The Arizona Native Plant Society

The Plant Press

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Special thanks from the editors to all who contributed time and efforts to this issue.

above A copulating pair of blister beetles feeding on brittlebush flowers.

Desert Insects and Desert Plants

by John Alcock[1]*. Photos courtesy the author.*

Because I am an entomologist, not a botanist, my biases tend to keep me focused on the insects I encounter in the Sonoran Desert. I don't need to apologize for my entomological favoritism because desert insects include many strikingly attractive creatures with intriguing life styles. Take the big black and red-orange blister beetles (*Lytta magister*) that show up as adults for a few weeks in most springs. (Blister beetles get their name from their ability to secrete noxious fluids when handled that can cause human skin to blister.) It is exciting to see dozens of these one- to two-inch long beetles come flying in from far away to plop heavily onto a plant that has already been chosen by several dozens of their fellow blister beetles.

When a group of beetles has assembled in a flowering brittlebush, a favorite destination of this species, some quickly begin to chew their way through the flowers of the unlucky plant. Others, always males, scramble through the maze of brittlebush stems and branches until they come to a female. When the male find an unoccupied female, he climbs upon her and proceeds to use his antennae to stroke the antennae of his counterpart. She typically does not stop to savor the courtship but continues to consume one bright yellow flower petal after another. If the female is not only hungry but sexually receptive, she may eventually permit the male on her back to insert his extruded genitalia into the appropriate opening. Once in

continued next page

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Editor's Note

by Barbara G. Phillips **bgphillips@fs.fed.us**

Coconino, Kaibab and Prescott National Forests, Flagstaff

On my morning walk before breakfast my dog, Bailey, and I search diligently for any exciting changes to the diverse components of the plant communities along the way. This week, returning after an absence from Flagstaff of two weeks, there have been considerable changes following the summer rains. Crag lilies and Tradescantias now have emerged in rocky areas that formerly looked barren. Sulfur-flowered buckwheat carpets with yellow blossoms the openings between the living and dying pine trees. My dog sneezes from ragweed pollen at his nose level while I cut the buds off the invasive Scotch thistle stems. But it is the more cryptic interactions I now look for after reading the enlightening articles about plant-animal interactions for this issue of *The Plant Press.*

I hope you will also begin to look more inquisitively at plants and flowers that you encounter to investigate the complexity that surely is out there everywhere. This issue of *The Plant Press* highlights how plant-animal biodiversity fosters resiliency in our native ecosystems, topics addressed by our 2011 Arizona Botany meeting speakers. If you missed that meeting, here is your chance to enjoy some of the presentations.

Book reviews are our opportunity to learn about exciting new literature to read and the book reviewed in this issue — *A Natural History of the Intermountain West* by Gwen Waring is one I have greatly anticipated. Gwen is a neighbor and long-time friend from my Museum of Northern Arizona days, so I have been getting a blow-by-blow update on the book's progress for several years.

Many thanks to Linda Marschner, our State Treasurer, for her contributions to managing the financials for AZNPS. It has not been an easy job and we greatly appreciate her time and efforts. We also wish to heartily thank Ana-Lilia Reina-Guerro and Tom Van Devender, who completed their terms on the State Board in February. Each has been an enthusiastic field trip leader and has provided invaluable insights at our Board and annual meetings. It was a real pleasure to be a part of the MABA expedition to northern Mexico this spring with them and see how they are stimulating exchange of native plant information and awareness with our Mexican counterparts.

Welcome to our new State Board members, Sue Smith and Val Morrill. We look forward to their input at the AZNPS State Board meetings as we know they have been providing their expertise to the Prescott and Yuma chapters, respectively.

Again a thank-you to Anna Van Devender, our new Administrative Assistant. Anna has been very helpful for the whole organization during this year of regrouping and transition.

As I eagerly look forward to my "daily adventure" to keep in tune with the constantly changing natural world around me during the different seasons, I hope you will be inspired by this issue to do the same. Let's explore together ways we can promote knowledge, appreciation, conservation, and restoration of Arizona's native plants and their habitats, the mission of the Arizona Native Plant Society!

above Three blister beetles flying in to an aggregation of their fellow beetles.

Desert Insects and Desert Plants *continued*

copula, pairs are in no hurry to terminate their relationship. Matings last for hours, even as long as an entire day. During this time, the male joins his mate in deflowering the brittlebush in which they are paired.

Notice that although my primary focus in this case has been on *Lytta magister*, I can hardly ignore the fact that the beetles are available for my inspection and admiration because of their desire to acquire a supply of calories from an edible plant. Female beetles presumably use the energy they secure from brittlebush flowers in part to help them produce a large clutch of eggs, which they will lay in the ground after receiving the sperm needed to fertilize those eggs from a mate. Male beetles almost certainly use the energy they get from brittlebush flower petals in part to manufacture the blistering agent, called cantharidin, which they transfer to the female along with their sperm during the lengthy copulation. The female stores the various materials she receives from her partner in a special receptacle linked to her reproductive tract. She will later use the sperm to fertilize her eggs while deploying the cantharidin as a coating for her gametes, the better to protect them against ants that would otherwise excavate and eat them.

Thus, blister beetles depend on the plants they assault. It is easy to see that the brittlebush cannot benefit from the attentions of the beetles, which are eating the plant's flowers, essential elements for botanical reproductive

clockwise from top left A male courting a female of *Lytta magister.* A blister beetle releasing its toxic blood by popping a vein in its leg. Males supply females with an active ingredient for use as a defensive toxin. A hillside with synchronously flowering brittlebush. A carpenter bee with flowers that it may pollinate in a mutually beneficial arrangement; the same bee nests in dead plant stalks that derive no benefit (or loss) from its nesting activities.

success. Because *L. magister* is an enemy of the plant, we might expect brittlebush to have evolved traits that help reduce the destructiveness of the herbivorous beetles that afflict the plant on occasion. Anyone who has broken a twig from a brittlebush will learn that the plant oozes a bad-smelling yellowish resin from the wound, and this presumably toxic substance surely makes consumption of the woody parts of the plant difficult. But this repellent cannot have evolved to deter blister beetles, which concentrate on the apparently unprotected, short-lived flowers, not the durable stems or long-lasting leaves of brittlebush. However, it is true that large numbers of brittlebush often produce masses of flowers more or less simultaneously. By flowering synchronously, a population of brittlebush might overwhelm the consumption capacity of flower-eating herbivores in their neighborhood, thereby reducing the chance that they suffer from an attack by a mob of blister beetles during the flowering period. If correct, synchronous mass flowering constitutes a defense against certain herbivores in this species.

The evolutionary relationships between all desert plants and desert insects can be categorized on the basis of who wins and who loses. Plant-herbivore interactions typically result in damage to the plant but benefit herbivores, with selection therefore favoring members of plant species able to reduce the harm done by their particular enemies. In contrast, plant-pollinator systems, of which there many in the Sonoran Desert (and elsewhere, of course), feature a relationship that provides mutual benefits for both parties. In these systems, it is commonplace for the plants to invest in attributes like sugary nectar, edible pollen, and flowers with special features designed to attract the best pollinators.

But there are also a great many examples of plant-insect relationships that do no harm to the plant while the insects involved gain from their botanical connections. Consider the carpenter bees that excavate nests in dead sotol stalks. Because the plant is dead, the construction activities of female *Xylocopa californica* cannot lower the reproductive success of the sotol. Likewise, the male bees that sleep on dried brittlebush flower stalks neither benefit nor harm the post-flowering plant. The same is true for the many insect species whose males fly to hilltops where they perch on plants growing in high place where the males can scan for arriving receptive females. Plants of this sort are not expected to have evolved adaptations for dealing with their insect companions, and they have not done so.

Thus, multiple kinds of plant-insect interactions occur in the Sonoran Desert with different costs and benefits for the participating species. Insects depend on plants for food, nesting substrates, even landmark perches while plants love, or hate, or ignore their dependents. Each kind of plant-insect relationship has its own evolutionary consequences for the parties involved. The resulting complexities are a delight for the entomologist and botanist alike.

Nectarless Flowers and Leaves with Extrafloral Nectaries: Insights from the legume genus *Senna*

by Brigitte Marazzi[1] *. Photos courtesy the author.*

Senna, formerly included in *Cassia*, is, with 300-350, species currently one of the largest legume genera. Especially known for its highly diverse flowers and unusual pollination biology, *Senna* displays a diversity of habits and has successfully colonized a wide range of habitats in different warm climates and latitudes worldwide, but Europe (Irwin and Barneby 1982). About 80% of the species occur on the American continent, and a few are native to Arizona. *Senna covesii* is the most common (Figure 1), and spring is a good time to observe small bees visiting its bright yellow flowers. Each time a bee stops on a flower you can hear a buzz. As you approach to have a closer look, the bee departs, so you inspect the flower. The stamens feel quite stiff; the single carpel is in the middle and arched… You do not see pollen or nectar. Intriguing! What was the bee looking for? Flowers of *Senna* offer pollen to their pollinators, hidden inside lignified and tubular anthers provided with an apical pore (or slit) at the tip. The bees vibrate the flowers with their wing muscles, causing the pollen grains to bounce and resonate in the anthers until ejected through the pore, and finally adhering on the bees. Pollen grains that escape the bees' grooming are eventually carried to the stigma of another conspecific flower. Only buzz-pollinating bees - e.g., carpenter bees, bumble bees, but not honey bees! - can access the pollen. Buzz pollination occurs in many other angiosperms, too (see Buchmann, 1983, for a review), typically in the Nightshade family, including crops such as eggplants, potatoes and tomatoes.

Hiding the pollen inside stiff, tubular anthers is only one of the many specializations displayed by buzz-pollinated flowers. Heteranthery, the presence of different kinds of stamens, is another outstanding feature. In *Senna*, there is commonly a set of three sterile, reduced stamens, a set of four "feeding" stamens from which pollen is collected for larval provision, and a set of two or three longer "pollinating" stamens with pollen that is actually transferred between flowers (Figure 2). Whether this division of function really works is still largely unknown.

Another example of adaptation to buzz pollination is enantiostyly: the displacement of the carpel to the left or the right in flowers of the same inflorescence (sometimes they appear as mirror-image flowers; Figure 3A). *Senna* is the only angiosperm genus known thus far to include both species with

Figure 1 Habit and flower of *Senna covesii* growing along Rillito River in Tucson.

symmetric flowers (= zygomorphic, monosymmetric) and species with asymmetric flowers (about half of the genus). Enantiostyly is generally thought to reduce pollen transfer within the same plant. In *Senna*, enantiostyly has been suggested to facilitate the access of the pollen-collecting bees to the "feeding" anthers, forcing the bees to adopt a position that results in a greater pollen removal and also protecting the carpel from damage by buzzing bees. However, enantiostyly in *Senna* is a far more complicated story than just carpel displacement to the side (see Marazzi and Endress 2008). In fact, one or all "pollinating" stamens too can be deflected to one side (always opposite to the deflected carpel) and one or both lower petals can be highly modified in shape and size, appearing "flag"- or "foot"-shaped and/or curved and highly concave (Figure 3). In flowers with such highly concave petals, the pollen ejected during buzz pollination is ricocheted by these petals toward the body of the bees. This means that the petals are positioned in such a way to avoid loss of pollen from the flower. Clever! The flowers of *S. wislizeni*, native in southern Arizona, and also often cultivated, are of the highly asymmetric kind (Figure 3C).

Senna covesii has monosymmetric flowers, the less exciting kind. But it has something interesting on the leaves. Between each pair of leaflets you will notice a slender stalk subtending a glittery tip. Most likely there are ants inspecting them. What are they looking for? The ants are interested in the nectar produced by these structures, which are called extrafloral nectaries (EFNs). EFNs are another distinctive feature of *Senna* (Figure 4),

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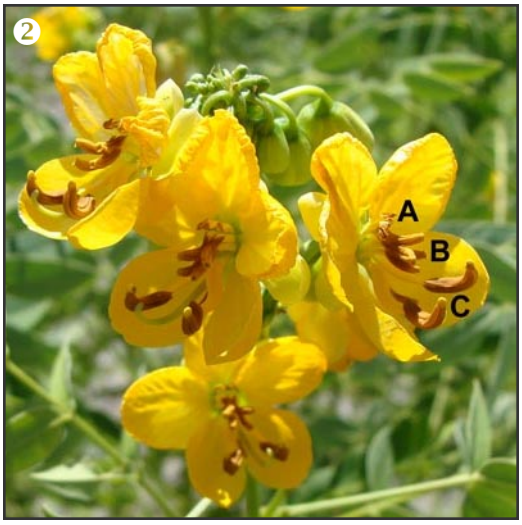

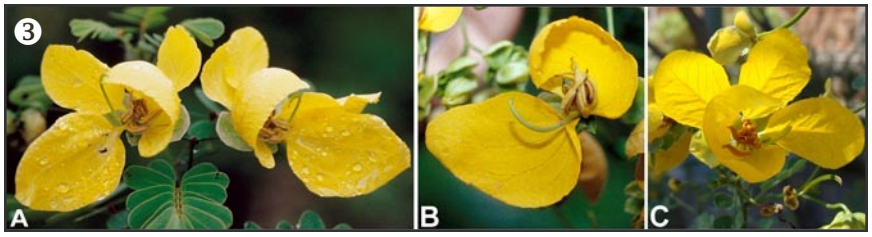

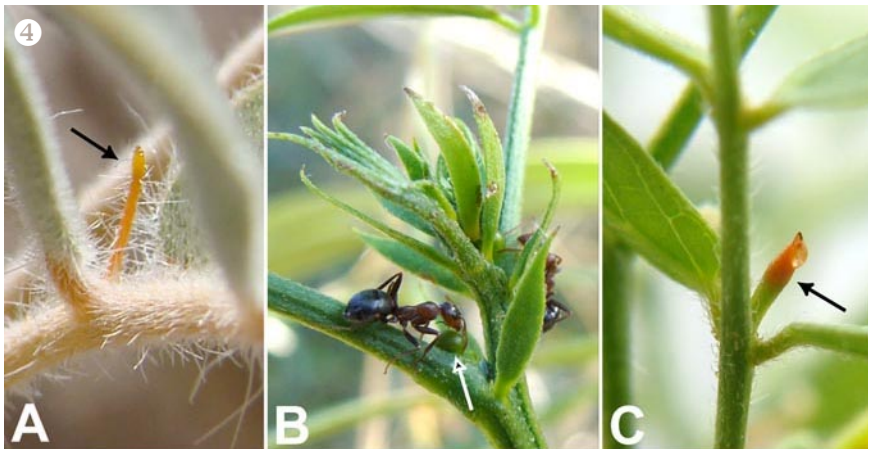

clockwise from top left **Figure 2 Flower of *Senna hirsuta* var. *glaberrima*, native in southern Arizona, and the different kinds of stamens: (A) three staminodes, (B) four shorter "feeding" stamens, and (C) two longer "pollinating" stamens. Figure 3 Examples of asymmetric, enantiostylous flowers in *Senna*: (A) Mirror-image flowers in the *S. aversiflora*, (B) *S. tonduzii* with one of the most highly asymmetric flowers in the genus (the left modified petal is flag-shaped, the other is foot-shaped), and (C) *S. wislizeni* with strongly concave petals surrounding the stamens. Figure 4 Examples of extrafloral nectaries (arrows) in *Senna*: (A) *Senna covesii*, (B) *S. hirsuta* var. *glaberrima*, and (C) *S. pallida*.**

although they also occur in few ferns and over 110 flowering plant families (Keeler 2008). EFNs on leaves are a characteristic of a large group with a common ancestor (hereafter called the EFN clade; Marazzi et al. 2006) including about 280 *Senna* species, which evolved about 40 million years ago. In general, EFNs are nectar-secreting organs on plant parts excluding flowers, which attract ants that feed on the nectar. These ants will attack other insects feeding destructively on the leaves and flowers, often forming a protective beneficial ant–plant interaction or mutualism (see Bronstein et al. 2006 for a review). Experimental studies have demonstrated that these EFN-visiting ants often increase plant success, allowing them to produce more seeds and to lose fewer leaves to consumers. In *Senna*, the EFNs seem to have played a key evolutionary role in triggering the diversification of the EFN clade. Compared to the closely related groups of *Senna* species lacking EFNs (including *S. wislizeni*), the EFN clade appears to have diversified faster, becoming significantly more species-rich (Marazzi and Sanderson 2010). Interestingly, EFNs seem to have never been lost, not even in *Senna* species that occur in desert habitats, where plants have to carefully manage water. For instance, *S. covesii*, common in the Sonoran desert, is part of a lineage of EFN-bearing *Senna* species distributed throughout the North American deserts. This includes also other two species native in Arizona, *S. armata* and *S. bauhinioides*, commonly found in the Mohave desert and Chihuahuan desert, respectively. EFNs in desert *Senna* species persisted in a functional state and are, thus, able to interact with desert ants.

Senna is only one example out of many plants that use insects for pollination and protection and offer them a reward in return for their service. These mutualistic interactions are widespread: Just go out and observe! You now will look at flowers, pollinators, leaves, EFNs and ants in a different way than just half an hour ago.

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The Columnar Cactus-Nectar Bat Connection

by Theodore H. Fleming[1]*. Photos courtesy the author.*

Columnar cacti of several tribes of subfamily Cactoideae, family Cactaceae, are ecologically dominant members of many arid and semiarid habitats in the New World. The flowers of many species in these tribes are pollinated by nectar-feeding bats. These tribes include Cereeae and Browningieae in South America and Pachycereeae and Leptocereeae of Mexico and the Caribbean, respectively. In this paper, I will briefly describe some of the details of the nectar bat-columnar cactus connection by focusing on research my colleagues and I have conducted in the Sonoran Desert. Further information about this connection can be found in the book edited by Fleming and Valiente-Banuet (2002).

Most species of Pachycereeae are pollinated by several species of bats in the New World family Phyllostomidae (American leaf-nosed bats). The most important species are *Leptonycteris yerbabuenae* in Mexico and the southwestern United States and its sister species *L. curasoae* in Colombia and Venezuela. Weighing 16-25 g, these bats are relatively large and very strong fliers. *L. yerbabuenae*, for example, often flies over 100 km each night while foraging, and many females migrate over 1000 km from their winter habitats in the tropical dry forests of south-central Mexico to form maternity colonies in the Sonoran Desert of northern Sonora and southwestern Arizona in the spring. These bats are ideal pollinators of large and sometimes widely spaced cacti in arid and semiarid habitats. They can carry large amounts of pollen (of many plant genotypes and several species) on their fur, and they can easily fly several kilometers between groups of plants. As a result, they are excellent long-distance pollen dispersers.

Because they are attempting to attract relatively large and energetically expensive pollinators, bat-pollinated columnar cacti must provide a substantial nectar reward for their visitors. They do this by producing 1-2 mL of sugar-rich nectar in their large, nocturnally opening flowers. The nectar of bat-pollinated cactus flowers contains up to 36 times more calories per flower than those of flowers pollinated by bees or hummingbirds. In addition, bat-pollinated flowers contain large amounts of pollen (about 1.5 g in *Pachycereus pringlei*), some of which is ingested by bats when they groom their fur. *Leptonycteris* and other nectar-feeding bats can digest the chemical contents of pollen grains and use the amino acids therein as a protein source. Nectar bats thus gain a relatively balanced diet of energy and proteins from cactus flowers.

Although bat pollination is probably the ancestral pollination mode in tribe Pachycereeae, the reliance of these cacti on bats as their exclusive pollinators varies geographically. For instance, the results of pollinator exclusion experiments indicate that columnar cacti rely more heavily on *Leptonycteris* bats for pollination in the Tehuacan Valley of southeastern Mexico than they do in the Sonoran Desert. In northern species such as saguaro (*Carnegeia gigantea*) and organ pipe *(Stenocereus thurberi*), less than 50% of fruit set results from bat pollination.

[1] Emeritus Professor, University of Miami and Adjunct Professor, University of Arizona **above Loreto cardon flower. inset Lepto at cardon flower.**

The most important vertebrate pollinators of these two species are white-winged doves and hummingbirds, respectively. A similar situation occurs in South America with *Leptonycteris* bats again being the most important pollinators of columnar cacti in northern Venezuela whereas bats and hummingbirds both contribute significantly to fruit set in *Weberbauerocereus* cacti in the Andes of southern Peru. The major factor that determines whether columnar cacti have bat-specialized vs. more generalized pollination systems is the residency status of nectar bats. In areas where these bats are year-round residents, cacti rely nearly exclusively on them for pollination; in areas where bats are seasonal migrants, cacti rely on a broader array of animals for pollination.

The columnar cactus-nectar bat connection is 10-15 million years old. This mutualistic interaction likely was fine-tuned well before the evolution of another family of arid zone plants, the Agavaceae, in which many members of subgenus *Agave* (paniculate agaves) are bat-pollinated. Rocha et al. (2006) have suggested that the existence of a cactus-bat connection in arid habitats facilitated the evolution of paniculate agaves some 10 million years ago. In Mexico today, the reproductive success of columnar cacti and paniculate agaves is linked by the migratory behavior of *Leptonycteris* bats. Most columnar cacti are late winter-spring bloomers with flowering seasons beginning earlier in southern Mexico than in the Sonoran Desert. The northward progression of cactus flowering along Mexico's Pacific coast in the spring thus provides a natural 'nectar corridor' for migrating nectar bats. Most paniculate agaves in western Mexico, in contrast, are summer-fall bloomers and are located at higher elevations in the Sierra Madres than the spring-blooming columnars. These agaves form a natural 'nectar corridor' for nectar bats when they migrate south from northwestern Mexico and southern Arizona in the fall. To successfully complete their annual migratory circuit, *Leptonycteris* bats need intact populations of both columnar cacti and paniculate agaves. This *Leptonycteris*/columnar cactus/paniculate agave connection obviously has important conservation implications.

The presence of bat-pollinated columnar cacti and paniculate agaves in arid North American habitats likely has facilitated the evolution of nectar-feeding in another family of bats. The desert pallid bat, *Antrozous pallidus*, is a member of the cosmopolitan insectivorous family Vespertilionidae. Its distribution ranges from southern British Columbia to central Mexico and as far east as west Texas. Normally a predator of large arthropods such as orthopterans and scorpions, this bat has been reported visiting flowers of columnar cacti and paniculate agaves in the Sonoran Desert and paniculate agaves in the Chihuahuan Desert. Recent research by Frick et al. (2009) indicates that it is a frequent visitor, along with *L. yerbabuenae*, to flowers of cardon and organ pipe cacti in Baja California Sur. Like *L. yerbabuenae*, its face becomes covered with pollen during visits to cactus flowers, and it is undoubtedly an effective pollinator.

In summary, the columnar cactus-nectar bat connection is rich in its ecological and evolutionary features. Conservation of habitats containing these cacti as well as paniculate agaves is essential if this connection is to persist.

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Would you like to take a more active role in protecting Arizona's native plants?
Please contact your local chapter (see back cover) for local volunteer opportunities.

Butterflies are Herbivores, too *by Rich Bailowitz*[1]

above *Erynnis juvenal* larvae.

The practice of eating plants is not only something vital to human beings but to other mammals, many birds, and, more to the point, numerous insects. Some orders of insects (Diptera, Coleoptera, Hemiptera, Hymenoptera, etc.) have both carnivorous and herbivorous members. Other orders may be limited largely to one or the other. Typically carnivorous orders of insects include Odonata and Neuroptera, which are predaceous, usually on other insects, or Anoplura and Siphonaptera which are parasitic, often on vertebrates. Typically herbivorous orders of insects include true Orthoptera (excluding mantids, cockroaches, etc.) and Lepidoptera. Some herbivorous insects feed by chewing leaves and other plant parts; others suck juices or saps from various parts of plants; still others are miners or gall-makers and live within the plant tissue. Butterflies are herbivores which primarily utilize the first technique as immatures (a few moths make galls), and the second technique as adults (largely sipping nectar from inflorescences).

In butterflies, the ties between plant and insect can be loose, so that a particular species of butterfly may be able to oviposit, and these larvae develop, on plants across a wide array of genera or even families. A species such as the painted lady, *Vanessa cardui*, breeds on many species of Asteraceae and Fabaceae, as well as some species in the Solanaceae, Ulmaceae, Rutaceae, etc. This has afforded it immense success so that it breeds on all continents and often occurs abundantly. Other butterfly species, while generalists, may limit oviposition to a single family. Case in point: orange sulphur, *Colias eurytheme,* can utilize a wide range of plants in the Fabaceae including alfalfa, at which time in can achieve epic numbers. Still other butterflies are more choosy, restricting their egg-laying to a single plant genus. The abundant Sonoran species, American snout (*Libytheana carinenta*), uses any members of the genus *Celtis* as a larval host. And finally, a number of species have the tie between plant and insect extremely tight, limiting successful breeding to the presence of a single species of plant. A prime example is the confinement of the Huachuca giant-skipper*, Agathymus evansi*, to stands of *Agave huachucensis.* Restriction by a larva to a plant does not often translate to a similar feeding restriction by the adult. To the gulf fritillary, *Agraulis vanillae*, oviposition must take place on various Passifloraceae. But the adults will eagerly take nectar from nearly anything available — *Bidens, Tithonia, Chrysothamnus, Baccharis, Zinnia, Verbena, Lantana*, etc.

Even within what appears to be a simple scheme — the female lays the eggs on the plant, the eggs hatch into larvae, the larvae develop and molt several times, the final instar transforms into a pupa, and after weeks or months, the pupa ecloses into the adult butterfly — the variation is seemingly endless. One common theme is discontinuity, either in the form of hibernation or aestivation. Hibernation is unrelated to plants and involves the adults or the immatures (diapause). During winters, those portions of Sonora and Arizona with sporadically low temperatures have corresponding butterflies species adapted to that weather regime. Species such as mourning cloak, *Nymphalis antiopa*, hibernate, shutting intake and outtake systems down and seeking shelter from the cold beneath bark, rocks, etc. During warm spells, they can reactivate, taking advantage of winter puddles, blossoms, sap, etc. On the other hand, aestivation is directly related to plants and almost always involves the immatures. During periods of extreme heat or prolonged dryness, development is arrested. Since larvae feed on tender shoots, young leaves, or developing flowers, it is biologically worthwhile for a population to turn off and await suitable plant growth before the insect resumes its own development. In hot, arid habitats such as the Sonoran Desert this technique is commonly used. In all immature stages — egg, larva, and pupa — development can be put on hold until the triggering devices of cooler weather or increased moisture signal the recurring growth of edible plant parts. The enormous butterfly response to the monsoon season, usually a few weeks after the onset of the rains, is an example of this phenomenon.

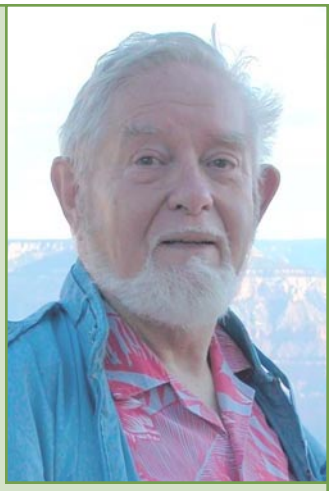
Several species can be used to illustrate various types of butterfly/plant interaction. A very typical scenario is exemplified by the giant swallowtail, *Papilio cresphontes.* While there are native desert plants that are suitable foodplants for this species, e.g., *Choisya*, oviposition is most easily seen in city and town gardens on various citrus trees. The female flies slowly, often within the canopy of the tree, searching for young leaves. The eggs are laid singly near the tip of the leaf and the small larva feeds generally from underneath the leaf. Some protection is afforded the larva, commonly called an "orange dog", by its similarity to a bird dropping.

The butterfly genus *Euphilotes* has approximately a half dozen species occurring in the desert southwest. They are all closely tied to one or several perennial species of the plant genus *Eriogonum.* Timing is extremely important since in this group of species the larvae eat only the flowers and young fruit of their respective foodplants. So, in the case of *Euphilotes rita*, adults are on the wing for a short period in August or early September, the exact time frame depending on the onset of monsoonal rains, when the *Eriogonum wrightii* flowers are just beginning to open. This provides the maximum length of time for full larval development. Atypically, the adult butterflies are also nearly confined to nectaring at their foodplants' inflorescences.

The value of knowing the tight relationship between butterfly and plant can be highlighted by the example of the hesperiine skipper *Atrytonopsis cestus.* In *Arizona Flora* (Kearney & Peebles 1951), the range of the foodplant *Muhlenbergia dumosa* includes

[1] Co-author of *Finding Butterflies in Arizona* and the upcoming *A Field Guide to the Dragonflies and Damselflies of Arizona and Sonora.*

Honoring H. David Hammond *by Dr. Tina Ayers*



The Arizona Botany Meeting's Lifetime Achievement Award for 2011 was presented posthumously to Dr. H. David Hammond at the February 2011 Arizona Botany Meeting at the Desert Botanical Garden. David was a steadfast volunteer curator at the Deaver Herbarium at Northern Arizona University for 17 years, working each morning seven days a week. David was also an important contributor to the Flagstaff Chapter of the Arizona Native Plant Society. He was officially the treasurer for many years and unofficially the provider of snacks for most meetings. David also instructed Budding Botanists in the AZNPS Plant Atlas Project of Arizona training sessions how to mount plants.

David completed his undergraduate work at Rutgers University and his Ph. D. in Botany from the University of Pennsylvania in 1952. He taught Botany for many years at Howard University in Washington, D.C., and SUNY Brockport, New York, while he also avidly collected the local flora and started a herbaria. David was an editor at the New York Botanical Garden for many years, and continued as a diligent and conscientious regional editor for Flora North America while at Deaver. He would surround himself with specimens while sitting at a microscope as he pored over the keys and descriptions of numerous treatments. During the summers David drove long circuitous routes to collect along the Mogollon Rim and in the White Mountains on his way south to visit his sister in Casa Grande.

David influenced, mentored, and, in his gentlemanly manner, cajoled many students, both undergraduates and graduate students, during his tenure at the Deaver Herbarium. He was a regular at departmental seminars where his questions revealed both the depth of his education and thinking as well as some crucial point that might have been overlooked by the speaker. In his 1990s vintage white Dodge pickup he accompanied many native plants classes and all the plant taxonomy spring field trips to the Mojave Desert. In the field and at the mounting table, he taught students how to collect appropriate material. He even tried to teach various graduate students, some numerous times, how to press grasses correctly so they would not need to be refolded during the mounting process.

David had relocated back to Rochester, NY, in July 2010 to spend time with his daughter Julie, son-in-law, and grandchildren. He was just getting settled when he suffered a fatal stroke. The presentation of the award in February occurred one day after what would have been his 87th birthday.

Maricopa County, a county in which the skipper had not been found. By using herbarium records, populations of the plant were located near Fish Creek in Maricopa County. And by visiting the site in early May, a field worker (Jim Brock 1992) was able to locate the butterfly. Conversely, on a collecting trip to Redfield Canyon in the Galiuro Mountains of extreme southwestern Graham County, specimens of *A. cestus* were found. This in turn led to the discovery of *M. dumosa* on north-facing slopes in the canyon, representing a new county record for the plant in Arizona.

The pyrgine skipper genus *Erynnis* is notoriously difficult to decipher. There are approximately a dozen species in Arizona, six of which also occur in Sonora. They are something like Calidris sandpipers or Empidonax flycatchers with regard to identification issues. While seasonality, location, and phenotype will all help in identifying them to species, they are far from failsafe. During copulation, males hold the females using claspers located at the abdomen tip. These claspers are non-symmetrical and species-specific so that interspecific hybrids are close to non-existent. But another method that is a great aid and does not involve microdissection is foodplant association. Of the six Sonoran species, the larvae of four of them feed on oaks. The other two, *E. pacuvius*, and *E. funerealis*, are Rhamnaceae and Fabaceae obligates respectively. This knowledge can be a valuable aid in identification, if species-level taxonomy is desired.

It is possible that butterfly/plant relationships may aid in cementing plant taxonomy problems. The skipper salt-bush sooty wing (*Hesperopsis alpheus*) has, as its common name suggests, *Atriplex canescens* as its larval host. Yet at Organ Pipe Cactus National Monument, the butterfly species has not been recorded. The Monument plant list cites their large salt-bush as *Atriplex canescens* var. *linearis*. On the contrary, Kearney & Peebles (1951) give full specific rank to *linearis*. The fact that the butterfly appears to be absent from this portion of the state suggests that the larvae cannot utilize *linearis* while they can feed on nominate *canescens*. This possible chemical separator might provide additional ammunition to systematists working on the species group.

One final example. The southwestern butterfly fauna of Arizona and Sonora is composed of somewhere between 400 and 500 species. Of the approximately 350 species occurring in Arizona alone, 50 or more of them are strays from the south. In addition to these 50, another 35 or so are what are termed to be influx species. These are species on the edge, for one reason or another. Most often it is a result of their susceptibility to subfreezing temperatures during some stage in their life-cycles, due to their tropical or subtropical roots. A perfect example is a species called the common mestra, *Mestra amymone*. It is a common Sonoran species, using various species of *Tragia,* especially *nepetaefolia*, as larval hosts. Several species in this plant genus occur in Arizona and toward the end of the monsoon season, if rains have been adequate, this nymphalid butterfly irregularly establishes breeding colonies along the state's southern border. However, when the first hard freezes occur in late fall, the butterfly is wiped out but not the plant. The requirements of the insect and the

continued next page

Nancy "Z" Zierenberg *by Greta Anderson*

Z passed away on December 2, 2011 at the age of sixty. She leaves behind her husband and partner of thirty years, Rod Mondt. She was an amazing person whose efforts to promote native plant conservation are unparalleled.

In addition to Z's work with the Arizona Native Plant Society (AZNPS) as its State Administrative Assistant handling membership, merchandise, mailings, and outreach, she was an active and integral part of the Tucson Chapter and the Conservation Committee. She was a tireless advocate and volunteer at tabling opportunities, developing activities for kids and materials for education, constantly improving and adapting our displays. She enthusiastically participated in all the fieldtrips and represented AZNPS at tree plantings and on municipal planning committees including the campaign, "1000 Trees Please!" to plant native species in urban Tucson. She also represented AZNPS as part of the Coalition for Sonoran Desert Protection, a regional coordinated planning effort that seeks to balance development with open space.

Her native plant advocacy and interest extended to her participation in the Tucson Cactus and Succulent Society, a regional group working on plant salvage and sales, to consistently volunteering at the UA Herbarium, where she enjoyed learning taxonomy while helping mount and preserve specimens. She was also active with the Florilegium Project, a botanical illustration effort, and she maintained membership in the California Native Plant Society's Bristlecone Pine Chapter because of her affinity and affection for the taxa of the high Sierra.

Because she so loved plants, she was also interested in maintaining their habitat and co-inhabitants. A founding member of Sky Island Alliance, she served on the board of that organization in various capacities until her death. She was a founder and key staff member of Wildlife Damage Review, a grassroots campaign to limit federal trapping and destruction of native wildlife at the behest of various industrial uses of public lands such as predator control for the benefit of the livestock industry. She was a member of Great Old Broads for Wilderness, an organization that uses a specific demographic and a lot of humor to advocate for change in public lands management. Additionally, she was an active member of Earth First!, believing her whole life that Nature is worth fighting for.

What Z brought to all of her many activities was an enthusiasm and "Can do" spirit that is rarely matched. She was funny and fun, always positive and encouraging and quick to laugh uproariously. She kept her word and her commitments and she was full of life, making her loss not only deeply sad but hard to fathom for those of us who knew, loved, and counted on her. We've got big shoes to fill, but Z would expect us to fill them, carrying forward the work of advocacy, education, appreciation, and conservation of our plant community. More information about Z can be found on **friendsofnancyz.wordpress.com**.

A Call for Sedge Collections:

To augment a new understanding of the genus in Arizona *by Max Licher and Glenn Rink, Flagstaff, Arizona*

Many members of the Arizona Native Plant Society have been frustrated in our attempts to identify sedge specimens. The authors are reviewing *Carex* (*Cyperaceae*) in Arizona and hope to write a new treatment for the genus in the next year. Our goal is to produce a treatment which is easier to use than past treatments, as well as up to date and accurate. When complete, we expect that the list of sedge species known to occur within the state to go from 85 or so currently listed in the SEINET database down to approximately 60. (That alone will make them easier to identify!)

We need your help with this task. We'd love to receive duplicates of your *Carex* collections, whether from within the state or out of state. It is critical to make good specimens: (1) roots and/or rhizomes are critical, (2) basal leaf sheaths are critical in some groups, (3) An adequate sample should contain at least 6-7 mature inflorescences, and (4) record a good description of the habitat, along with accurate location data. Send collections to the Deaver Herbarium, Attn: Licher and Rink, Biological Sciences Department, NAU, P.O. Box 5640, Flagstaff, Arizona 86011-5640.

Butterflies are Herbivores, too *continued*

supporting plant do not seem to mesh, the larval host being able to withstand colder temperatures than the butterfly.

The myriad examples of butterfly/plant interactions can be endless. Each species is herbivorous, and each has a tale to weave. Many stories are well-known, many are not. Discoveries are made all the time. With global warming just beginning, we have a new variable to contend with. And, of course, what we need is additional study. Always.



From left A visiting hoverfly on a Sentry milk-vetch plant. A quarter shows how tiny this plant it. A closeup of the blossoms.

Preliminary Pollination Study on Sentry Milk-vetch *(Astragalus cremnophylax* Barneby var. *cremnophylax),* Grand Canyon National Park's only Endangered plant species

by Janice Busco[1], Emily Douglas[2], and Jennifer Kapp[3]. Photos courtesy the authors.

Of the 1,737 known plant species in Grand Canyon National Park, including 63 rare special status plants and 12 endemics, the rarest of the rare is sentry milk-vetch (*Astragalus cremnophylax* Barneby var. *cremnophylax*) the park's only federally-listed Endangered species. Sentry milk-vetch is not only endangered, it is endemic, meaning that Grand Canyon National Park is the only place on earth this plant lives. The specific name *cremnophylax* means 'gorge watchman' — an apt name for a little plant that grows only on the edge, watching over Grand Canyon.

A member of the pea family (Fabaceae), sentry milk-vetch is a tiny, perennial that grows only in shallow soil pockets in cracks and crevices and on graveled slopes on outcrops and edges of Kaibab limestone. In areas where sentry milk-vetch is found, this limestone forms large, flat platforms in open areas within the pinyon pine-juniper forest. Sentry milk-vetch is found in association with a suite of limestone-loving species including *Petrophytum caespitosum* (rockmat), *Calylophus lavandulifolius* (lavender-leaf sundrops), *Chamabatiaria millefolium* (fernbush), *Hedeoma drummondii* (Drummond's false pennyroyal), *Eriogonum jamesii* var. *flavescens* (James' golden buckwheat) and *Phlox* sp. (phlox).

Sentry milk-vetch plants grow to only 1 to 2 inches (2.5 to 5 cm) tall and 1-10 inches (2.5 – 25.0 cm) in diameter. Their short, creeping stems have compound leaves composed of 5-9 tiny leaflets. Mature plants bloom in the spring, and produce many tiny lavender flowers: 100-200 per plant is not uncommon.

Sentry milk-vetch was discovered at Grand Canyon by Marcus E. Jones in 1903. Jones, an esteemed scientist and early explorer of the western United States reported the newly discovered sentry milk-vetch as "common." Forty years later another noted botanist, Rupert Barneby, determined that the plant was "of great rarity" in the park. The decline of the species is somewhat of a mystery, and may be attributable to ever-increasing visitation in the ensuing years. In 1903, sixteen years before Grand Canyon became a national park, visitation was very low. By 1947, when Barneby visited, more than 600,000 people visited Grand Canyon each year, and many structures, roads and walkways had been constructed on the rim.

Like other rare plants with very specific habitat requirements, sentry milk-vetch is threatened by habitat loss, drought and climate change. The sentry milk-vetch population near Maricopa Point was fenced in 1990 after scientists discovered that the plants were unable to withstand inadvertent trampling by visitors seeking to enjoy views of the canyon.

In 1990, sentry milkvetch was listed as Endangered with fewer than 200 individuals comprising its one known population near Maricopa Point. In 1991, Theran Taylor, of the park, located another tiny population of only three individuals on the East Rim, and in 2002 he located an estimated 341 plants at six closely spaced sites at another East Rim location. Today, there are less than 2,500 known individuals of sentry milk-vetch.

The 2006 US Fish and Wildlife Service *Sentry Milk-Vetch Recovery Plan* outlines steps necessary to achieve and document long-term stability of sentry milk-vetch by removing threats, enhancing existing populations, discovering new populations, and creating new populations if needed. Monitoring of the Maricopa Point population has been completed annually since 1988. The Arboretum at Flagstaff and Grand Canyon National Park have both been active partners in carrying out recovery plan actions and research on Sentry milk-vetch. Each year seed from wild populations is collected; some of this seed goes into

continued next page

[1]Grand Canyon National Park Horticulturist, [2]Student Conservation Association Intern, [3]Restoration Biologist

Preliminary Pollination Study on Sentry Milk-vetch *continued from page 11*

long term storage while other seed has been used to grow out two ex situ populations, one at The Arboretum and one at the Grand Canyon Native Plant Nursery. In addition, Grand Canyon National Park is growing seedlings to be planted in a population augmentation at Maricopa Point in Spring 2011.

One Recovery Plan recommendation is to conduct research on the biology and ecology of the species to determine its requirements. Allphin et al. (2005) discovered the plants are obligate outcrossers, that is each plant needs pollen from a different plant to produce viable seed. The Arboretum has been hand-pollinating plants to produce seed for several years and is experimenting with controlled crosses. In 2010 Grand Canyon began regular hand-pollination of its ex situ population.

Even though Sentry milk-vetch has been known to science for over a hundred years, little was known about its specific pollinators until the Park conducted a preliminary pollinator study in spring 2010. We conducted this study to answer two questions: Who is the primary pollinator for Sentry milk-vetch? Do these pollinators also pollinate associated species?

Studies were conducted at Maricopa Point on the South Rim between April 26 and May 3, 2010. Study sites consisted of a closely spaced group of five flowering Sentry milk-vetch plants, such that an observer did not need to move to see pollinators in action. Sites were also chosen that were within viewing distance of Curveseed butterwort (*Ceratocephala testiculata*) in the Buttercup (Ranunculaceae) family, the only nearby associated plant species blooming during the study period.

Spring weather was blustery and cold, with rain, sleet, hail, high winds and snow. Because of weather conditions, there were only three days suitable for observation. For 12 hours (from 6am to 6pm) on each of three days we observed visitors to the Sentry milk-vetch, alternating between 30 minutes of observation and 30 minutes of collecting or photographing visitors. One group of plants, or study site, was observed throughout the day. A tally of pollinators and visitors to Sentry milk-vetch was recorded for each half-hour interval from 6am to 6pm.

To determine visitation rates and identify pollinators, we recorded each visit by each category of visitor (flies, bees, butterflies, ants, etc). Next, we calculated visitation rates by dividing the number of times a visitor lands on one of the flowers by the total number of flowers observed.

One sunny, calm day, each flower received a combined average of 13.08 visits from all categories of visitors. Only 2% of visits occurred before 9am, with 42% between 10 am and noon, 36% between 1pm and 3pm and 20% between 3pm and 5pm. 97% of all visits were made by two different types of mason bees, mason bee type one (*Osmia ribifloris ribifloris*) and mason bee type two (*Osmia ribifloris*). Mason bees have generally been seen and collected pollinating plants in the Barberry family (*Berberidaceae)* as well as manzanitas (*Arctostaphylos* species). They have been less frequently collected from other Milk-vetches *(Astragalus* spp.*)*. We observed both pollinating sentry milk-vetch flowers. Although the similarity of their names is quite confusing, and both are similar in size, shape and behavior, the two types of bees can be easily identified by color. The primary pollinator, mason bee type one (*Osmia ribfloris ribifloris),* is black and visited flowers more times than any other insect (87% of all visits). Mason bee type two, (*Osmia ribifloris),* is metallic green and is a lesser, but still significant pollinator (with 10% of all visits to sentry milk-vetch flowers).

Sometimes alone, these bees (type one or type two) frequently arrived in groups of three. During each visit they pollinated flowers, moving from one flower to an adjacent flower, usually on the same plant. Occasionally they would also travel to another nearby sentry milk-vetch plant and pollinate its flowers. We observed these bees fighting over flowers within their groups, but not with other species. After visiting a number of flowers, the black mason bees (type one) flew away for some time, returning later to repeat their performance. The green mason bees (type two) behaved similarly, but appeared flightier and more random in its behavior than the black bee (type one). They spent less time at each visit, and pollinated fewer flowers.

The hoverflies (also known as flower flies) *(Syrphidae),* while not as commonly seen as the mason bees, still spent a significant time on the plants. These showed up on the last day of the study when the weather was not as favorable — with cloudy, cold, windy weather all insect visits decreased but the hover fly appeared in greater number. Always solo, the hoverfly would visit a number of flowers next to each other on one plant. Much more sporadic in its movements than the mason bees, this species was impossible to collect and therefore could not be identified to species.

Visitors to Sentry milk-vetch included root-maggot flies (*Diptera*: *Anthomyiidae*, *Hylemya* species), Tephritid fruit fly/gall fly (*Diptera*: *Tephritidae*, *Trupanea* species), butterflies, ants and beetles. These insects were seen less often than the others so we deemed them to be visitors instead of primary pollinators. Although they may contribute to pollination (the flowers are so small and parts are so close together that the slightest touch can trigger the anthers to release pollen), their contribution is not as substantial as the other insects who are primary pollinators.

Our plans for future study in 2011 include repeating the study to determine if the visitation rates and primary pollinators remain constant, and performing the study at all three sentry milk-vetch populations.

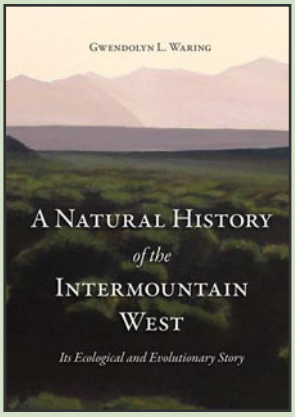
We would like to thank the following people: Vince Tepedino of the ARS USDA Bee Biology and Systematics Lab at Utah State University for his input in creating a pollination study; Ryan Hanavan, Forest Entomologist, Arizona Zone of USDA Forest Service, for identifying our insects. Kris Haskins at the Arboretum at Flagstaff for reviewing our ideas and offering

BOOK REVIEW

A Natural History of the Intermountain West *by G.L. Waring*

Reviewed by Lawrence E. Stevens, Museum of Northern Arizona and Grand Canyon Wildlands Council, Inc.

Biologist and artist Gwendolyn L. Waring has compiled a remarkable amount of pithy information in her new overview of the ecology of the Intermountain West (University of Utah Press, 2011). In this work, Waring pulls together many threads of life and evolution in western North America. Encompassing desert and mountain ecosystems, the enormity of the geologic timeframe here, and how life has developed and changed in relation to the changing landscape, she provides a delightfully readable perspective that is at once grand and intimate.



Dr. Waring has organized her in-depth story around the theme of natural history through time and space, proposing an understanding of landscape evolution through geologic time. Her chapters focus on the essentials: the story of water and how it has become such an essential resource between the two intermountain geologic provinces: the Colorado Plateau and the interior-draining Great Basin. Her descriptive skills bring alive for the reader the scope of life's arising and change across deep time, and the magnitude of transformation in the landscape, particularly through the climate changes associated with the conclusion of the recent ice ages. All of human history has taken place during an anomalous 10,000-year period between ice ages, making one wonder how our anthropogenic warming phase will last before the Earth plunges back into the icebox conditions that dominated the past several million years. Although many large, wonderful beasts were lost after the last ice age, Waring recounts the life histories of many fish and wildlife survivors of that transition, whose adaptations are testimony to the resilience of life. What a fine new book!

Dr, Waring is both an evolutionary ecologist and a landscape artist, one who can relate the history of a river by its fish, and see in a flower the endless lifetimes it took to bring it to bloom over geologic time. Her chapter on mountains relates present day vegetation to the variable pace of plant evolution and range transition. The small patch of alpine habitat at the top of the San Francisco Peaks contains more than 75 species of plant species that are otherwise found only in the arctic. Waring describes in excellent detail the ecology of the dominant ecosystems of the West, with chapters on ponderosa pine forest and pinyon-juniper woodlands that are essential reading for Western literati. Her chapter on grasslands is an enjoyably readable account of the evolution and development of the Western range, shaped in part by herbivory from Pleistocene grazers to the focused onslaught of domestic cattle. Dr. Waring details how the climate regime selects for grasses with different photosynthetic pathways, framing the diet and food chains of the West.

Her final chapter summarizes the life histories of six common wildflowers of the West, and the improbabilities of their reliance on insect pollinators. She describes in focused detail their herbivores and their evolutionary adaptations to their plant prey. Her focus on these six plant species provides an effective synopsis of the subject of her book, as the factors of geology, geography, evolutionary time, climate, fauna, and changing relationships among biota collectively affect the life of each individual organism.

The dynamism of Western ecology comes to life in this book. She has consolidated information from the life work of innumerable dedicated scientists who have worked over the past century and a half. Western science is rich with intellectual insight, and the information drawn together provides profound insight into the nature or nature. This book both celebrates the richness of that collective insight, and bemoans the anthropogenic insults that senselessly degrade Western ecosystems.

Dr. Waring has provided us with tremendous insight into this Western land many of us call home. Although many insights are small and cumulative, some of the findings and insights presented here are sufficiently vast that it leaves one's head reeling in new dimensions of discovery. This book is a gift about the pursuit of truth through science, and an appreciation of science as fodder for basic philosophy and art. This is the real story, the story that we should read and reflect upon more fully, the story of our natural heritage.

input on the pollination study; and Joe Janakin Grand Canyon volunteer, for putting up with terrible weather and helping out.

If you or someone you know would like to volunteer with the Grand Canyon Vegetation program, please call Volunteer Coordinator Laura Getts 928.638.7753.

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Found Then Drowned

Three noteworthy collections from Tempe Towne Lake

by Elizabeth Makings[1], Lane Butler[2], Matt Chew[3], and Julie Stromberg[4]. Photos courtesy the authors.

On 20 July 2010, the inflatable bladder dams that created the Tempe Towne Lake ruptured, spilling water downstream and exposing the lake bed sediments that had been submerged for almost 10 years.

Some interested botanists were intrigued by the marshland that almost immediately appeared in the aftermath, and, through the efforts of Lane Butler, the City of Tempe allowed us to explore the riverbed. The photos are from our site visit 27 September, 9 weeks after the failure of the bladder dam (Figure 1). We collected only 20 taxa that day, but three taxa turned out to be surprisingly rare and/or noteworthy:

***Ammannia coccinea* (Rottb.)**(Lythraceae) **Valley redstem**
Valley redstem (Figure 2) is not new to Arizona, but has an interesting story. It is an obligate wetland species found throughout the US, except for some Pacific Northwest states, listed in *Natureserve* as critically imperiled in some eastern states. In Arizona it is not ranked. *A. coccinea* has been popping up in the state flora occasionally for some 80 years, so it's presence in the Salt River is not remarkable. What is noteworthy, however, is that this plant was scarce in Arizona until around 2000, and has suddenly appeared in huge numbers in this particular reach.

Regionally, there are scattered collections of *A. coccinea* in the southern half of AZ, and a couple localities along the wetlands of the Rio Grande in New Mexico. The first voucher for Arizona was a McClellan and Stitt collection from "Papago Park, Tempe" in 1936. It was not collected again until 28 years later by Elinor Lehto at Lake Pleasant. Then there was a Catherine Irwin collection from along the Colorado River in Yuma Co., in 1975; and in the late 1990s Jere Boudell, a graduate student in Julie Stromberg's lab, vouchered it from the Agua Fria River below Lake Pleasant, where it emerged in a growth chamber from a seed bank study. Next, there were two collections from wetlands in Cochise County in 2003. In 2004, 2005, and 2007 there were several more collections along the Salt River in metro Phoenix, from Stromberg's students working in these areas. And then, in 2010, came the spectacular population explosion in the temporary wetland of Tempe Towne Lake.

A. coccinea was growing co-dominant with cattail (*Typha* sp.) (Figure 3). While anecdotal information is rare in older specimens, even the newer material makes no mention of this sort of abundance, so the questions are: "Why was there so much of it here? And why now?" In an e-mail communication, Shirley Graham, a *Lythraceae* expert from the Missouri Botanical Garden who studies the genus had this to say…"A drying, previously flooded habitat is ideal for *Ammannia* and the irregular appearance of the genus at any one locality of this kind is absolutely typical. In Tanzania where *Ammannia* was in a rice field in great quantity one year according to collection data, when I visited the next year at the same place, same time, there was no sign of it. As for seed source, it might have been introduced by dispersal downriver from rice cultivation… It floats nicely and is adapted to varying water levels, often starting in standing water and fully developing on dry mud flats."

Whatever the source, the potential for mass germination of this species is well documented, and the "boom and bust" nature was on display in a spectacular way for a few of us lucky observers.

***Cyperus michelianus* subsp. *pygmaeus* (Rottb. Asch. & Graebn.)**(Cyperaceae)
In 2005, on behalf of graduate students in Julie Stromberg's lab, I was asked to identify a small sedge collected along the Salt River near Tempe Towne Lake. I got nowhere with every key I could find, and resorted to manually thumbing through herbarium folders in desperation. I was lucky enough to find what looked like a match identified as '*Cyperus pygmaeus*' (Figure 4), a lone collection held at ASU Herbarium from Rajasthan, India. Duplicates of our material were sent to Tony Reznicek at Michigan where he confirmed the ID and also that it was a

continued next page

[1]Arizona State University Herbarium, [2]City of Tempe, [3]ASU Center for Biology + Society, [4]ASU School of Life Sciences

significant collection: a North American record. *C.m. pygmaeus* is an annual, typically of silty riverbanks and similar disturbed sites from hot (often arid) areas of the Old World. Specimen occurrence data accessed through GBIF and Tropicos websites suggest it is common in Australia, India, China, the Middle East, and Mediterranean.

The Salt River at Tempe Towne Lake was not the first collection of *C.m. pygmaeus* in Arizona, but it was the first time its identity was confirmed and, therefore, the other collections brought to light. Since I now had the recognition factor, I was comfortable annotating several other sheets I remembered as misidentified - two additional sheets from ASU, and one from the Forest Service herbarium on the Tonto National Forest. *C.m. pygmaeus* was collected in Arizona about the same time in two different localities, Jim Hurja, a Forest Service soil scientist, collected it at Roosevelt Reservoir in a place called School House Point in October 1998. Jere Boudell (in the same seed bank study mentioned before) had it emerge in a growth chamber from a soil sample collected below Lake Pleasant in 1998.

Though we will never know for sure when, where, or how this plant first arrived, it's reasonable to assume it was introduced by people (vs. birds or wind). Given the localities, along the banks of these two reservoirs, it was probably recreation-related and we will certainly see expansion of its range throughout the Colorado River watershed in the near future.

***Ludwigia erecta* (L.) H. Hara** *Yerba de jicotea* (Onagraceae)
L. erecta (Figure 5) was immediately interesting in the field that day for three reasons: it was a beautiful plant; it was conspicuous because many stood out relative to the height of the other graminoids; and it was not familiar to us. Again, I got nowhere with any local reference material, and the manual search didn't work this time, so duplicates were sent to Peter Hoch and Peter Raven at Missouri Botanical Garden, where they were gracious and prompt with their ID.

"We agree that your material is *Ludwigia erecta* (L.) H. Hara. Based on known distributions, this is somewhat surprising… since this species is currently known in the USA only from southern Florida. However, it ranges widely across South America, the Caribbean, Central America at least to central Mexico, and — probably naturalized — in Africa... I think your collection warrants some sort of published note, since this is a significant range extension, and will be of interest to many, especially those working on invasive plants (some *Ludwigias* in California have become serious problems) and on the predicted spread of species northward in association with climate change…"

Using the Google Earth ruler tool, the nearest collections are 950 air miles (from the Mexican state of Nayarit) and 1,200 miles (from a Hinds County, Mississippi, voucher) — so this is a significant range extension indeed.

In conclusion, it's not surprising that this area produced novelties given the surrounding influences — there are several storm drains emptying from both directions; it is immediately downstream from the confluence of Indian Bend Wash, which empties a large urban watershed; and there are two major freeways that pass over the River. However, considering the flora that emerged was remarkably "native" or at least "non-horticultural" given the number of potential non-natives available from the perimeter, something else is going on here. Ironically, the formation of the Lake inadvertently created the substrates suitable for the establishment of this specialized suite of wetland plants. At the time of its construction, Tempe Town Lake was lined with clay to reduce water infiltration. The lakebed sediments we sampled were high in clay, silt, and organic matter, and were anaerobic, and our hypothesis is that this created a habitat reminiscent of cienega wetland soils that historically blanketed many rivers in the region - quite different from the sandy soils that typify many of our rivers today.

The habitat is now gone as the bladder dams were replaced, and the Lake refilled, but we were lucky to get a rare glimpse of the resilience of a desert riparian ecosystem with its self-assembling diversity — evidence that our rivers and their connection to cienegas is not lost. This exercise was a also a lesson in the importance of collecting in urban watersheds — areas that may harbor novelties, but are often overlooked.

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