranged over 37°C (100°F) within a four-day period three times during from October 2003 through June 2004. Highly erratic weather patterns above treeline require that pollinators have specific emergence and behavioral responses to temperature, day length, and other climate factors. However, since bumblebees and other alpine bees nest in the ground, they may be able to wait out bad weather and emerge during brief sunny periods. These emergence and behavioral adaptations

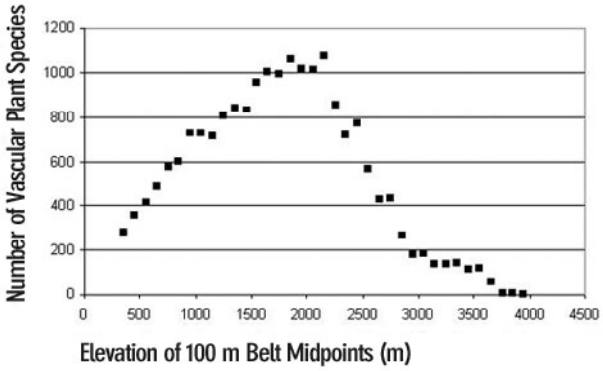

Figure 1. Number of vascular plant species across elevation in 100 m belts in northern Arizona.

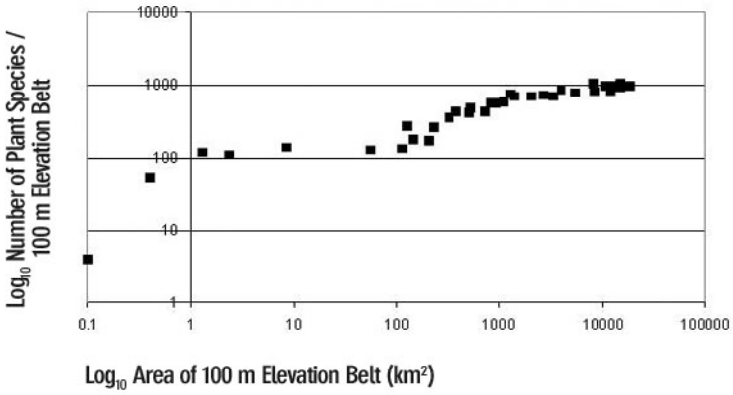

Figure 2. Plant species–area relationship in northern Arizona as the $\log_{10}$ (number of plant species / 100 m elevation belt) in relation to the $\log_{10}$ area of that 100 m elevation belt (km^2).

may help them cope with the vagaries of alpine climate.

Other factors also are likely play a role in this plant-pollinator diversity pattern. For example, the proportion of angiosperms that outcross may be lower, potentially in reciprocal response to lower bee diversity in harsh alpine environments. Pollination may shift toward flies and beetles, away from bees. Also, the proportion of anemophilous (wind-pollinated) plants may be greater at high elevations, and such species do not require insect pollinators. Also, what about the role of flower color? Unlike humans, insects perceive ultraviolet wavelengths of light. Yellow (e.g., *Senecio* spp.) and white flowers are common above treeline, but what is the relative abundance of blue and red flower colors there?

Global climate change, and particularly the pattern of increased variation in weather patterns, may have a stronger immediate impact on short-lived pollinators than on their longer-lived host plants. However, because native bees may be responsible for plant reproductive success, and because bee diversity is relatively lower at high elevations, climate changes may relatively quickly exact a larger impact on montane vascular plant floras, as compared to those at lower elevations.

With an improving inventory of northern Arizona's biota we can begin to examine, test, and explain these pollination pattern more fully, and address other basic and applied pollinator research questions. Some of those questions include: the biodiversity of pollinators other than bees, host-plant specificity across elevation, the impacts of non-native honeybees on native pollinator populations, and the impacts of global climate change on pollinator distribution and population dynamics. We look forward to continued research into these and other biodiversity topics in northern Arizona's extraordinary array of natural and altered habitats.

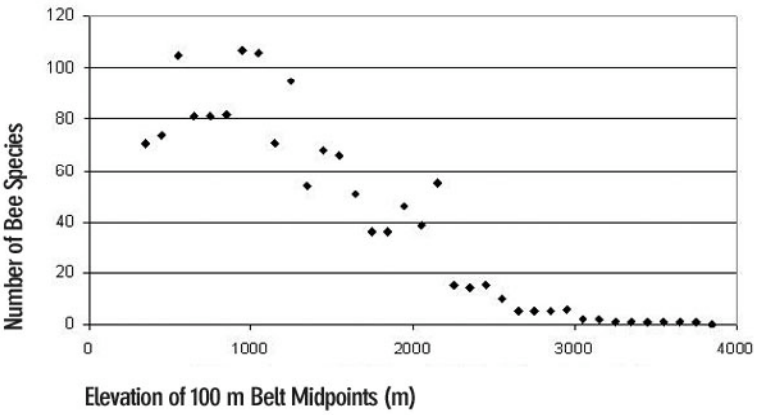

Figure 3. Number of bee species across elevation in 100 m belts in northern Arizona.

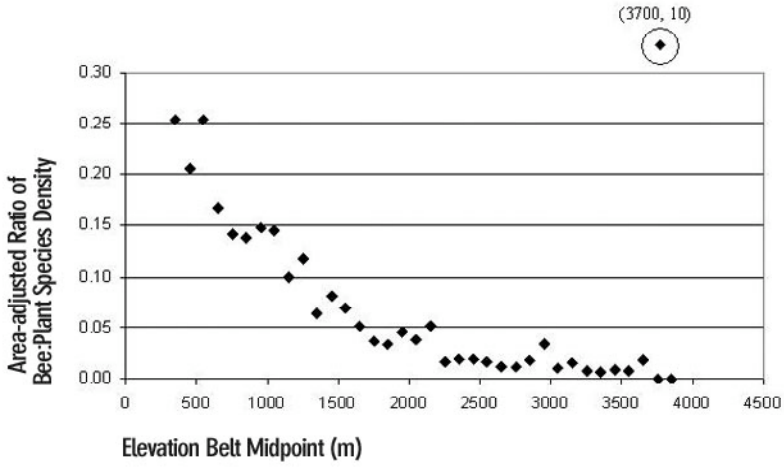

Figure 4. The area–adjusted ratio of bee:plant species density/ km^2 across elevation in 100 m belts in northern Arizona.

Acknowledgements

We thank the staff of the many federal agencies, volunteers, and assistants who have supported our work or otherwise helped with our data compilation, particularly Mr. Chris Brod for his assistance with GIS analyses.

Friends of Friends? Barrel Cactus and its Interacting Mutualists

by Judith L. Bronstein[1] and Joshua H. Ness[2]

Plants require the services of animals to accomplish some of their most essential life functions. Animals do not provide these activities out of an interest in benefiting the plants: rather, they are generally paid handsomely for their services. The best-known of these mutually beneficial exchanges (mutualisms) are pollination, in which animals receive a nectar reward for moving pollen between flowers, and seed dispersal, in which they transport seeds away from the plant while feeding on the surrounding fruit. A third, less well-known mutualism takes place on certain plants (including species in over ninety plant families) that secrete nectar from specialized organs located away from the flowers (extrafloral nectaries). Ants are attracted to and feed upon this nectar, while aggressively defending their food source from organisms attempting to consume the plant. In effect, these plants use ants to conduct "biological warfare" on their enemies.

There are plenty of examples of all three kinds of mutualism in North American desert plants. Let us consider just the cacti. Although our more spectacular columnar cacti, including saguaros, are pollinated by vertebrates such as bats and white-winged doves, insects are the chief providers of this service. In fact, the southwestern deserts have the highest diversity of bees on the planet; many of them serve as critical pollinators for prickly pears, chollas, pincushion, and barrel cacti. Animal-mediated seed dispersal in desert habitats is much less prominent. However, the few species that do produce juicy, sugary fruits, including saguaros and prickly pears, are particularly important because they likely subsidize much of the desert vertebrate community at times when other water sources are scarce. Finally, essentially all of our southwestern cacti take a "biological warfare" approach to defending themselves. The extrafloral nectar is secreted from small organs located near the buds, fruits and flowers; the ants that collect it appear to be particularly important in defending the cacti from insects that might otherwise feed on these delicate reproductive organs.

For several years, we and our colleagues have been studying the diverse animals that exchange benefits with the fishhook barrel cactus, *Ferocactus wislizeni*, around southern Arizona. Here we wish to focus on its pollinators and the ant defenders, as well as on how they interact with each other.

Figure 1a. A male *Lithurgus*, a specialized cactus bee in the family Megachilidae (leafcutter bees), burrowing deep into a flower of the fishhook barrel cactus, *Ferocactus wislizeni*, to collect nectar. Upon emerging he will be covered with pollen, which will be transported to the next flower he visits. *Photo by Josh Ness.*

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Fishhook barrel cacti produce a memorable display of bright yellow, orange and red flowers during the monsoon season. These flowers attract a variety of visitors that may collect both pollen and nectar. Perhaps surprisingly, visits by butterflies, flies, and the ubiquitous European honeybee provide no benefit. Only a few specialized bee species ('cactus bees') successfully pollinate these flowers (Fig. 1a). (Chollas and prickly pears depend on many of these same bees.) We find it fascinating that a plant that attracts so many visitors benefits from so few of them, and that the reproduction of the plant is in the hands (or, rather, legs!) of only a few native bee species.

The extrafloral nectaries of fishhook barrel cactus are raised, bright-yellow bumps located in several rings on the top of the plant; they are highly modified spines. If you look closely at the top of a barrel cactus, you are likely to see anywhere from a few to nearly a hundred ants intermittently feeding at these nectaries (Fig. 2). At every site we have checked, there are about eight to ten different cactus ant species; one group of species characterizes desert sites, while another is found in grassland habitats. Each individual barrel cactus, however, is almost always dominated at any one time by only one ant species. If an intruder ant species wanders onto the plant, it is promptly attacked by the residents. The resident species can tend that plant for months at a time, for, unlike virtually all other southwestern cacti, fishhook barrel cactus secretes extrafloral nectar year-round rather than only during its reproductive season. Cactus ants range in quality from excellent defenders to virtual freeloaders; barrels occupied by the most effective defender ants do in fact reproduce more.

The three different forms of plant/animal mutualism that we have discussed have been studied by ecologists for many decades, but almost always in isolation from one another. This is curious, because the same plant individual may often be interacting with animals conferring different kinds of benefit at the same time. How do the different groups of mutualists *themselves* interact? For instance, one might expect the cactus ants and cactus bees that share a barrel to stay out of each other's way, or even to cooperate somehow, since a healthy plant is in their mutual interest. Is this actually the case? That is, are the friends of my friends really my friends too, as human nature would lead us to believe?

We are getting some very surprising results in this regard. Certainly, a better-defended barrel cactus bears less damaged flowers (compare Figures 1a and 1b). In this regard, ant defenders do benefit the cactus's pollinators. More indirectly, pollination leads cacti to reproduce more, which in the distant future will benefit cactus ants (since they will have more extrafloral nectar-producing cacti to feed upon). Looked at this way, cactus ants and cactus bees do benefit each other, by

Figure 2. An ant, *Crematogaster opuntiae*, visiting an extrafloral nectary on a barrel cactus. *Photo by Will Wilson.*

independently increasing the success of the resource they share. But consider a much shorter-term scale. What happens when ants and bees feed on the same cactus at the same time? We are discovering that the result depends on which ant species happens to be defending the plant. *Crematogaster opuntiae*, a small black ant, is one very common barrel cactus associate (Figure 2). We noticed that this species almost never enters barrel flowers. Further experiments showed that a chemical in the petals of barrel cactus flowers is quite repellent to this ant. When we rub flower petals over half of a dish and let *Crematogaster* loose on it, they will actively avoid that part of the dish. *Crematogaster*, then doesn't get in the way of the pollinators at all.

We have, however, found something very different with another common cactus ant, *Solenopsis xyloni*. This ferocious little defender is a close relative of the invasive fire ant; it is native to our region but seems to be spreading rapidly, for reasons we do not yet understand. *Solenopsis* is very, very good at getting rid of cactus herbivores. In that sense, it is a valuable partner to the cactus. Unfortunately, it is also very good at getting rid of pollinators. This ant has no compunction whatsoever about entering cactus flowers. While there, it feeds on nectar and pollen. It also attacks bees. In fact, we have seen cactus bees flying around with *Solenopsis* heads still clamped to their legs! Bees are excellent learners. We have found that they visit these particularly dangerous flowers more rarely, and spend less

continued next page

Figure 1b. Grasshoppers cover this barrel cactus and have heavily damaged the flowers on this individual, located at a site unusual for lacking effective ant defenders.

Barrel Cactus and its Interacting Mutualists *continued*

time there when they do visit. Our studies are showing that barrel cacti tended by this ant species are very well-defended and produce more fruits. However, these fruits include fewer and smaller seeds than fruits from plants tended by other ant species. In this case, then, two sets of mutualists of the same plant species are decidedly not friends — apparently, to their own detriment.

We have much to learn about these interactions, both separately and in association with each other. Which ant is the better mutualist for barrel cacti? *Crematogaster* doesn't defend the plant as well as *Solenopsis*, but at least it doesn't discourage pollination; *Solenopsis* scares away everyone, enemies and friends alike. Why is *Crematogaster* repelled by the flowers, while *Solenopsis* is not? Why do barrel cacti produce extrafloral nectar year-round when the benefits that ants provide seem to accrue only during the fairly short reproductive period, when flowers, buds, and fruits require protection? Finally, do barrel cacti have any control over which ants and bees they attract and how those insects interact with each other, or are they passive players in these games?

While the spectacular flora of the desert is readily appreciated, the small invertebrates upon which these desert plants depend are quite easy to overlook. Cactus bees and ants provide basic services to the plants, although these interactions seem to be changing as 'weedy' species, such as exotic fire ants and European honey bees, become increasingly common (albeit poorer) partners to the plants. We hope that this article has provided one glimpse into the complex and subtle networks of relationships, both friendly and antagonistic, that shape the flora we see today.

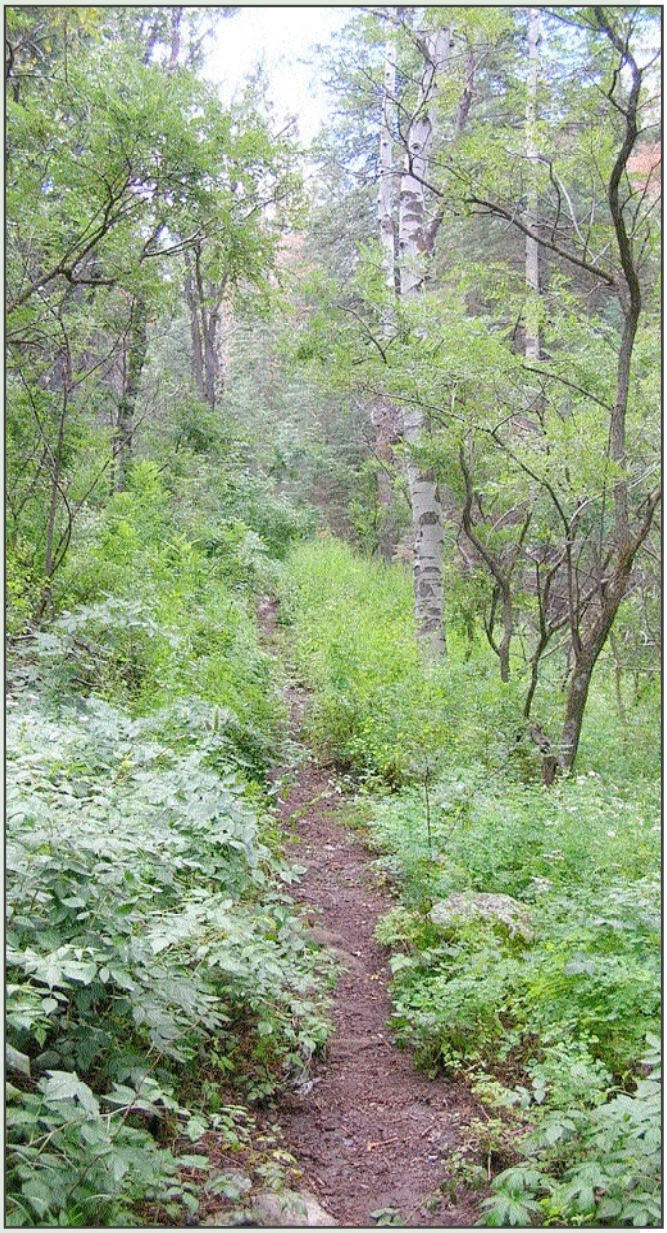

Photo 1. Type locality of Arizona bugbane on Bill Williams Mountain. *Courtesy Barbara Phillips.*

Photo 2. Flowering Arizona bugbane plants. *Courtesy Barbara Phillips.*

SPOTLIGHT ON A NATIVE PLANT

Arizona Bugbane

by Barbara G. Phillips **bgphillips@fs.fed.us**
Coconino, Kaibab and Prescott National Forests, Flagstaff

Arizona bugbane *(Cimicifuga (Actea) arizonica)* is a fascinating member of the Buttercup *(Ranunculaceae)* family. It is a relict from the Miocene, endemic to four disjunct population areas in northern and central Arizona. Bill Williams Mountain, the highest site at 8300 feet (2515 m), is the type locality where it was first collected in August 1883 by H. H. Rusby. Mr. and Mrs. J. G. Lemmon also collected it there in a ravine on the north slope (Photo 1). This population is protected by the Kaibab National Forest in a Botanical Area. The West Fork of Oak Creek and its side tributaries hold the bulk of the sites. These are in the West Fork of Oak Creek Research Natural Area and Red Rock-Secret Mountain Wilderness. Another population area is within the West Clear Creek Wilderness Area and the fourth population is in the Sierra Ancha Mountains. The typical habitat is moist shady canyons with mixed conifers and deciduous trees with a diverse herbaceous understory and lots of duff. The high relative humidity is immediately noticeable when entering the vicinity and lichens hang off the trees. Canyon walls and cliffs usually provide shade during most of the days and during the winter the sites are usually snow-covered for long periods of time.

The herbaceous perennial plants have rhizomes that elongate horizontally through the soil, palmately compound leaves, and grow up to 6 feet (1.8 m) tall (Photo 2). It is often difficult to determine individual plants because the underground relationships of the stems and rhizomes cannot be determined without excavation.

According to Olle Pellmyr, a Swedish biologist who studied the American bugbanes in the 1980's, the floral structures in the *Ranunculaceae* have evolved in parallel with evolving pollinators. The *Cimicifuga* genus belongs to an archaic species group within the family. The flowering raceme consist of small white flowers each of which has about 50-70 stamens that have long filaments and form most of the visual display. The numbers of carpels per flower vary from one to four. There are no petals and the sepals fall off one day after floral opening. Four orders of insects (Hymenoptera, Lepidoptera, Diptera and Coleoptera) visit Arizona bugbane. However, social bees, and especially bumblebees *(Bombus occidentalis, Separatobombus morrisoni and Probombus huntii)*, are almost exclusively the pollinators. The bumblebees alight preferentially in the upper part of the open flowers where pollen is most abundant. They run in a spiral over the inflorescence, pressing their bodies against the flowers. Pollen adheres to the legs and to the hairy underside of the hind section of the thorax and the abdomen. The stamens are depressed several millimeters and the stigma is stroked by the pollen-laden body, effecting pollination.

Some bumblebees buzz the flowers, i.e. use flight muscles to bring the anthers into rapid vibration. Pellmyr observed the bees repeatedly grasping bundles of five to ten undehisced stamens, pressing them against their bodies, putting their wings in resting position over the abdomen and buzzing loudly for one or a few seconds. Reasonably mature anthers burst open so that the bees got considerable amounts of pollen.

The pollinators of Arizona bugbane visited several flowering species simultaneously, including phacelia *(Phacelia magellanica)*, beebalm *(Monarda fistulosa)*, showy milkweed *(Asclepias speciosa)*, golden columbine *(Aquilegia chrysantha)* and Richardson's geranium *(Geranium richardsonii)*. Under normal conditions Arizona bugbane flowers receive a very limited number of visits by its pollinators so it is essential to maintain a diversity of plant species so that the bees will be in the area when Arizona bugbane is flowering.

PHOTOS THIS PAGE Floral racemes of Arizona bugbane, with insects on right photo. *Courtesy Max Licher.*

Pollinators and Plants in Peril: Can we prevent a pollinator crisis in North America?

by Stephen Buchmann[1] *Photos courtesy the author.*

We are losing many of our native plants and their pollinators at ever-increasing rates in the Sonoran Desert and other lands. A 2006 European study found that populations of native bees and flower flies had dropped 40–60% in study plots from the United Kingdom and The Netherlands during the last decade. These are alarming and widespread downward trends. Unfortunately, the same things are probably happening in the United States but we don't have the background baseline data to support the widespread belief that we have lost and are losing many pollinators to local extirpations or outright extinction.

Around the globe, at least two hundred thousand invertebrates, mostly bees and other flying insects, and over 1,000 vertebrates — nectar-feeding birds, bats and a few non-volant (flying) mammals — pollinate most of the world's quarter million angiosperm species. These sexual go-betweens move pollen from flower to flower, effecting pollination and subsequent fertilization during their food-collecting activities for themselves and their broods (pollen, nectar, oils), or other activities for substances used as building materials or sex attractants (resins, and fragrances). We owe roughly a third of our diet along with the production of many fibers, beverages, medicinals and nutraceuticals to the world's pollinating animals. Less than 20% of flowering plants utilize wind or water to vector pollen grains between blossoms, although wind-pollinated (anemophilous) cereal crops are critically important as our dominant food plants. At first glance, the rocky low elevation slopes of environments like the Tucson Mountains west of the advancing metropolis don't appear to be a Sonoran Desert biodiversity hotspot. But, like so many mountain habitat "sky islands," the Tucson Mountains boast over 600 species of native flowering plants along with a host of insects and other

Photo Xylocopa (carpenter bee) with the world's smallest bee, *Perdita minima* from the Sonoran desert.

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invertebrate animals. Not one complete survey for any site has been made but I predict the Tucson basin and its surrounding bathtub ring of mountain ranges are homeground to at least 500 species of ground-living or twig-nesting native bees. Arizona undoubtedly has over 1,000 bee species, and might lay title to the richest bee real estate on the planet. Israeli deserts and the Cape region of South Africa would also be top contenders. There are almost 20,000 described bee species worldwide and the continental United States is home to 4,000 native bees. Arizona has what may be the world's smallest bee — *Perdita minima*, under two mm (.078 inch) in length — which visit and pollinate flowers of sandmat euphorbs (e.g. *Chamaesyce*). Melittologists notice these bees by the shadows they cast on the ground and need an ultra-fine net to catch and hold them.

Photos LEFT What may be the most beautiful Sonoran bee, *Centris eisenii,* collecting floral oils from a malpigh blossom *(Mascagnia/Callaeum macroptera)*. RIGHT A male *Centris pallida* bee. This species visits and pollinates palo verdes (*Cercidium* spp.).

In a book entitled *The Forgotten Pollinators* (Buchmann and Nabhan 1997), I, along with ethnobotanist Gary Nabhan, called attention to what we noticed as declines, extinctions and regional extirpations of pollinators and their plants. During that period we co-founded and directed the Forgotten Pollinators Campaign from the Arizona-Sonora Desert Museum and built public education pollinator gardens. Today, my conservation efforts are with the North American Pollinator Protection Campaign and its member organizations (see **www.napp.org** and **www.pollinator.org** for more information and educational resources). Sadly, the same threats that were impinging on plants and pollinators eleven years ago (habitat loss and modification due to increasing urbanization and agriculture, pesticide use, competition from invasive non-native plants and animals) have not gone away. If anything, these driving factors have worsened in their impacts on our native Arizona biotas.

We now know of several pollinator extinctions, especially among flower-visiting butterflies (see the Xerces Society Red List at **www.xerces.org/Pollinator_Red_List/index.htm**). In the Hawaiian archipelago, at least seven species of small native bees (Yellow-faced bees; *Nesoprosopis* spp.) have gone extinct due to habitat loss and ecological degradation. Even among our charismatic black and yellow bumblebees changes are occurring rapidly. Franklin's bumblebee *(Bombus franklini)* from the Pacific northwest States of Washington and Oregon has likely gone extinct in the past few years. Despite intensive searches throughout its former small range, no workers, queens or colonies have been found by bee experts. Bumble bee species that were omnipresent and abundant in the coast and interior ranges of California while I was a graduate student at the University of California at Davis are now exceedingly rare, if they can be found at all. In the western United States, *Bombus occidentalis*, and in the east, *B. affinis,* bumblebees have disappeared across much of their former ranges beginning in the late 1990s. These losses are presumably due to infection with introduced colony parasites (the protozoans *Nosema* and *Crithidia* spp.) from their contact with commercially-reared bee colonies used for greenhouse pollination of tomatoes. Greenhouses are notoriously "leaky" for managed bee colonies used for pollination.

One of the least appreciated, but most lethal, threats to our native Arizona pollinators and their plants are direct and indirect ecological pressures: competition from non-native (introduced) plants and animals, many of which have become established. Certainly one of the worst is buffelgrass *(Pennisetum ciliare)* purposefully introduced by the USDA into Arizona in the 1930s as a potential fodder plant for livestock. It now chokes thousands of hectares in Sonora, Mexico, and many sites (for example Tumamoc Hill; see the recent *Plant Press* article by Travis Bean and Julio Betancourt, February 2006). This plant is a major threat to our native Sonoran Desert plants and many animals. It forms a green sea of stems sucking up water and forcing out other plants. Most native bees require open bare ground for nesting, and about 10% of our other bees form a guild of twig-nesters that utilized abandoned beetle burrows in dead trees, or some like carpenter bees (*Xylocopa* spp.) that excavate their own galleries in *Agave, Dasylirion, Yucca* or soft timbers like Fremont's cottonwood *(Populus fremontii)*. An insidious property of buffelgrass is its ability to carry hot wildfires, something that our native desert plants have never experienced. Fires are especially damaging to our native cacti and small leguminous trees. No studies are underway, but invasive plants like buffelgrass will undoubtedly have a major negative impact on native desert bee, and other pollinator communities. Want revenge? Join the Sonoran Desert Weed Whackers and get even (see **www.aznps.org**).

Even introduced bees are causing problems. "Aren't all bees genuinely beneficial, or at least harmless?" We tend to think of all bees as generally helpful, in fact keystone organisms in plant communities and natural biomes. But some introduced bees, especially those with wide dietary breadth (e.g. bumble bees, some digger bees and honey bees; they are called polylectic) negatively impact other bees and native plants. There are 22 species of exotic bees now established in the continental United States. Hawaii alone has 15 species of introduced and naturalized exotic bees. The most pervasive of these is the introduced European honey bee *(Apis mellifera)*. Of course honey bees are crucial, often the only managed,

continued next page

LEFT An oxaeid bee — a female *Protoxaea gloriosa* collecting nectar and pollen from a *Kallstroemia grandiflora* blossom.

Pollinators and Plants in Peril

continued

pollinators for the more than 100 major crop plants grown in the United States, but few people other than some ecologists and conservation biologists realize their downside (e.g. competition for floral resources and nesting sites, spreading weedy plants by pollinating them, competition with other pollinating animals). The negative effects of advancing Africanized bee populations are especially dramatic on people, native plants, and animals. Some organizations and natural parks in Arizona have made attempts to remove feral bee colonies in rock outcroppings because they are not part of our native insect fauna.

What can we do to protect and conserve our native bees, and other pollinating animals?

All is not gloom and doom, but we must be vigilant and take action. There are a few simple things that land and homeowners, land managers and policy makers can do to assure that we protect and conserve our native bees, and other pollinating animals. First, habitat protection is the most important step: retaining as much contiguous desert lands as possible. Whenever landscaping or wildflower gardening is practiced, native Sonoran Desert plants should be used. These plants are adapted to the climate, soils and growing conditions found in Arizona. They are minimum maintenance survivors which need no pampering with augmentative fertilizer applications or massive amounts of irrigation water. They are resistant to local pests and diseases. Use them. Often, when horticultural varieties, especially modern hybrids (double or triple flowers anyone?), are used, these cultivars may have been inadvertently selected out for floral volatiles, or worse; even the very pollen and nectar that we would expect. Sometimes, you can spend a fortune on landscaping plants only to have pollinators show up and ask, "Where's the pollen?" It is important when planting for pollinators to plant in clumps of six of more plants instead of individuals. Also try to plant species that bloom continuously, or for long periods of time, from spring into our fall months. Using few or no insecticides on your property will also benefit bees and other pollinators. Reduce your impact, your carbon footprint. Walk or ride a bicycle now and then. Buying local and organic produce helps farmers and pollinators.

Dead limbs or entire trees (e.g. mesquites and palo verdes) are often considered "eyesores" in managed or wild habitats. Think again. These are crucial resources for bees, wasps and other wildlife (lizards, birds, mammals). Holes of various diameters commonly found in dead limbs are left as exit holes by emerging adults of native beetles. Many native bees are incapable of tunneling their own nests. Instead, they depend upon these ready-made tunnels carved out by the former beetle tenants. Gardener or woodcutter, spare that limb and you will help build or re-build essential populations of pollinating bees, wasps and other insects.

Similarly, you can build a "bee condominium" to entice pollinating twig-nesting bee guilds into your area. Many species of native leafcutter and mason bees (the genera *Megachile* and *Osmia*) are very abundant, especially in southeast Arizona, both in town and in the surrounding desert. They readily take up occupancy in man-made domiciles. Simply take thick pieces of wood or scrap lumber and drill holes into them. The holes should be 3-5 inches deep and not emerge from the backside of the wood. Vary the diameters from 2 to 10 mm. Hole diameters of 7–8 mm are especially attractive to our AZ bees. Securely attach your drilled board bee nests under the eaves of your house or an out building, protected from direct sun and rain.

Females of these wood-nesting bees can sting, but usually don't. They won't come after you like honey bees sometimes will. Relax and let them entertain you and your family. Female bees returning home with leaf pieces, resin or bright yellow pollen loads are great fun to watch. They can be watchable wildlife on your patio. In addition to hummingbird feeders, bee nests make great family, school or scouting projects.

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ABOVE Attract native wood-nesting bees (leafcutter and mason) bees by drilling holes into a block of wood and making a "bee condominium." *Illustration by Vera Ming Wong.*

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ETHNOBOTANY: PEOPLE USING PLANTS

Hummingbirds in North and South American Mythology

by Jessa Fisher **nightbloomingcactus@yahoo.com**
Flagstaff Chapter President

"A Route of Evanescence– With a revolving Wheel– A Resonance of Emerald– A Rush of Cochineal" begins a poem about hummingbirds by Emily Dickinson. How aptly this describes their flighty nature and brilliant coloring, which has always attracted human attention and curiosity. Hummingbirds are one of the pollinators most beloved and revered by people all over North and South America (they are only found in the Western Hemisphere).

These miniature birds are the smallest in the world. They can be spotted hovering over brightly colored flowers, their iridescent feathers flashing in the sun as they dive back and forth, displaying their erratic flight patterns. In fact, hummingbirds are the only bird species that can fly right, left, up, down, backwards, and even upside down. Their wings beat up to 50 times a second, enabling them to hover over their favorite nectar-rich flowers. Popular native plant genera for hummingbirds in the southwest include beardtongue (*Penstemon),* four o'clock *(Mirabilis),* water-willow *(Justicia),* sage *(Salvia),* Indian paintbrush *(Castilleja),* sky rocket *(Ipomopsis),* agave *(Agave),* and ocotillo (*Fouqueria).*

Hummingbirds figure prominently in indigenous peoples' legends. Almost every tribe has some sort of myth about the creatures. A Mayan legend says the hummingbird is actually the sun in disguise, and he is trying to court a beautiful woman, who is the moon. In an Akimel O'odham (Pima) legend, a hummingbird acted like Noah's dove, bringing back a flower as proof the great flood was subsiding. In the high Andes of South America, the hummingbird is taken to be a symbol of resurrection. This is because each hummer becomes lifeless and seems to die on cold nights, but it comes back to life again when the miraculous sunrise brings warmth. The Aztecs came to believe that every warrior slain in battle rose to the sky and orbited the sun for four years. Then they became hummingbirds. In the afterlife these transformed heroes fed on the flowers in the gardens of paradise, while engaging from time to time in mock battles to sharpen their skills. The Pueblo Indians have hummingbird dances and use hummingbird feathers in rituals to bring rain. Pueblo shamans use hummingbirds as couriers to send gifts to the Great Mother who lives beneath the earth.

The most important lesson from these little birds might be in their relationship to the flowers they pollinate. In the book, *Animal Speak*, Ted Andrews says hummingbirds teach us how to draw the life essence from flowers. "They can teach us how to use flowers to heal and win hearts in love."

This article was adapted and in some parts quoted from information on the excellent hummingbird reference website, **www.hummingbirdworld.com** by Larry and Terrie Gates.

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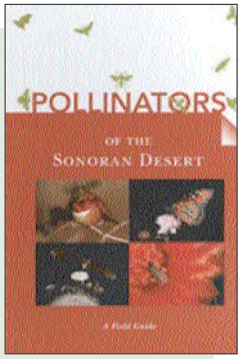
BOOK REVIEW *by C. Douglas Green, AZNPS Board of Directors*

Pollinators of the Sonoran Desert



A Field Guide—First edition, 2004 by Nina Chambers, International Sonoran Desert Alliance; Yajaira Gray, Arizona-Sonora Desert Museum; Stephen Buchman, The Bee Works.

First of all, this excellent "Field Guide," is a spiral bound publication of which 81 pages are in English; and when "flipped over," there are 81 pages in the Spanish translation. This then becomes *Polinizadores Del Desierto Sonorense, Una Guia de Campo.* There are many partners who contributed to this field guide and AZNPS proudly provided funding to this worthy project.

The guide is separated into eight (8) main sections of pollinators as follows:

1) Hummingbirds (Family *Trochilidae*) These feathered friends are very efficient pollinators. Not only are they rewarded by harvesting nectar, but are effective carriers of pollen for cross-pollination purposes. Additionally, the six (6) species of hummers are detailed for this area: Anna's, Black-chinned, Broad-billed, Costa's, Rufous, and on occasion, Allen's. Certainly there are other species in the Sonoran Desert area but this publication dwells on these six main hummer pollinators.

2) Bats (Family *Phyllostomidae)* The two main bats of the Sonoran Desert are the Lesser Long-Nosed Bat and Mexican Long-Tongued Bat. They are both very effective pollinators that feed on the pollen, nectar, and fruit of agaves, saguaros, cardons, and organ pipes (columnar-type cacti). So, not only do they play a major role in the cross-pollination process of the above plant life but they also spread seeds via the natural defecation process. Although not a bat, the White Winged Dove (*Zenaida asiatica*) is mentioned as a very effective pollinator of the saguaro flower, as well as an excellent fruit seed disperser, via defecation.

3) Butterflies (Order *Lepidoptera)* There are many species of butterflies shown in this section. Most are absolutely beautiful, and serve our plant community well. The swallowtails, whites and sulphurs, gossamer-winged, brush foots, milkweeds, and skippers are primarily reviewed here along with their "host plants," that provide food sources for their larvae (caterpillars).

4) Moths (Order *Lepidoptera)* Most moths are twilight/nocturnal feeders, as opposed to the daylight activities of butterflies. The moths included here are: sphinx/hawk types, as well as Yucca moths. These are truly great natural cross-pollinators.

5) Bees (Super family *Apoidea)* This family contains our most important and diverse pollinators. Of particular interest in this section are sweat bees, squash/gourd bees, cactus bees, leaf cutter and mason bees, digger bees, carpenter bees, and bumble and honey bees. There are over 1,000 different species of bees just in the Southwest USA region, with over 4,000 species in all of the USA. They are great honey producers as well as serve a very crucial pollination function. There are, however, major concerns with diminishing bee populations due to habitat loss, chemical/pesticide misapplications, fungal/bacterial infestations, etc.

6) Wasps (Order *Hymenoptera)* This family is not as important to the natural process of pollination as bees. They don't always have the hairy body surfaces of bees, so as a consequence wasps are not as effective as bees in cross-pollination. However, we wouldn't have edible figs were it not for fig wasps. And all of us "Fig Newton" lovers would be at a loss.

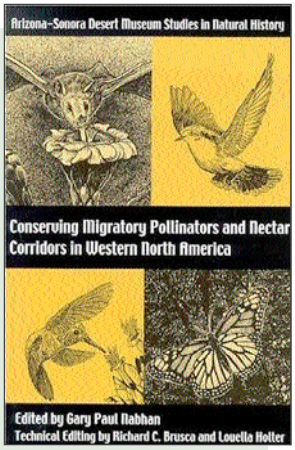
7) Flies (Order *Diptera)* Although flies are usually thought of as disgustingly unsanitary, etc., they do provide another source of cross-pollination in our natural world. Examples examined in this text are bee flies, flower, hover or syrphid flies, and tachinid flies. These are surprisingly key players in nature's pollination program.

8) And lastly, **Beetles** (Order *Coleoptera)* This is the largest and most diverse group of insects in the world—i.e., over 30,000 species in the USA and 10 times that in the world. Species that are headlined herein are: soldier, checkered, sap, metallic wood boring, and tumbling flower beetles. They are definitely a key factor in the cross-pollination process.

Final thoughts are: Great color photography throughout the entire field guide in each and every section. Excellent drawings/anatomies of bees, insects, bats, butterflies, hummers, wasps, beetles, flies, etc. in each of the above sections. Very good technical and educational content on our most prevalent pollinators. Good basic thoughts on creating hummingbird and butterfly pollinator gardens. Our AZNPS Gardening Series are recommended, which are excellent sources of information. Recommended pollinator garden plants are included herein, but not all are native plants to Arizona. Likewise, "Larval Food Plants" (Host Plant) recommendations are provided as well. All in all, this is a very good booklet that has been distributed throughout Arizona. To my knowledge, it has not been available for sale via book stores, gift shops, arboretum, etc. so it has had limited distribution to the general public. But it can be recommended in this edition of *The Plant Press* because pollination is being addressed throughout our publication.

BOOK REVIEW *by C. Douglas Green, AZNPS Board of Directors*

Conserving Migratory Pollinators and Nectar Corridors in Western North America



Edited by Gary Paul Nabhan, The University of Arizona Press and The Arizona-Sonoran Desert Museum, First Printing—2004

In Dr. Nabhan's introduction he relates, "This is a book of comparative zoogeography and conservation biology, one that considers the similarities and differences among the behavior and habitat requirements of several species of migratory pollinators and seed dispensers." This says it all. The four (4) main species considered are the rufous hummingbird *(Selasphorus rufus)*, western white-winged doves *(Zenaida asiatica* var. *mearnsii)*, lesser long-nosed bats *(Leptonycteris curasoae)* and, of course, the monarch butterfly *(Danaeus plexippus)*.

There are nine chapters devoted primarily to the discussion of these four main species of differing types/styles of migrating pollinators. The collaborating authors also offer excellent studies not only on the migrators but on their nectar producing plant hosts as well.

My primary interests were in our avian members — rufous hummingbirds and western white winged doves — as well as the many contributing nectar plants. That's not to say that the authors' studies on bats and butterflies are unimportant. Far from that! Bats and butterflies, along with bees, flies, beetles, moths, etc., all are an important part of a very complex pollination matrix within our Southwestern deserts.

Nabhan reflects in his intro as follows: "despite tremendous gains over the past decade in understanding these interactions, researchers remain humbled by how little they know relative to what they sense is possible to know or is needed in order to better conserve these relationships." This theme seems to resonate throughout this collection of offerings by some really elite contributing authors, such as Dr. Hummingbird, the late William A. Calder, and others.

As an example, I was very impressed with one of the many findings in the symbiotic relationship between the saguaro and the western white-winged dove. Chapter Seven : (to quote): "Saguaro is not only the most frequent item in the dove's diet but is also the primary source of incorporated carbon for a large fraction of the breeding season. In July, during the peak of saguaro use, the isotopic composition of the doves' tissues was almost indistinguishable from that of the saguaro. In isotopic terms, breeding white-winged doves are warm, feathered fragments of saguaro flying around in the desert." Isn't that fascinating?—-A FLYING ISOTOPIC FORM OF SAGUARO!

All in all, this tome is an excellent read on migratory pollinators, our environment, and the nectar trail or corridors. I highly recommend it to all.

Pollination stamps released this Summer!

The U.S. Postal Service unveiled four beautiful Pollination stamps at the North American Pollinator Protection Campaign (NAPPC) Symposium last Fall and proclamation was issued by Secretary of Agriculture Mike Johanns declaring June 24–30 National Pollinator Week.

Paired on the stamps are Morrison's bumble bees with purple or chaparral nightshade, a calliope hummingbird with hummingbird trumpet, a lesser long-nosed bat with saguaro, and a Southern dogface butterfly with prairie or common ironweed.

"Farmers see the connection between plants and pollinators every day. Thanks to these beautiful stamps, that same point is illustrated for everyone," said Deputy Secretary of Agriculture Chick Conner.

For additional information about the NAPPC Symposium, go to: www.pollinator.org.

AZNPS Merchandise

Jaguar in Red & Green

This full-color card was donated to AZNPS by Prescott artist, Carolyn Schmitz, and notice that jaguar is decorated in all native attire! We are honored to be able to pass this wonderful card on to you. AZNPS is selling these cards in a packet of 10, with envelopes, for **$20** *(includes postage). You will love sending these to your friends and family. All proceeds from card sales benefit the AZNPS Conservation Committee and their work. To view more of Carolyn's art go to* **www.desertdada.com**

More New Items!

The Arizona Register of BIG TREES
$5 (includes postage) *This is the latest listing of Arizona's champion trees and how they are chosen. Includes some color pictures.*

Canotia, a new journal.
AZNPS is contributing to the printing of this new effort to make available editions of the new updated **Arizona Flora**, *as they are published, to libraries. We offer the extra printed editions to you at* **$6** *per copy (includes postage).*
Note that you can also download them from the web at http://lifesciences.asu.edu/herbarium/canotia.html — on that page you can elect to receive an email when new editions become available.

Volume I — **Index to Families of the Vascular Plants of Arizona**, by VPA editorial committee; and **Vascular Plants of Arizona:** *Polemoniaceae,* by Dieter H. Wilken and J. Mark Porte

Volume II, Issue 1 — **Vascular Plants of Arizona:** *Portulacaceae,* by Allison Bair, Marissa Howe, Daniela Roth, Robin Taylor, Tina Ayers and Robert W. Kiger; and **Vascular Plants of Arizona:** *Rhamnaceae,* by Kyle Christie, Michael Currie, Laura Smith Davis, Mar-Elise Hill, Suzanne Neal and Tina Ayers.

You can purchase AZNPS t-shirts, booklets and posters from our local chapters or by mail order. In addition, you can find posters at the Arizona-Sonora Desert Museum, Audubon Society, Boyce Thompson Arboretum, Desert Botanical Garden, Organ Pipe National Monument, Saguaro Park (East and West), The Arboretum at Flagstaff and Tohono Chul Park.

Questions? Sending an international order? Please contact Nancy Zierenberg at **anps@aznps.org**

AZNPS T-shirts

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**Shipping/handling are an additional charge and depend upon the size of order. Please contact Nancy Zierenberg for specifics on shipping costs.*

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Desert Wildflowers
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Sonoran Desert Trees (new edition)

Price per booklet ordered includes postage for US addresses only:

1-9 **$3.50** each (any combination of titles)
10-49 **$2.75** each (any combination of titles)
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AZNPS Bumpersticker

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No glue! This is static stick so it can be easily moved. Display it proudly on your window.

For order forms, please go to the AZNPS website at **www.aznps.org** click on the *merchandise* button and send your order to:

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Don't forget people on your gift list.
And thank you for your order!

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The Arizona Native Plant Society

Upcoming Issue: Ethnobotany and Inherited Landscapes

Contact *Plant Press* Technical Editor, Barbara Phillips, at **bgphillips@fs.fed.us** for more information on contributing articles, illustrations, photos, or book reviews on this topic … as well as themes you'd like to see us cover in future issues.

The Plant Press is a benefit of membership in the Arizona Native Plant Society. Suggestions are welcome for book reviews, and articles on plant use, conservation, habitats, and invasive species

Virginia Saylor

October 17, 1915 — January. 28, 2007

We regret having to pass on the news that Virginia "Ginny" Saylor died at the end of January this year. She was a longtime member of the Tucson Chapter and an avid gardener and native plants fan. Many of you probably knew her. We will all miss her wealth of knowledge, enthusiasm, and volunteer work for AZNPS.

She and her husband, Cliff, who died in 2005, travelled extensively around the United States and retired to Green Valley in 1976. They were quite active, spending time in the field hiking and Ginny botanizing. She drew, pressed and catalogued many native plants from around the U.S. She left her natural history library to AZNPS — her thoughtful gift a wonderful legacy for our organization.

New Members Welcome!

People interested in native plants are encouraged to become members. People may join chapters in either Phoenix, Flagstaff, Prescott, Tucson, Yuma, or may choose not to be active at a chapter level and simply support the statewide organization. For more information, please write to AZNPS at the address below, visit the AZNPS website at **www.aznps.org**, or contact one of the people below.

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