



# Sego Lily



Newsletter of the Utah Native Plant Society

Fall 2015  
(volume 38 number 3)

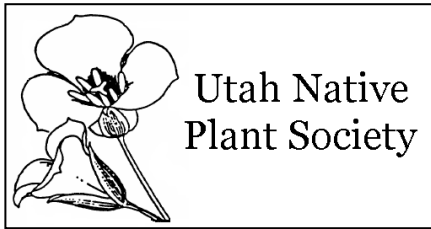
*In this issue:*

Unidentified Flowering Object.	2
Bulletin Board .....	3
UNPS News.....	4
Big Genera: Why are some Genera so much Bigger than Others? .....	5
Whites in the Minority: Albino Flowers .....	8
Botanist's Bookshelf .....	10
<i>Flora of Colorado &amp; Cacti and Succulents of Arizona</i>	

**Cedar Breaks buckwheat** (*Eriogonum panguicense* var. *alpestre*) is one of the 115 taxa of wild buckwheat in Utah, making the genus the second largest in the state flora. Like many species in mega-diverse genera, *E. panguicense* var. *alpestre* is an edaphic endemic, occurring only on Claron limestone in the Cedar Breaks area. To learn more about 'big genera' see the article on page 5. Photo by Doug Reynolds.



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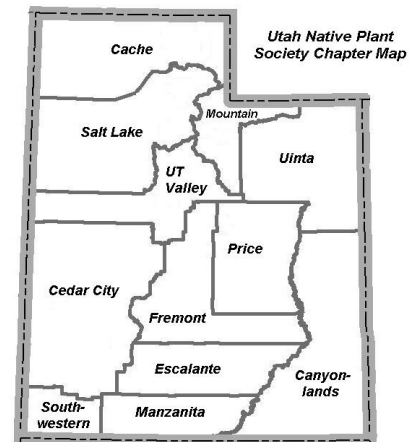
Website: For late-breaking news, the UNPS store, the *Sego Lily* archives, Chapter events, sources of native plants, the digital Utah Rare Plant Field Guide, and more, go to [unps.org](http://unps.org). **Many thanks to Xmission for sponsoring our website.**

*Sego Lily* Editor: Walter Fertig ([waltola64@gmail.com](mailto:waltola64@gmail.com)). The deadline for the Winter 2015/16 *Sego Lily* is 1 February 2016.

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The *Sego Lily* is a quarterly publication of the Utah Native Plant Society, a 501(c)(3) not-for-profit organization dedicated to conserving and promoting stewardship of our native plants.

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Utah Native Plant Society Chapters

## Unidentified Flowering Object

This month's UFO might be mistaken for a series of little rocket ships, or any angry sea creature lashing out with its tentacles. It is actually a closeup of the inflorescence of a widespread but infrequently observed mountain plant. Steve Hegji took the photo in July while botanizing along Dry Creek in Alpine, Utah. Any guesses?

The Summer Unidentified Flowering Object was King's bladderpod (*Physaria kingii*) photographed by Steve Hegji on Delano Peak in the Tushar Range. The four-merous flowers and lack of a hypanthium should have made it easy to identify it as a member of the mustard family (Brassicaceae), but without fruit (or leaves) getting it to genus and species was a challenge. Scotty Smith of Denver, Colorado, was the first reader to come up with the correct genus.

## Bulletin Board

**2016 Utah Rare Plant Meeting:** The annual Utah Rare Plant meeting is scheduled for Tuesday, March 8, 2016 at the Natural History Museum of Utah, Swaner Forum (301 Wakara Way, Salt Lake City). This year's meeting is being co-hosted by the Utah Native Plant Society, the Garrett Herbarium of the University of Utah, and the Natural History Museum of Utah. If you are interested in giving a 20 minute presentation or displaying a poster, please contact Jason Alexander (801-863-6806, alexanja@uvu.edu) or Elizabeth Johnson (801-587-5745, johnson@nhmu.utah.edu) by February 22 about submitting an abstract. Registration is \$25 and includes morning snacks, beverages, and a catered lunch (vegetarian and gluten-free meals can be provided if requested in advance). Based on responses from last year's meeting, we have switched to a new caterer. Registration can be done through the Utah Native Plant Society website. Please note that Red Butte Garden is not a co-sponsor this year, and so will not be accepting registrations.

**Salt Lake Chapter Meetings:** Wednesday, February 3: Maria Gaetani will talk about the National Science Foundation's National Ecological Observatory Network "NEON". Salt Lake City has been chosen as one of the NSF's field sites for studying urban ecology. The meeting will be at REI at 3300 South.

**Great Basin Native Plant 2016 Annual Meeting:** The Great Basin Native Plant Project and the Society of Ecological Restoration will hold their 2016 annual meeting on 11-12 April 2016 in Boise. The meeting will include a field tour of the Soda Fire and a poster "Ignite" session on the evening of the 11th. For more information, and to register, go to the SER website: <http://chapter.ser.org/greatbasin>.

**Washington County Rare Plant Meeting:** The US Fish and Wildlife Service and other partners working on rare plant conservation in Washington County, Utah are planning a meeting on Thursday, February 11 at the BLM St. George Field Office from 9 AM to 5 PM. If you are interested in making a presentation, please contact Jena Lewinsohn by 22 January ([jennifer\\_lewinsohn@fws.org](mailto:jennifer_lewinsohn@fws.org)).

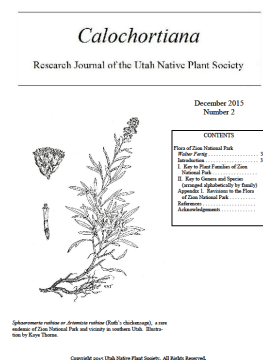
**Lichen Research Funded by UNPS Scholarship Program:** In December, the UNPS board approved a \$500 grant proposal to Dr. Emily Holt of Utah Valley University for a research project on whether genetic variation within the lichen *Xanthomendoza fulva* matches variability in its host (Gambel's oak). Lichens are the byproduct of a symbiotic relationship between fungi and algae (see the November 2014 issue of *Sego Lily*), but few studies have addressed potential symbioses between lichens and their host plants. Dr. Holt and her students will conduct their study in Red Butte Canyon. Look for their results in a future newsletter.

**UNPS Wildflower Poster Back in Stock:** This fall, UNPS made a new printing of David Gardner's classic Utah Wildflowers poster. If your old copy is faded or torn and in need of replacement, or you need a gift for that someone special, order a new poster (or two) at the UNPS online store ([unps.org](http://unps.org)).

***Calochortiana* # 2 is available, # 3 coming soon ....:** The long-delayed second edition of the UNPS research journal, *Calochortiana*, is now available for free downloading as a pdf from the UNPS website ([unps.org](http://unps.org)). This issue features a key to the vascular plant flora of Zion National Park by Walter Fertig. *Calochortiana* # 3 will be out in February 2016 and will include the revised Utah Native Plant Society Rare Plant List, compiled by Jason Alexander.

Have a botanical meeting or chapter event to publicize? Send announcements to the editor.

**In Quotes:** " Mars will come to fear my botany powers" Actor Matt Damon's character, astrobotanist Mark Watney, in the 2015 movie *The Martian*.



## UNPS News

### Annual Meeting

The UNPS annual members meeting was held on Saturday, November 7, at Red Butte Garden in Salt Lake City. Dr. Mary O'Brien of the Grand Canyon Trust was the featured speaker and described her work on mountain goat issues in the La Sal Mountains. Mountain goats were recently introduced into the La Sals by the Utah Division of Wildlife Resources over the objections of the Forest Service and conservation groups. In the short time they have been present, volunteers from the Trust and other environmental groups and citizen scientists have documented significant impacts to native plants and the high mountain ecosystem. The presentation was followed by the usual potluck supper and general botanical-themed merriment. (Photo of Mary O'Brien addressing UNPS members by Tony Frates.)



### Canyonlands Chapter Resurrected

After several years of inactivity, the UNPS Canyonlands Chapter has been reinvigorated. Covering Grand and San Juan counties, the chapter is named for the legendary sandstone canyons of the Colorado River that draw millions of explorers each year to Arches, Canyonlands, and Natural Bridges national parks and the Moab area.

This past summer, local residents Diane Ackerman and Sarah Topp started putting out feelers about restarting the chapter. Ackerman had previously helped organize the Columbia Basin Chapter of the Washington Native Plant Society and Topp was formerly a botanist for the National Park Service in southeastern Utah. In October, they held an initial meeting at the Grand County public

library and gathered enough enthusiastic local support to formally propose reactivating the chapter to the UNPS state board. The board overwhelmingly supported the motion, and the “new” chapter resumed business.

The first chapter meeting was held in November 2015 at the Castle Valley native plant garden of Mary and O.B.

O'Brien. Fifteen plant enthusiasts attended and later had a potluck dinner at the nearby home of Diane and Scott Ackerman for the inaugural business meeting. Among the items discussed was whether to retain the Canyonlands name, or replace it with a new one. A suggestion was made to incorporate “Moab” into the title, or to call the group “Bruce’s Plant Club”,

but ultimately the traditional name was retained (sorry Bruce). The group proceeded to elect officers. Diane Ackerman and Sarah Topp were selected as co-chairs and Wyn Smith was chosen as Secretary.

The next meeting of the Canyonlands Chapter will be on Tuesday, January 19 at 6:30 PM at the home of Tiger Keogh (contact the chapter leaders for directions). Sarah Topp will present a slideshow on her summer trip to the Mt. Moriah Wilderness in far eastern Nevada. She will talk about Bristlecone pines and alpine tundra plant biogeography. Sarah Karinen was originally slated to talk about her work with the National Park Service’s Inventory and Monitoring program, but this program will be rescheduled in February.

Anyone interested in learning more about the Canyonlands Chapter and its plans for field outings in 2016 and meetings should contact Sarah Topp (scarletgilia@hotmail.com) or Diane Ackerman. Look for future chapter announcements on their homepage linked to the UNPS website.



## Big Genera

Why are some genera so much bigger than others?

By Walter Fertig

“Give me a large genus and several subgenera” wrote botanist William Griffith, “rather than the modern way [of increasing the number of genera]. This [latter], by the bye, is most illogical, for a genus, being a genus, should have a certain amount of character” (Griffith in Frodin 2004).

Although Griffith was writing in 1848, he captures the sentiments of many contemporary botanists (often called “lumpers”) who find comfort in the stability of large and familiar taxonomic groupings. Others (the so-called “splitters”) prefer taxonomic categories that are more homogeneous and smaller. The lumpers vs. splitters debate may seem modern, but has actually been taking place since Linnaeus made the first revisions to his *Species Plantarum* in 1753 and decided to lump *Chamaesyce* and *Tithymalus* under *Euphorbia* and create the first “megagenus” - though with only 56 species at the time (Frodin 2004).

The concept of the genus can be traced to Caspar Bauhin in the late 1600s, decades before Linnaeus formalized species nomenclature. Bauhin recognized that some species were more similar than others and could be united by common characteristics. For example, oaks were easy to recognize as a group or “genus” because they shared similar traits, such as acorns, and clustered buds. While there were many kinds of oaks (each differing in leaf shape, pubescence, acorn features, etc.), it was easy to differentiate oaks from other genera\*, such as maples, pines, or sycamores.

Linnaeus formalized the use of genera and species epithets to provide a unique name for each taxon of flowering plant and animal that he recognized. Although it was the first word in the binomial, the genus name became analogous to a surname in Linnaeus’s system. Species that were similar in appearance could be placed in the same genus, but distinguished by a unique “specific epithet” that also was descriptive. Although it would be another century before Darwin’s theory of evolution by natural selection provided the scientific underpinnings of taxonomy, Linnaeus’ system was remarkably useful in distinguishing and organizing different species, which is why it has remained in use to this day.

Genera vary widely in size. At a bare minimum, a genus can contain a single species, in which case it is called monotypic. Examples include False mermaid

\*The plural of genus is genera, and not, as sometimes pronounced, “genuses”. The latter are eminent scholars, such as Einstein, Fermi, or Madame Curie.



Above: Escarpment milkvetch (*Astragalus striatiflorus*) from Johnson Canyon, east of Kanab. Photo by W. Fertig.

(*Floerkea proserpinacoides*), a tiny annual herb with three-merous flowers in the Limnanthaceae, and Ginkgo (*Ginkgo biloba*), cultivated widely in the Northern Hemisphere but native to China.\* At the other extreme are the so-called megagenera (containing more than 500 species). Currently the largest genus in the world is *Astragalus* (milkvetch) with 3270 species (Govaerts 1995). In all, 57 genera currently have at least 500 species. Many of these are tropical or otherwise unfamiliar to western botanists, but a surprising number of temperate genera fall into the megagenus camp, including *Euphorbia* (1836 species), *Carex* (1795), *Acacia* (1353), *Solanum* (1250), *Senecio* (1250), *Croton* (1223), *Salvia* (945), *Allium* (815), *Galium* (661), *Ranunculus* (600), *Quercus* (531), and *Potentilla* (500) (Frodin 2004, Govaerts 1995).

It can be difficult to predict why one genus becomes extraordinarily species-rich, while a similar or related genus does not. *Astragalus* (Fabaceae) is not just the largest genus globally, it is also the most species-rich genus in western North America with about 500 taxa, and the largest in Utah with 170 taxa (124 full species and 46 distinct varieties). At least one kind of *Astragalus* is typically found in a given habitat type and locally endemic species or varieties are usually associated with each mountain range or basin. Morphologically, the genus *Oxytropis* (locoweed) strongly resembles *Astragalus*, differing primarily in some technical characters

\*There were other *Ginkgo* species in the fossil record, but only one is extant today, making the genus monotypic by default.

## Big Plant Genera of Utah

1. *Astragalus* (milkvetch, Fabaceae). 170 taxa in Utah (124 full species and 46 varieties). Of these, 115 taxa are state or regional endemics that are restricted to Utah or adjacent states.
2. *Eriogonum* (wild buckwheat, Polygonaceae) 115 taxa (66 full species and 49 vars.) This diversity increases by 2 if the genus *Stenogonum* is included. *Eriogonum* has the greatest number of varieties of any of the UT megagenera though authorities disagree as to whether some should be elevated to full species.
3. *Carex* (sedge, Cyperaceae) 99 taxa (97 full species, 2 varieties). Compared to other megagenera, sedges have the fewest varieties and tend to be the most wide-ranging. Most are adapted to wetland habitats. Rare sedges tend to be limited to high elevation wetlands or sites with unusual water chemistry, such as fens.
4. *Penstemon* (penstemon or beardtongue, Plantaginaceae or Scrophulariaceae) 96 taxa (73 full species, 23 varieties).
5. *Erigeron* (fleabane, Asteraceae) 69 taxa (58 full species, 11 varieties).
6. *Cryptantha* (cats-eye, miner's candle, cryptanth, Boraginaceae) 60 taxa (55 full species, 5 varieties). Recent molecular data suggests that *Cryptantha* is polyphyletic (crossing multiple evolutionary lines) and needs to either be expanded to include *Amsinckia* and other borages, or split into several, smaller genera.
7. *Phacelia* (phacelia, Boraginaceae or Hydrophyllaceae) 50 taxa (43 full species).
8. *Potentilla* (cinquefoil, Rosaceae) 44 taxa (32 full species and 12 vars). Recent work by Barbara Ertter and colleagues strongly suggest that *Potentilla* should be split into several genera, including *Drymocallis* and *Dasiphora*. At least 5 new *Drymocallis* for Utah are named in FNA vol 9, published in 2014.
9. *Senecio* (groundsel or butterweed, Asteraceae) 39 taxa (30 full species, 9 vars). Molecular systematists split *Senecio* into several genera, the largest being *Packera* with at least 16 taxa in Utah. Morphologic differences are subtle and not especially convincing, but *Packera* species tend to have larger basal leaves than stem leaves and these are often deeply lobed.
10. *Atriplex* (shadscale, Amaranthaceae or Chenopodiaceae) 37 taxa (27 full species, 10 vars).
11. *Ranunculus* (buttercups, Ranunculaceae) 35 taxa (28 full species, 7 vars). The Intermountain Flora splits bur buttercup (*R. testiculatus*) out into its own genus, *Ceratocephala*.
12. *Draba* (draba or whitlow-grass, Brassicaceae) 35 taxa (30 full species, 5 vars) Many new cryptic species



Above: *Carex aurea* by Steve Hegji, spring at Skull Valley Dunes

have been recognized in recent years, most of which are rare and localized.

13. *Artemisia* (sagebrush, Asteraceae) 33 taxa (24 full species, 9 vars), at least 3 UT taxa are introductions.
14. *Physaria* (twinpod or bladderpod, Brassicaceae) 33 taxa (24 full species, 9 vars). Diversity has been enhanced by including the genus *Lesquerella*.
15. *Arabis* (rock cress, Brassicaceae) 32 taxa (24 full species, 8 vars). All but two UT *Arabis* have been transferred to the genus *Boechea* according to the FNA treatment and research by Mike Windham, Loreen Allphin, and their associates. Diversity in this group has been enhanced by rampant hybridization and polyploidy.
16. *Lepidium* (pepperwort, Brassicaceae) 32 taxa (20 full species, 12 vars). Richness increases by 3 if *Cardaria* is transferred to *Lepidium*. FNA did not recognize the many varieties of *L. montanum*.
17. *Lupinus* (lupine, Fabaceae) 32 taxa (14 full species, 18 vars). A notoriously complex genus with the unusual distinction of having more named varieties than species.
18. *Cirsium* (thistle, Asteraceae) 31 taxa (23 full species, 8 vars). Although *C. arvense* and *C. vulgare* are introduced, the remaining species are all native, and several are rare.
19. *Chrysothamnus* (rabbitbrush, Asteraceae) 31 taxa (10 full species, 21 vars) Recently 21 taxa have been split out as part of the genus *Ericameria*, which also includes many species formerly in *Haplopappus*. *Haplopappus* itself, formerly with 30 species, has been completely eliminated, with its species being sent to 6 other genera.
20. *Salix* (willows, Salicaceae) 30 taxa (27 full species, 3 vars or hybrids).

of the keel petal, fruit, and stipules. Yet there are only 300 species of *Oxytropis* worldwide (nothing to sneeze at, but less than 1/10 the number of Astragali) and only 25 or so in western North America (10 species and 5 varieties in Utah). Why is *Astragalus* so much more diverse than *Oxytropis* (at least in North America) when they seem to have so much in common in appearance and habitat?

One explanation is that some groups are evolving and speciating much more rapidly than others. Much of the diversity in *Astragalus* comes from species or varieties that have become specialized on unusual geologic formations or soil types, especially ones with peculiar soil chemistry. Over-specialization can allow populations to persist in areas where their nearest relatives cannot, and over time results in populations becoming geographically and reproductively isolated. By comparison, most North American species of *Oxytropis* are wide-ranging habitat generalists and not adapted to unusual soil conditions, thus presenting fewer opportunities for speciation.

High species richness in *Penstemon*, another megagenus in western North America with about 270 species, has been facilitated by co-adaptation with specific pollinators. Bee-pollinated penstemons typically have blue flowers that vary in corolla width and positioning of the anthers depending on the body size of its pollinator. Bees often have limited foraging ranges (especially compared to birds), and so bee-serviced beard-tongues tend to show greater genetic diversity between populations than red-flowered hummingbird-pollinated species. If these genetically distinct local populations become isolated from other populations they can begin to diverge in morphologic and ecologic traits, eventually becoming distinct varieties or full species.

Hybridization can result in new species if the hybrid event is coupled with a doubling of the chromosome number so that the resulting plants are fertile. In nature, hybridization is fairly rare, as most species have various chemical, morphological, or phenotypic barriers to prevent pollination with the wrong type of pollen, but mistakes can happen. In the megagenus *Boechea* (rockcress, recently split from *Arabis*), diploid species are fairly distinct and recognizable, but few barriers exist to prevent hybridization and the resulting hybrid plants are often able to survive and persist through asexual reproduction (apomixis) until chance chromosome doubling events occur that make them fertile and full-functioning species. This odd reproductive strategy accounts for the bewildering array of rockcress taxa that are intermediate between their parent species and which have increasingly high polyploid chromosome numbers. Other complex genera with large numbers of cryptic species derived from hybridization, apomixis,

and polyploidy include *Potentilla* (cinquefoil), *Draba* (draba), and *Ranunculus* (buttercup).

Some taxonomists have argued that large genera are an abstraction created by their overzealous colleagues naming too many species or varieties on the basis of trivial differences. Others have suggested that big genera become a dumping ground for species that are not easily placed elsewhere, or which have not been sufficiently studied. Several studies have shown that large genera tend to become smaller over time as they are better studied and natural subgroups are recognized and elevated to the status of their own genus. Indeed many of world's 57 megagenera are tropical groups that are much less understood than temperate zone genera.

Historically, taxonomists relied on differences in physical traits (especially flowers and fruits) to infer relationships among species and genera. Today this is augmented by data from cell structure, anatomy, genetics, breeding experiments, and the fossil record. Most importantly, taxonomists are collaborating more across states and continents to assess genera too large and complicated for any one person to understand. The results have been interesting and sometimes unpredictable. New data sets have ripped apart some formerly mega-diverse genera, resulting in the recognition of many smaller, but more natural groups. One such case is the genus *Eupatorium* (thoroughworts, Asteraceae), once thought to contain 800 species worldwide, but now split into more than a dozen genera, of which just 40 or so remain as true *Eupatorium*. But these new datasets also have reinforced the treatment of other large genera, and even justified re-constituting some mega-groups. Despite the best efforts of generations of splitters to break up *Astragalus*, molecular evidence supports its recognition in the usual, broad sense. Even Linnaeus's decision to lump *Euphorbia* is verified by recent phylogenetic studies showing *Chamaesyce* and other segregate genera to be nested within *Euphorbia*.

If taxonomy teaches us nothing else, we should recognize that our current concepts of genera will change as new data accumulate and different analytical tools are applied. The lumper/splitter debate isn't likely to be resolved either. Big genera will continue to exist because they help us make sense of the diversity of the plant kingdom.

#### References

- Frodin, D.G. 2004. History and concepts of big plant genera. *Taxon* 53(3):753-776.  
 Govaerts, R. 1995. World Checklist of Seed Plants. Vol. 1. MIM, Continental Publishing, Antwerp.

Above: *Penstemon subglaber* from Mt. Nebo. By Steve Hegji.





## Whites in the Minority: Albino Flowers

By Peter Lesica, from *Kelseya*, newsletter of the Montana Native Plant Society, Fall 2015



Seems like almost every year someone I know will excitedly tell me that they saw a white shooting star or a white lupine. Of course I'm too jaded to get as excited as they are, but the occurrence of albino flowers does raise some interesting questions. Why is it that albino morphs usually occur in blue- or pink- or red-flowered species but rarely occur in yellow-flowered plants? And why is it that for some species the white-flowered forms are always rare, but in other cases they can become quite common or even dominant? The answer to the first question is pretty straightforward but not so for the second one.

The blue, red, pink or purple color of flowers is the result of pigments called anthocyanins which are manufactured by plants from flavonoids. When one of the genes that contributes to the production of these anthocyanins becomes mutated, the flowers are white instead of colored. Sometimes the occurrence of white-flowered forms relates to pollination. In this case, white- or blue/red-colored flowers dominate in different populations. For example, Rocky Mountain columbine (*Aquilegia coerulea*) is commonly blue in the central Rocky Mountains where it is most often visited by bumblebees. However, white-flowered forms, like those found in Montana, are

*Above: White and normal pink-flowered forms of Shooting-star (Dodecatheon conjugens) can occur in the same population. Photo by Peter Lesica.*

thought to be pollinated more by hawk moths which are attracted to the lighter-colored flowers. Mathew Streisfeld and collaborators studied the red and whitish forms of orange monkey-flower (*Mimulus aurantiacus*) in California. They found that a single gene was responsible for the difference in flower color, and that the two forms had different pollinators. They suggest that the two forms are on their way to becoming two different species because interbreeding is unlikely when different insects are attracted to the different forms.

Pollinator preference is not always the explanation when different flower colors are both common. Sandblossoms (*Linanthus parryae*) is an annual of the Mojave Desert with blue and white color forms. Some locations have a preponderance of white-flowered forms, but just a little ways away the blue-flowered form predominates. Doug Schemske and Paulette Bierzychudek examined one such site and found strong evidence that different plant communities with different soils supported different color forms in spite of the fact that they were in close spatial



proximity. They were unable to pinpoint the exact mechanism, but it must have been some trait(s) that was connected to flower color rather than the flower color itself.

Missoula phlox (*Phlox kelseyi* var. *missoulensis*) occurs on the hills immediately north of Missoula. Plants with deep blue or white or intermediate flowers occur together. It was assumed that flower color affected pollination, but Lisa Campbell, a graduate student at the University of Montana, spent many hours observing all the different color forms and found that the same insects in equal numbers visited all the forms, and there was no difference in seed set. In this case it appears that flower color has little bearing on survival or reproductive success, just like eye color in humans.

White and colored flowers may both be common in some species, but more often than not albino forms are rare throughout a plant's range. So what's with that? People often assume that albinos are rare because they lose their pollinators. For example, a common species of larkspur (*Delphinium nelsonii*) is ordinarily blue, but rare white-flowered plants occur near Rocky Mountain Biological Lab in Colorado. Experiments conducted by Nick Waser and Mary Price showed that white-flowered plants produced very few seeds because the primary pollinators, hummingbirds and bumblebees, discriminated against them.

However, pollination is often not involved in albino rarity because anthocyanins do more than just color the flowers. They occur throughout plant tissue and have been shown to protect the leaves and stems from damage by too much solar radiation. Anthocyanins and especially their flavonoid precursors also help protect plants against diseases and insect pests. So anthocyanins and the genetic machinery that make them have a number of functions besides just coloring the flowers and helping attract pollinators, although this is probably what is most noticeable to us. This situation, when a single gene or gene complex influences more than one trait, is called pleiotropy, and it is the overarching reason that albino plants are rare in most populations, although the details vary among species.

Drummond's phlox (*Phlox drummondii*) is a pink- or red-flowered species endemic to Texas with rare white-flowered forms occurring sporadically. Donald Levin and his collaborators found that albino plants were visited as often by their insect pollinators as were their pink- or red-flowered neighbors. However, white-flowered

plants produced fewer flowers and had much lower survivorship, and the researchers found that the loss of the gene that produced pink or red flowers also made the plants less able to cope with dry conditions that can be common in Texas.

Northern wallflower (*Parrya nudicaulis*) is a mustard that is common in Alaska. The flowers are usually purple. White-flowered plants do occur, but they are more common in the southern part of the state and virtually non-existent in the north. Researchers found that the same biochemical pathway that produces the purple pigment also enhances cold tolerance. For this reason white-flowered plants can persist in the warmer parts of the state (if any parts can said to be warm), but do not occur where it is colder.

John Warren and Sally Mackenzie studied five species of British plants that have both bluish and whitish color forms. They found that blue-flowered plants performed better under drought-induced stressful conditions. They surmised that the flavonoids and anthocyanins, which are anti-oxidants and were lower in white-flowered plants, helped the blue-flowered plants overcome stress.

It's a complex world out there. That little albino flower you found could be suffering from lack of pollination or cold or drought or some disease. Perhaps you should take your little white buddy to the natural food store nearest you and get her some anti-oxidants. She'll thank you for it.

#### Further reading

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Miller, R. B. 1981. Hawkmoths and the geographic patterns of floral variation in *Aquilegia caerulea*. *Evolution* 35: 763-774.

Schemske, D. W. and P. Bierzychudek. 2007. Spatial differentiation for flower color in the desert annual *Linanthus parryae*: was Wright right? *Evolution* 61: 2528-2543.

Streisfeld, M. A., W. N. Young and J. M. Sobel. 2013. Divergent selection drives genetic differentiation in an R2R3-MYB transcription factor that contributes to incipient speciation in *Mimulus aurantiacus*. *PLoS One* 9 e1003385.

Warren, J. and S. Mackenzie. 2001. Why are all colour combinations not equally represented as flower-colour polymorphisms? *New Phytologist* 151: 237-241.

Waser, N. M. and M. V. Price. 1981. Pollinator choice and stabilizing selection for flower color in *Delphinium nelsonii*. *Evolution* 35: 376-390.

Botanist's Bookshelf:

## New Guides to the Flora of Colorado and Cacti and Succulents

**Flora of Colorado.** 2015. Jennifer Ackerfield. Botanical Research Institute of Texas Press, Fort Worth, TX. 818 pp.

Edwin James was one of the first botanists to explore Colorado. In 1820, he was part of a small party that made the first recorded ascent of Pike's Peak. James was delighted by the beauty of the alpine but lamented "we met, as we proceeded, such numbers of unknown and interesting plants, as to occasion much delay in collecting, and were under the disagreeable necessity of passing by numbers which we saw in situations of access" (Williams 2003). Many notable botanists have been drawn to the mountains, plains, and high deserts of Colorado ever since, including Asa Gray, John Torrey, George Engelmann, Charles Parry, Alice Eastwood, Joseph D. Hooker, Per Axel Rydberg, and others of more fleeting fame. Not surprisingly, Colorado has a rich and well-documented flora, ranking at least 14<sup>th</sup> among the fifty United States in vascular plant species richness (Stein 2002).

Starting with Porter and Coulter's *A Synopsis of the Flora of Colorado* in 1874, each generation of Colorado botanists has produced a new flora of the state. The latest is Jennifer Ackerfield, collections manager of the Colorado State University Herbarium in Fort Collins, Colorado. Ackerfield's new *Flora of Colorado* is the first to cover the entire state in one volume and to include species descriptions since H.D. Harrington's 1954 *Manual of the Plants of Colorado*. Botanists and plant enthusiasts interested in Colorado now have two current floras available, with the *Flora of Colorado* coming just three years after the fourth edition of Weber and Wittmann's two-volume *Colorado Flora* in 2012. Despite their similar subject matter, the two floras differ in their taxonomic philosophy, nomenclature, and depth.

Ackerfield's *Flora of Colorado* is a heftier volume than either of Weber and Wittmann's floras, but will still fit in a knapsack (if not in one's back pocket). Part of the reason for its larger size is that *Flora of Colorado* covers more taxa: 3322 full species, varieties, and subspecies, compared to 2100-2300 for the western and eastern slope floras of

Weber and Wittmann, respectively. Ackerfield's flora also includes concise descriptions of each species to supplement information in the family and genus keys, as well as a sentence on relative abundance, general habitat, and elevation range. Most species accounts include a thumbnail map of Colorado with county-level distribution indicated by gray shading. By comparison, Weber and Wittmann's *Colorado Flora* consists only of keys, although some additional information is provided on county distribution, habitat, taxonomic problems, or other information. There are no range maps or formal descriptions of individual taxa.

The two floras differ in their treatment of several plant families. Ackerfield primarily follows the recent classification of the Angiosperm Phylogeny Group (APGIII 2009) and the *Jepson Manual* of the flora of California (Baldwin et al. 2012). Among the traditional families affected by these changes are the Scrophulariaceae (parsed into four redefined families), Aceraceae, Adoxaceae, Asclepiadaceae, Callitrichaceae, Cuscutaceae, Lemnaceae, Portulacaceae, and Sparganiaceae. In contrast, Weber and Wittmann retain all of these families in their conventional sense and make some additional splits that are not widely followed in other North American floras. These include segregation of the Boraginaceae, Caryophyllaceae, Dryopteridaceae, Ericaceae, Liliaceae, Orchidaceae, Pteridaceae, and Ranunculaceae into one or more segregate families. Both floras diverge from APG III in keeping Hydrophyllaceae separate from Boraginaceae, and in not revising Agavaceae, Alliaceae, Chenopodiaceae, Fumariaceae, Parnassiaceae, Valerianaceae, Viscaceae, and several other small groups.

Ackerfield's flora differs from Weber and Wittmann in the treatment of many genera, although given Weber's reputation as a taxonomic splitter there are fewer areas of disagreement than one might suspect. Many of the generic splits accepted by Weber from Rafinesque, Greene, Rydberg, and other 19<sup>th</sup> Century taxonomists have been recently adopted by the Flora of North America project based on molecular research. Ackerfield accepts most of the FNA revisions, with the exception of some changes in Rosaceae published in 2014 (perhaps after her manuscript was submitted). Some notable



differences in genus concepts remain, however, especially in Weber and Wittmann's recognition of numerous segregate genera in *Anemone*, *Artemisia*, *Bromus*, *Cornus*, *Crepis*, *Euphorbia*, *Gentiana*, *Geum*, *Hymenoxys*, *Linum*, *Mentzelia*, *Ranunculus*, *Rubus*, *Saxifraga*, *Silene*, and *Symphyotrichum* that are not adopted by Ackerfield. Ironically, Weber's taxonomy is actually more conservative than current conventions for some genera, such as *Camissonia*, *Conyza*, *Gilia*, *Leptodactylon*, *Linanthus*, *Machaeranthera*, and *Oenothera*.

The taxonomic keys in Ackerfield's flora often emphasize different characters than those used by Weber and Wittmann. This can be advantageous for those field or armchair botanists who would like a second opinion for a particularly onerous genus or family. In an unscientific and non-random comparison of certain genera, I found I preferred Ackerfield's key to *Carex*, but Weber and Wittmann's key to *Erigeron* (both keys to *Cirsium* were comparable).

Perhaps the biggest difference between the two Colorado floras is in the supplemental text and illustrations associated with each family, genus, and species. Ackerfield's book is nearly devoid of line drawings outside of the illustrated glossary, but includes over 900 color photographs of selected taxa. Rather than just depicting showy species, Ackerfield has carefully selected photos that illustrate important but often cryptic morphological features of critical importance in successful keying. Many of the photos therefore are close-ups of *Carex* perigynia, *Phacelia* seeds, grass florets, fern sori, mustard fruits, or similar morphological characters. Weber and Wittmann's most recent edition no longer has color plates but continues to use line drawings to illustrate representative examples of each family and genus. These drawings vary in quality from excellent to murky and indecipherable. Although I ordinarily prefer line drawings to photos in floras, Ackerfield's photographs are often superior in illustrating important taxonomic features.

Choosing between these two books is difficult, because each has its own merits, and the treatments are largely complementary. Users who desire a treatment employing the most contemporary species names and family concepts, species descriptions, and range maps, will probably prefer Ackerfield's new *Flora of Colorado*. Those with a higher tolerance of synonymy and who can forgo the convenience of a single volume, species descriptions, and maps, and who actually like to read floras for their entertainment value, might choose

Weber and Wittmann's *Colorado Flora* series. As for me, I will be using and enjoying both sets of books. - *W. Fertig*

## References

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***Field Guide to Cacti and other Succulents of Arizona***. By Peter Breslin, Rob Romero, Greg Star, and Vonn Watkins, with Doug Dawson, Matt Johnson, A. Dean Stock, and David Yetman. 2015. Tucson Cactus and Succulent Society, Tucson, AZ. 302 pp. \$25.95.

Arizona's nickname is the Grand Canyon State, but for botanists it should be called the Cactus State. No other U.S. state can match Arizona for its diversity of cacti and succulents.

*Field Guide to Cacti and other Succulents of Arizona* is an homage to the state's spiny citizens. Each species is illustrated by beautiful color photographs of its growth form, flowers, and typical habitat. Species descriptions avoid technical jargon and are intended for a lay audience. Detailed range maps are provided too, though just for Arizona. Although the main focus are species in the Cactaceae, the book also addresses other succulents, such as *Yucca*, *Agave*, and their relatives.

Utah readers will find the vast majority of their species covered in the field guide, though not the narrow endemics of the Uinta Basin or Colorado Plateau. Many names are different from those used in Welsh's *Utah Flora*. The guide also does not have a key for those who find them helpful for highlighting the main differences among species. Nonetheless, this book should be useful to most cactophiles in the southwest and also serve as an enticement to visit Arizona and see its cacti in person. - *W. Fertig*

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