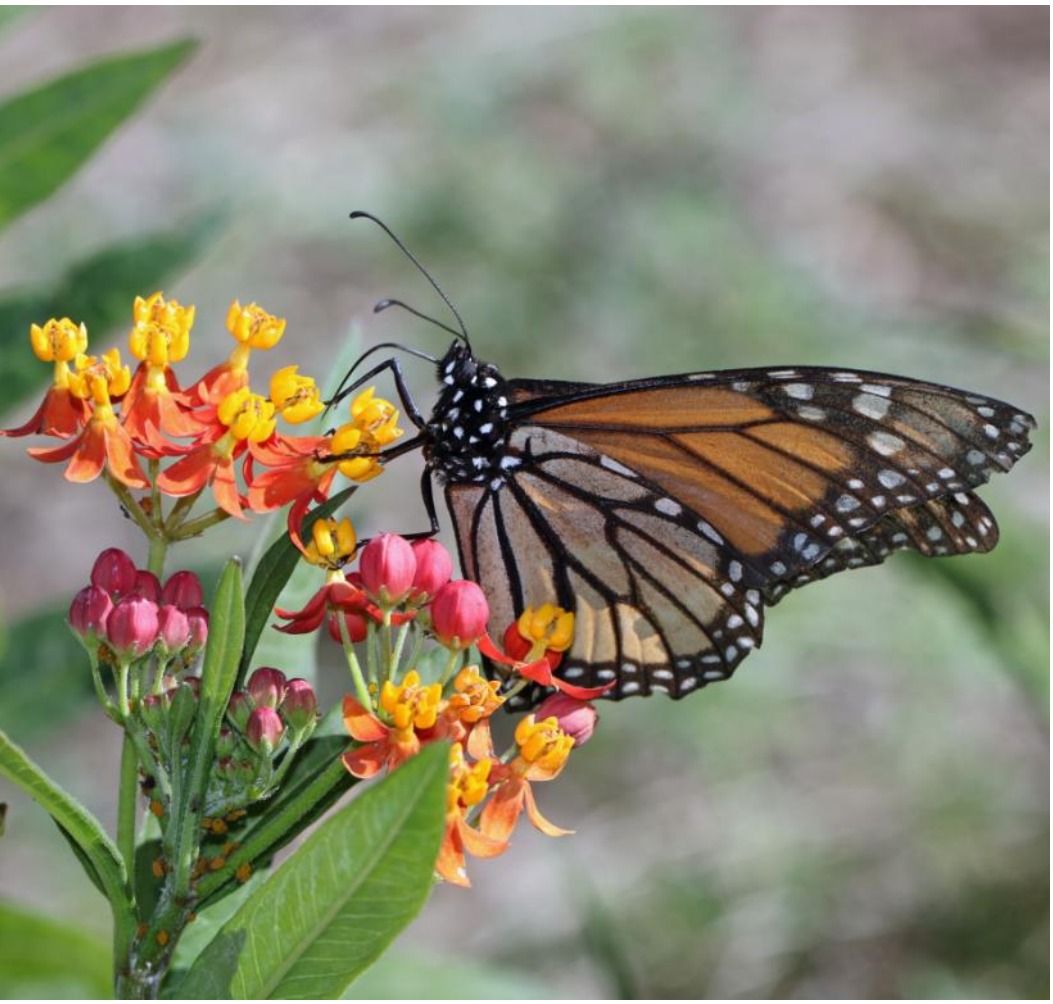
Sego Lily
Newsletter of the Utah Native Plant Society



November 2014-
January 2015
(volume 37 number 5)

In this issue:

Monarch butterflies (*Danaus plexippus*) migrate 1200-2800 miles or more from their summer habitat in the United States and Canada to wintering grounds in the mountains of central Mexico or along the coast of California. Monarch numbers are in a steep decline due to deforestation and habitat loss in their winter range and loss of native vegetation across much of the United States. Increased corn prices have prompted US farmers to till formerly fallow land and to increase the use of herbicides that target milkweeds (*Asclepias* sp.) and other wildflowers necessary for feeding monarch caterpillars. A recent study documented a 58% decrease in the abundance of milkweeds in the American Midwest since 1999, resulting in a 81% decline in monarch butterfly egg production. The abrupt decrease in monarchs has prompted some conservation groups to seek legal protection for the iconic butterfly. To learn more about monarch butterflies, their migration, and native plants that can be cultivated to encourage their survival, see the articles by Ty Harrison and Bill Gray starting on page 5. Photo of a monarch butterfly on Tropics milkweed (*Asclepias curassavica*) by Elizabeth Makings, taken at Boyce Thompson Arboretum, east of Phoenix, Arizona.

Utah Native Plant Society

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. **Many thanks to Xmission for sponsoring our website.**

Sego Lily Editor: Walter Fertig (waltola64@gmail.com). The deadline for the February 2015 *Sego Lily* is 25 January 2015.

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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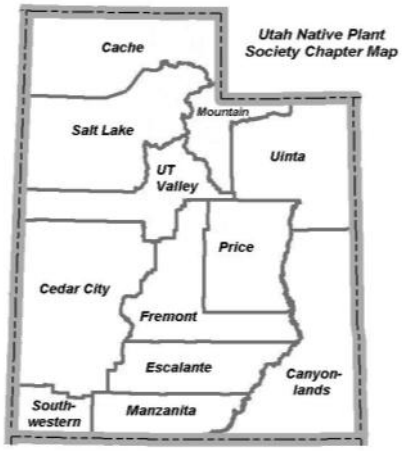


Utah Native Plant Society Chapters

Unidentified Flowering Object

This month's UFO looks like a fruit, and in some ways is analogous to one, but technically is not. The plant is a ubiquitous shrub found across most of Utah. But can you guess what the fuzzy structures are?

The August Unidentified Flowering Object was *Erigeron linearis* in the Aster family (Asteraceae or Compositae) submitted by Julie Kraft of Pinedale, Wyoming. *E. linearis* is unusual, though not unique, in having yellow ray flowers, whereas most *Erigeron* species are white, blue, or purple-flowered.

Have a UFO to share? Send it in! - *W. Fertig*

Bulletin Board

Salt Lake Chapter Meetings: All meetings at 7PM at REI, 3300 South and 3300 East, SLC.

Wednesday, December 3, 2014: Potpourri Night. Members are invited to make a 3-5 minute presentation on their favorite native plant(s) accompanied by photos.

Wednesday, January 7, 2015: Utah Master Naturalist Program. It is a rare person who loves plants who does not also love just about every other aspect of the natural world. Most of us pick up a smattering of bird and insect knowledge as we go along. Come learn about a program that focuses on a more systematic approach to putting us in touch with the whole picture. The Utah Master Naturalist program is part of the mission of the USU Extension Service. Mark Larese-Casanova, the coordinator, will introduce us to the program's goals and the possibilities for taking part in its activities.

Wednesday, February 4, 2015: Tentatively planned is for Bill Gray to talk about his recent Madagascar trip. Isolated from the rest of the world for about 80 million years, this very large island (about the size of California and Oregon combined) is home to an amazing array of plants and animals.

2015 Utah Rare Plant Meeting, March 10, 2015: The annual Utah Rare Plant meeting, hosted by the Utah Native Plant Society and Red Butte Garden, will take place on Tuesday, March 10, 2015. To accommodate a larger group, the meeting will be moving from its usual home at Red Butte Garden to the Swaner Room in the Natural History Museum of Utah in the Rio Tinto Center (next door at xxx Wakara Way, Salt Lake City). For more information on registering for the meeting (a nominal fee is charged to cover refreshments and lunch) or to submit an abstract for a presentation, consult the Red Butte Garden website or contact Jason Alexander, chair of the UNPS Rare Plant Committee.

Department of Corrections: In my haste to get the August issue out before the end of September, I neglected to proof the cover caption and inadvertently left off the URL link to Al Schneider's SW Colorado Wildflowers website: http://www.swcoloradowildflowers.com. - W. Fertig

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

In Quotes: "That other eyes fail to see what he sees; that even from similar observations different judgments are formed and different conclusions drawn are not to him of such serious moment that each may not go on with friendship for the other, each cultivating his own wee bit of the ever-widening field. To live honestly with nature, to deal justly with your fellow worker, to love mercy is a creed to which we can all subscribe. … Differ as we may as to what constitutes a species, the object of us all is to know plants and to help others know them. To know and to use plants that they may contribute to our wealth is well; to know them that they may contribute to the health and pleasure of body and mind is better; to know them that we may read a few of God's thoughts after Him and thus enrich our souls is best." - Aven Nelson, pioneer western botanist from the University of Wyoming, toasting E.L. Greene on the occasion of Greene's 70th birthday at a meeting of the Botanical Society of Washington in 1913. Greene was a taxonomist of the late 19th and early 20th centuries with a keen eye for novel species (at least in the early and middle portions of his long career), but who ran afoul of his contemporaries and competitors, such as Utah's own Marcus E. Jones. Nelson was attempting to bridge the divided among his peers regarding taxonomic philosophies by reminding us all of why we study and love botany. (Photo of Police-car moth, *Gnoophaela vermiculata*, on Joe Pye weed (*Eupatorium maculatum*, by Blake Wellard)

Highlights of the UNPS Annual Members Meeting

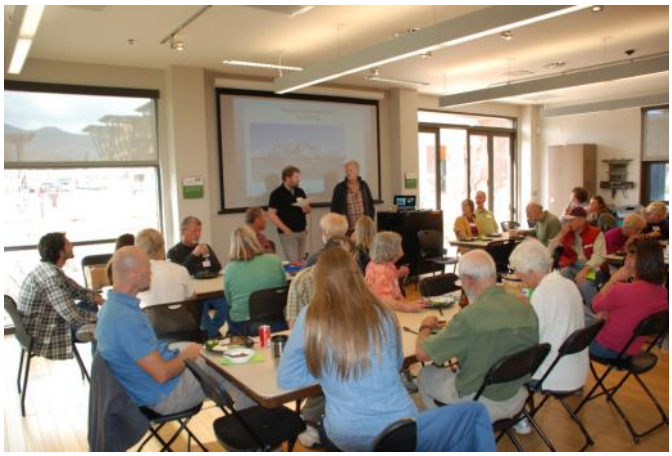
By Elise Erler, Salt Lake Chapter President

The Salt Lake chapter hosted the annual Utah Native Plant Society members meeting on Saturday, October 25th, at Swaner Nature Preserve and Ecocenter in Park City. Swaner is part of Utah State University and managed by the USU Extension Service. Thirty people attended the potluck feast with a New World cuisine theme. Bill King and Jason Alexander conducted a brief business meeting that elected a new UNPS board. Then, the artist-creator of the UNPS Utah wildflower posters, Dave Gardner, introduced Swaner's herbarium, which he created.

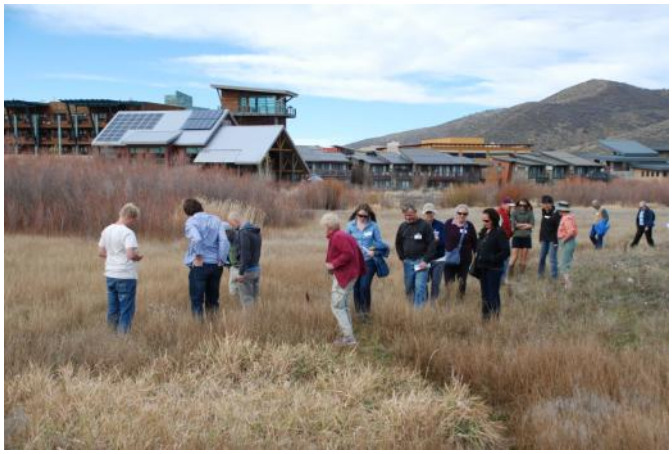
The group took a break for a field trip into Swaner's meadow using the comprehensive plant list prepared by Gardner and Abby Moore. A Swaner volunteer took us into non-public parts of the meadow to see late-autumn plants and discuss Swaner's invasive-weed challenge encountered during meadow-wetlands restoration.

Following the field trip, the group assembled in the meeting room to hear talks by Tony Frates and Blake Wellard on their collaborative efforts with Ty Harrison and Salt Lake County to protect and restore small relict wetlands along the Wasatch Front. The meeting concluded with Tony Frates, co-chair of the Conservation committee, giving an update on the tortuous wranglings to try and protect the Uinta Basin's endemic Graham's and White River penstemons.

Mindy Wheeler arranged for the meeting location at Swaner and the turkey, Elise Erler provided the paper products for the meal and Bill Gray provided the technology for the presentations. Ample food was prepared by the attendees. The weather held and everyone enjoyed a beautiful Autumn afternoon at Swaner's meadow-side location.



Scenes from the annual meeting: Top: Swaner Nature Preserve; Above: UNPS President Jason Alexander (standing left) and Board Chair Bill King (standing right) address the throng; Bottom: Fall botanizing at the Swaner Preserve. Photos by Kipp Lee.



Utah's Monarch Butterflies and Their Plants

By Dr. Ty Harrison, Emeritus Professor of Biology, Westminster College

Many of us have been reading about the recent collapse of the Monarch Butterfly migration in North America and would like to do something to help out this once-abundant butterfly. I vividly remember my second grade teacher, Mrs. Peterson, taking us on a fall walking fieldtrip from our rural elementary school in Crescent, 11 miles south of Salt Lake City. This was over 60 years ago. While wandering down the narrow gravel road behind our school, we found the white, yellow and black striped Monarch caterpillars eating the Showy milkweed leaves. Mrs. Peterson helped us to carefully take both the caterpillar and milkweed back to the classroom to observe the marvelous metamorphosis for which this creature is famous. I remember drawing with crayons on manila paper the life cycle of the Monarch: the milkweed, the caterpillar, the spectacular emerald-green pupae with shiny gold spots, and finally the beautiful orange and gold winged adult which emerged from the pupal case before our very eyes. The drawing even had arrows in a circle showing the life stages. After the Monarch's wings expanded, we let it go out of the unscreened, classroom window, not knowing its fate.

It wasn't until last year that I learned that these September-emerging Monarchs are informally termed "super butterflies". They are the final generation of Monarchs which have hopped, skipped and jumped, from milkweed to milkweed from Coastal California, across the Great Basin, to here along the Wasatch Front. The September butterfly finds a milkweed plant on which to lay its eggs and the hatched caterpillar eats voraciously, storing up energy for the winged adult's, non-stop flight back across the Great Basin or on to Mexico via Arizona (Pyle 2014). Very little is understood about the exact route of these fall-migrating super Monarchs. This past October I saw several heading south looking for flowers and nectar to fuel their long-distance migration. We need a marked butterfly release to see where these super butterflies go when they leave the Wasatch Front.

Over the last several years Blake Wellard, Tony Frates and I have been examining relict areas of wetland vegetation along the Wasatch Front which have several milkweed species as well as other late-summer, or early-fall flowering plants which provide nectar for fall-migrating Monarchs as well as other native insect pollinators. We think that many of these native wetland species could be cultivated in urban yards, replacing useless irrigated bluegrass. The Salt Lake Chapter of UNPS has been given permission by Salt Lake City's new open space program to create a small, 100 square foot native tall meadow flower demonstration planting at the 900 South Oxbow Wetland Restoration Area on the west bank of the Jordan River near the intersection of the Jordan River Parkway Trail and the Nine-line paved trails. This web site describes this $300,000 restoration project: http://www.slcgov.com/oxbow.

*Above: Monarch butterfly on Joe Pye weed (*Eupatorium maculatum*). Photo by Blake Wellard.*

The public education potential for this site is remarkable. It is also across the river from the newly planted filtration wetland created by Salt Lake City Public Works and the adjacent Jordan River Peace Gardens.

Our proposed " Utah Native Tall Forb Garden" will be planted in the spring or fall of 2015. The garden will contain many of the following species: Joe Pye weed (*Eupatorium maculatum),* Nuttall sunflower (*Helianthus nuttallii*), Blue vervain (*Verbena hastata*), Tall goldenrod (*Solidago gigantea*), Autumn sneezeweed (*Helenium autumnale*), Missouri iris (*Iris missouriensis),* Water groundsel (*Senecio hydrophyllus),* Hooker's evening-primrose (*Oenothera elata*), Swamp milkweed (*Asclepias incarnata*), Beggar ticks (*Bidens frondosa*), Western goldenrod (*Euthamia occidentalis*), Marsh aster (*Symphyotrichum lanceolatum* var. *hesperium*), Showy milkweed (*Asclepias speciosa*) and Annual paint-

brush (*Castilleja exilis*). All of these species have been recently observed in Wasatch foothill spring-fed wetlands. It is not clear which species can tolerate the more alkaline soils of the Jordan River. Many of the species are not commercially available as Utah local genotypes, but we are hoping that local commercial nurseries can be encouraged to provide them in the future. In the mean time, UNPS members might be interested in growing many of these themselves. Most are easy to propagate from seed once a local seed source is found. Finding these plants is the hard part. Some of these species are fairly rare while others are abundant in what few wetlands have managed to survive grazing animals, mosquito abatement drainage projects and developers. I suspect that undisturbed wetlands may be one of the rarest habitats here in northern Utah. The presence of the attractive, pink Joe Pye weed with its 6 foot tall flower clusters, the skinny Blue vervain and yellow Autumn sneezeweed here in their Wasatch wetland habitat is very interesting since they are more typically found in the wetlands of the midwest and are disjunct here.

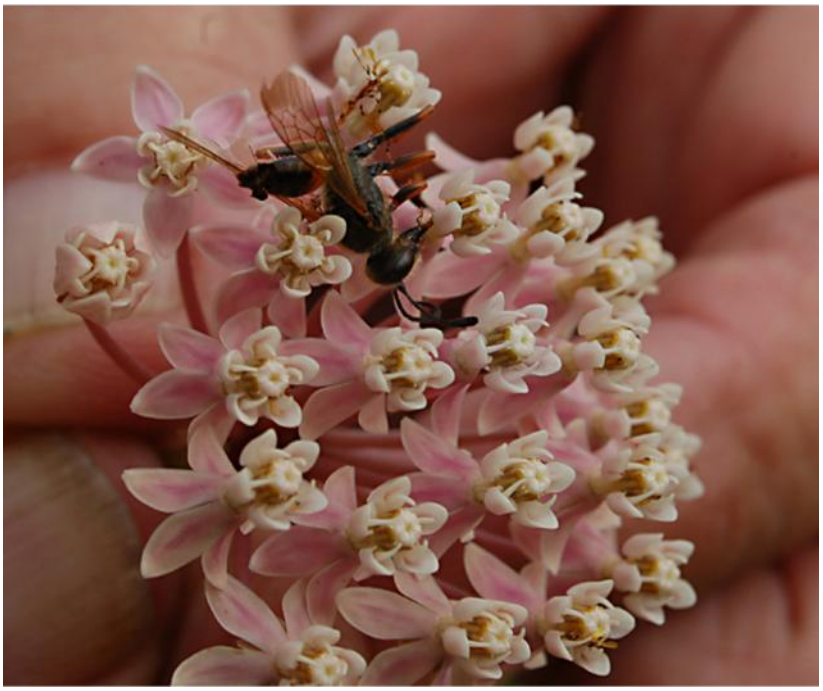
Nearly all of these tall, wetland forbs flower in the late summer and fall and provide nectar for migrating "super monarchs" headed for coastal California. A variety of other native insects benefit from the nectar and pollen prior to their winter dormancy.

*Above: Monarch butterfly on Showy milkweed (*Asclepias speciosa*) in Big Cottonwood Regional Park, Salt Lake City. Photo by Tony Frates.*

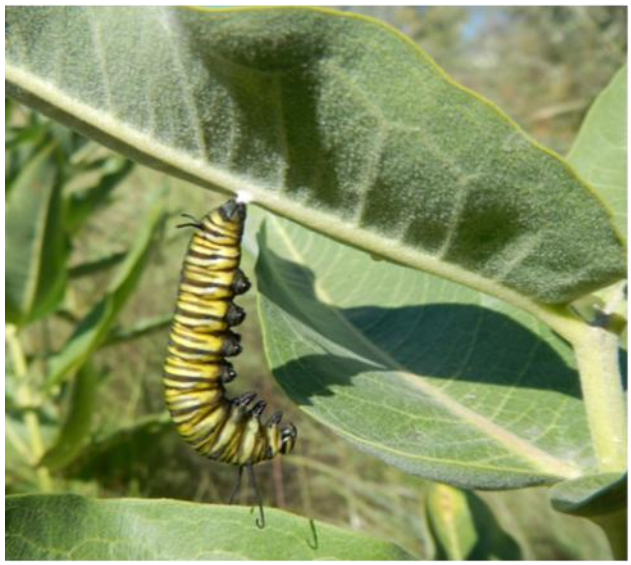
It is important that milkweeds native to Utah are used in our residential and commercial landscapes as well as in Utah-based restoration projects. As discussed in a recent New York Times article "For the Monarch Butterfly, a Long Road Back?" by Liza Gross, Nov. 17, 2014, The New York Times, http://www.nytimes.com/2014/11/18/science/monarchs-may-be-loved-to-death.html), Monarchs may become confused by the tropical milkweed species which may cause them to stop migrating in the fall. If you currently have tropical milkweed plantings and do not want to remove them, the article recommends that you at least cut them back in the fall to make them less of a distraction to migrating Monarchs.

Utah has some 16 native species of *Asclepias* , the milkweed genus, which includes rare and even endangered species such as the federally listed Welsh's milkweed (*Asclepias welshii*). Gardeners in the southern half of the state have many more to choose from than those of us living in the north, even after excluding the rare species. The very beautiful Orange or Butterfly milkweed (*A. tuberosa*) is a plant very much worthy of consideration.

Utah native milkweed species are available for both wet and dry places. Along the Wasatch Front, there are primarily three native species that should be encouraged (and these are also for the most part widely distributed throughout the state making them potential candidates for use in other places in Utah as well). Marsh Milkweed (*Asclepias incarnata*) is fast disappearing along with the kind of habitats that support it and needs to be used much more widely in restoration projects and in backyard habits. It requires full sun in an area that is moist and that does not usually dry out. Homeowners often have habitat like this, i.e. native plants like Marsh milkweed should not be shunned simply because they do not fall into the category of plants appropriate for xeriscapes.



A plant that can survive in both semi-wet meadows and semi-dry environments is Showy Milkweed (*Asclepias speciosa*). This is the plant that most people associate with milkweeds since it often shows up along roadsides and around telephone poles or anywhere that there may be a slight increase in concentrated moisture. Probably many also consider it to be an undesirable weed (it is native), but it has many potential uses in residential or commercial naturescapes and should be encouraged whenever possible. For those that want to attract Monarchs along the Wasatch Front (and elsewhere in Utah) but are looking for a plant that is suited for a xeriscape or dry meadow, Spider Milkweed (*Asclepias asperula*) is a wonderful potential addition that will add great interest to any dry Utah garden setting for much of the year. All three of these species are herbaceous perennials and can easily be grown from seed (these plants should not be dug up and transplanted). All prefer open sun, although Spider milkweed can tolerate some amount of shade.



There is ample opportunity in our urban yards to use our local milkweed species as well as other native plants which can to be grown with the milkweeds to provide adult Monarchs with sources of nectar throughout their migrating cycle. Government agencies and individuals/businesses alike should use only local species and genotypes in their restoration projects. Projects that involve the removal of Russian Olive and replacement with native trees, shrubs and forbs will also benefit Monarchs and all local wildlife diversity.

If we in UNPS are serious about helping the Monarch, we need to be growing native milkweeds in both our yards and in wetland restoration areas along Utah's rivers and streams. Showy Milkweeds and Swamp Milkweeds are easy to grow from seed. They grow along ditch banks and field edges which have not been sprayed with herbicides. A plant has been growing in my back yard for 25 years. Butterfly organizations are encouraging all of us to grow milkweeds to compensate for the broad scale use of industrial agricultural herbicides. We all need to be doing our part. Find a patch of Showy or Swamp Milkweed , collect the seed in October, dig up a patch of irrigated bluegrass and start growing milkweeds together with some of our other tall, beautiful native marsh wildflowers and grasses.

References:

Pyle, R.M. 2014. Chasing Monarchs: Migrating with the Butterflies of Passage. Yale University Press.

Credits: Special thanks to Tony Frates for manuscript additions and Blake Wellard for photos

*Top: Showy milkweed (*Asclepias speciosa*): Bees get their legs caught in the slits of the milkweed flower while gathering nectar and can die. Above: A Monarch butterfly caterpillar beginning pupation on a Showy milkweed, Jordan River, 20 September 2013. Photos by Ty Harrison.*

What's Behind Monarch Migration?

By Bill Gray

Most people nowadays are familiar with the idea of using DNA to study evolution, especially tracking relationships among organisms. For example, a 2013 study examined parts of 5 genes in nearly 200 *Euphorbia* species to deduce a relatively detailed tree of this very diverse group of plants[1]. In just the past few years new sequencing methods have gone way beyond this, providing vast amounts of data at greatly reduced cost. About a year ago researchers deduced the complete genome of a Neanderthal woman – from a 50,000 year old fossil toe bone[2]! Evolution of the Hawaiian honeycreeper birds has now been analyzed in exquisite detail[3].

This past October an international team published a remarkable paper about monarch butterfly migration[4]. It was based upon sequencing complete genomes from over 100 individual insects, and then searching for differences that distinguished migratory from non-migratory races. Some very surprising patterns emerged.

First, let's get an idea of what it entailed. Think of DNA as a very long string of letters embodying a code on how to make proteins, and to control when and where they are made. The proteins carry out all sorts of jobs in the body, such as deriving energy from food, driving muscle contraction, interpreting light signals in the eye, and many more. Even a simple butterfly makes about 17,000 proteins. Each monarch was found to have about 270 million letters in its DNA string: equivalent to a novel 100 times the length of *War and Peace*, or a 600 mile line of *Sego Lily* type. Multiply that by a hundred to get the amount of raw information provided by the DNA in this study.

Obviously one does not try to make sense of all this by just sitting down to a good long read – it's way beyond a human mind and lifespan. Instead, a whole suite of statistics programs chomped away at the data, much as Google and NSA work away at their specialized tasks, searching for patterns. Although a great majority of places in the butterfly DNA showed no variation among individuals, that left about 32 million points that did carry useful genetic information: quite a treasure trove, and enough to draw some fascinating conclusions.

What distinguishes migratory from non-migratory populations? The most notable difference lay in a single protein, a particular kind of collagen involved in muscle structure. The authors speculated that it might confer some advantage in terms of long-distance flight, and indeed found that migratory butterflies used less energy when flying than did non-migratory ones. This finding did not pinpoint *why* they migrate, which probably involves multiple factors, but does suggest *how* they might be enabled to succeed in such daunting flights.

Monarchs occur not only as the well-known North American migratory race, but are settled as non-migratory forms in Florida, Europe, South America, Hawaii, Australia and New Zealand. It had long been thought that they originated in South/Central America and became migratory after moving to North America. Populations in Europe and Asia were thought to have emigrated (perhaps with man's assistance) in the past couple of hundred years. Instead, it appears most likely they originated in the southern US or northern Mexico and spread from there. You can see them making a stepwise progression southwards in the Americas. Moreover, the amount of variation sets a most likely date for dispersal to Europe and Asia at 2000 to 3000 years ago, rather than 200 to 300.

Finally, Hawaii has a variant form of Monarch which is black and white, with no orange pigment visible. It turns out that the genes for making the pigment are all intact: the difference lies in a protein that is responsible for spreading the pigment throughout the cells so that it can be seen.

Lots more information will undoubtedly be mined from this huge batch of DNA sequence, and we should expect to see many more such studies in the future.

[1] B. Dorsey, "*Phylogenetics and Morphological Evolution of* Euphorbia *subgenus* Euphorbia*"* Thesis, University of Michigan, 2013.

[2] K. Prüfer et al., "The complete genome sequence of a Neanderthal from the Altai Mountains". *Nature* **505,** 43-49, 2014.

[3] H. Lerner et al., "Multilocus Resolution of Phylogeny and Timescale in the Extant Adaptive Radiation of Hawaiian Honeycreepers." Current Biology 21, 1838–1844, 2011.

[4] S. Zhan et al., "The genetics of monarch butterfly migration and warning colouration." *Nature* **514,** 317-321, 2014.

Margaret Malm (1928-2014)

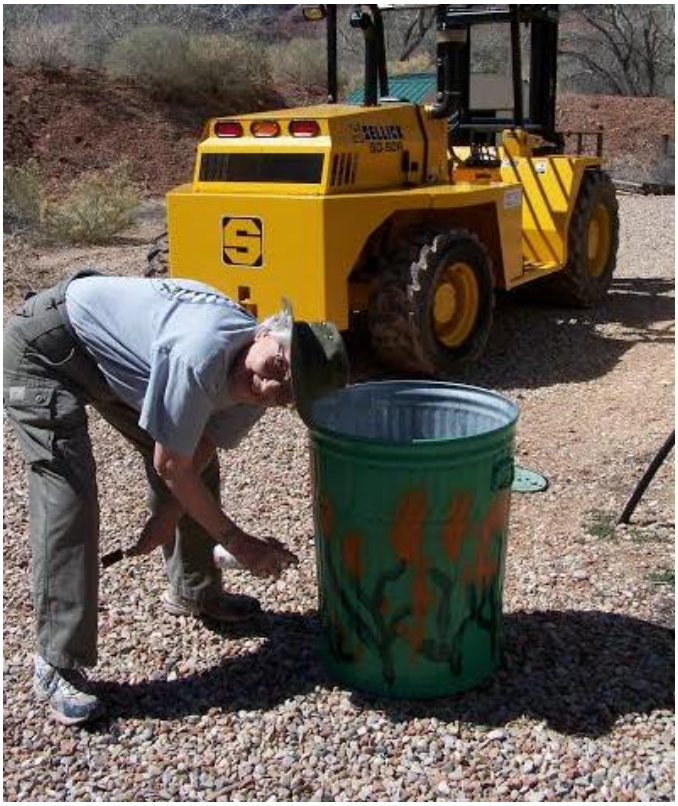
On November 15, 2014, Margaret Mae Malm died peacefully at the Hurricane Health and Rehab center following a long struggle with cancer. Long-time *Sego Lily* readers will recognize Margaret's name from the list of Utah Native Plant Society board members, where she served for more than 10 years. In addition, Margaret was president of the society's Southwestern Bearclaw Poppy chapter covering Washington County.

Margaret was born on May 6, 1928 in Tallant Oklahoma, a tiny Cities Service company town on the Osage Indian Reservation, northeast of Oklahoma City. She received a Masters degree in Psychology and did some graduate studies in her real love: botany and geology. Professionally, Margaret worked in the film industry in Hollywood, troubleshooting Technicolor film for Kodak. In her spare time, she volunteered for the Los Angeles Sherriff's Department and led field trips for the Sierra Club.

Margaret enjoyed travelling and visited Antarctica, Alaska, Hawaii, Australia, and many national parks in the western United States. One such trip to Zion National Park was life-changing. In subsequent years Margaret would take unpaid leave from her job in Los Angeles to volunteer at Zion as a naturalist. Eventually, she took early retirement and moved to Silver Reef, Utah (west of Zion) and built a home for herself and her nonagenarian mother. She continued to work as a ranger (when budgets allowed) and as a volunteer at Zion NP well into her 80's until finally stopped by declining health.

Among her many contributions to Zion National Park was collecting and organizing specimens for the park herbarium, compiling a checklist and identification manual of the flora, volunteering in the park's greenhouse to propagate plants for restoration, and helping eradicate noxious weeds. As a volunteer Ranger she shared her wealth of knowledge on the plants and geology of Zion with thousands of visitors.

In addition to her love of Zion's wildflowers, Margaret was an avid rock hound, photographer, and artist, working with enamel and making silver jewelry using semiprecious stones she found while rock-hunting. - *Walter Fertig*



Margaret Malm in her natural habitat, pulling invasive weeds to protect rare plants on the Chinle Trail in Zion National Park (above) and demonstrating her artistic abilities decorating a garbage can at the Zion National Park greenhouse. Photos by Cheryl Decker.

Ten Things You Might Not Know About Lichens … But Wish You Did

By Walter Fertig

Lichens occur throughout the west but are easy to overlook because of their small stature. These miniature plant-like organisms perform many important ecological functions. The following compilation of lichen factoids will help you impress your friends and could make the difference if you are ever on a quiz show and the category is lichenology (the study of lichens).

#1. Lichens are neither fungi nor plants – they are both! The outer skin and internal structure of a lichen is made of strands of fungal hyphae. Interspersed among the strands inside the lichen are individual cells of algae. This kind of interaction between two different organisms is called symbiosis or mutualism.

#2. The fungus may be getting the better end of the deal . The fungal partner in the lichen symbiosis provides a home for its algal associate to live that is relatively safe from predators and somewhat climate-controlled (the algae get exposed to sunlight, but are protected from drying out). Being photosynthetic, the algae provide food for themselves and the fungus. The algal partner can usually live outside of the lichen in streams, ponds, or wet soil. The fungal partner, however, has become dependent on the algae for its food and cannot live off of decaying organisms like other fungi. Some scientists think the relationship between lichenized fungi and algae is actually a controlled form of parasitism.

3. Lichens typically consist of one species of fungus and 1-2 species of algae. The algal partner may be a species of green algae (Chlorophyta) or a cyanobacterium (Cyanophyta, formerly called blue-green algae). Lichens are named for the fungus species rather than the type of algae in the partnership, since the fungus is the more conspicuous member. Some lichens contain additional microbes and the entire structure might be better considered its own little ecosystem.

4. There are at least 18,000 species of lichens … but probably lots more!. Taxonomists estimate that between 17-30% of all fungus species are capable of becoming lichens. With the number of fungi species believed to number over 1.5 million, there may be at least 250,000 lichen species. Since many fungi look alike superficially, taxonomists have resorted to genetic analysis to differentiate

*Above: The three main growth forms of lichens: Top - "crustose" or crust-like (*Acarospora rouxii*), Middle - "foliose" or leaf-like (*Ramalina puberulenta*), Bottom - "fruticose" or shrubby (*Ramalina pacifica*). Photos of type specimens from the Consortium of North American Lichen Herbaria website (www.lichenportal.org).*

species. In a 2014 study, what was assumed to be one species of lichen (*Dictyonema glabratum*) turned out to be 126 genetically distinct "species". Based on records from the Consortium of North American Lichen Herbaria website (www.lichenportal.org) the lichen flora of Utah consists of at least 800 species**,** or about 16% of all lichen taxa known in North America.

5. Lichens are not just gray, drab, crusts. Actually, lichens come in a rich variety of colors, ranging from bright yellow, red, and orange to green, black, brown, silver, and gray. Many lichens are flat and leaf-like ("foliose"). Lichens growing on bark or the ground sometimes have a central stem with small branches that give them the appearance of a dwarf shrub ("fruticose"). Some lichens become embedded in the upper surface of a rock or cliff and cannot be removed without breaking off a chunk of their substrate. These "crustose" lichens are especially resistant to herbivory. The many colors of lichens help protect them from too much sunlight or low temperatures. Colors are a by-product of the complex chemistry of lichen tissues. Over 700 organic chemical compounds have been isolated from lichens (90% are not known elsewhere in nature). These compounds help protect the lichen from being eaten. Chemistry is an important factor in identifying different species of lichens which are otherwise morphologically similar.

6. Lichens occur in nearly all habitats, from the Arctic to deserts, grasslands, and temperate and tropical forests. Worldwide, the environments with the greatest diversity of lichens are coastal areas, the canopy of temperate rain forests, and montane tropical cloud forests. Lichens may be important components of sites that are too extreme for other green plants to grow, such as wind-blasted mountain cliffs, frigid arctic boulder fields, or baking deserts. About the only places where lichens are poorly represented are aquatic or marine areas—but some lichens occur on barnacles! Lichens frequently grow on rocks, but can also be found on bark, leaves, soil, and even other lichens. Tiny fragments of lichen have been found on the larvae of lacewing insects to help camouflage them and the insects disperse asexual lichen soredia (spore-like bits of lichen and algae) in return.

7. Some lichens can live for decades or centuries, but grow very slowly. The exact age of a lichen is difficult to pinpoint, but those that grow on buildings or tombstones can often be dated based on historical photographs or archives. Using lichens to age structures is called lichenometry. In nature, the presence of healthy, mature lichens is an indication that a site is relatively undisturbed.

8. Lichens derive much of their nutrition from trace chemicals in the atmosphere. Lichens do not have roots or vascular tissue to uptake or transport nutrients from the soil. Most of their water and chemical nutrients are absorbed from the air. This makes lichens very sensitive to toxic chemicals and pollution. Herbarium specimens are invaluable for tracing changes in the range of lichens in the vicinity of polluted areas. Researchers can also sample lichen tissue to chemically reconstruct atmospheric pollution levels at different times in the past.

9. What good are lichens? Besides being valuable bio-indicators of pollution, lichens provide important ecosystem services, such as binding and building soil and fixing atmospheric nitrogen. Lichens are a major winter food source for caribou (reindeer moss is actually a lichen) and are eaten by flying squirrels, red-backed voles, and a variety of invertebrates. Many birds use lichens for nest material.

Humans use lichens in many ways too. Various cultures across northern Europe, Asia, and North America consume lichens as food (bread moss is an edible lichen popular in Scandinavia). Lichens have also been used to flavor bitter beers. Fruticose lichens, such as *Bryoria* and *Alectoria*, have strong fibers used for clothing. The many colorful chemicals found in lichens are used to dye fabric. Lichens have many antibiotic properties and have been used since prehistoric times to dress wounds or as tonics or laxatives. One lichen species has been found to inhibit growth of the HIV virus that causes AIDS.

10. Lichens are declining in many areas due to pollution and habitat modification. Urban sprawl and air pollution are the greatest threats to lichen survival in cities and suburban areas across the United States. The unique lichen flora of California has been especially hard hit by the double whammy of smog and rampant real estate development. Soil lichens of the Great Basin, Colorado Plateau, and other arid areas of the west have been impacted by trampling from livestock and off-road vehicle recreation. Rock-climbing, mining, and competition from invasive weeds have been implicated in lichen declines in some areas. Fortunately, lichens are hardy and recover if given half a chance.

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