MANZANITA

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The Mysteries of Growing and Studying Liveforevers *by Stephen McCabe*

A cross of the Cedros Island liveforever with the chalk dudleya or Anthony's liveforever, made in cultivation by McCabe.

How can a plant tough enough to survive being taken out of the ground, pressed between cardboard, and set aside for a year, recover from this abuse to be an attractive garden plant once again—and still be in danger in the wild? There are a number of mysteries about the liveforever (genus *Dudleya*), but the ability to survive certain kinds of stress is one of the more interesting ones.

Trying to identify specific individuals in the field can produce stress in humans. Reid Moran of the San Diego Natural History Museum, who had studied liveforevers for over 75 years and was considered the leading expert for decades, told me more than once, "The more I know about *Dudleya*, the less I know." He started so young that he had a species of *Dudleya* named after him by the time he was barely 16 years old. D.A. Johansen (1932) wrote that by that point Moran had already "forwarded to the writer innumerable specimen plants of many species of *Dudleya*." Moran (1978) joked, at 62 years old, that he was personally embarrassed by the difficulties in *Dudleya*.

The genus *Dudleya* Britton & Rose (1903), consists of approximately 47 species and 67 taxa (including subspecies) of leaf-succulent perennials native to California, Oregon, Arizona, Nevada, Utah, Baja California, and (barely) Sonora, Mexico. More than half the species are in California. They range in size from tiny, essentially stemless, short-leaved *D. brevifolia* with half-inch wide plants and one-inch tall flower stalks with open white flowers, to Anthony's liveforever (*D. anthonyi*) with rosettes over a foot across, five-foot long stems, four-foot tall flower stalks, and red tubular flowers. Some species branch and some never do. (Branching occurs when the apex splits to make two similar branches.) Leaves in the genus can be waxy or not, in shades of green, red, or purple-green.

The small, summer-deciduous species of subgenus *Hasseanthus* tend to grow in less than one-inch deep soil pockets on coastal mesa tops. After rains,

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The Board of the *Friends* generally meets at the Visitor Center in the Regional Parks Botanic Garden the second Wednesday of the month at 10:00 AM. All members are welcome. Call ahead to verify meeting date and time.

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Agave! *by Bart O'Brien*

Of California's three primary agaves, only one is easy enough to grow in California gardens and landscapes well beyond its native habitat, and that plant is *Agave shawii* var. *shawii*. Shaw's agave is a true denizen of California's mediterranean-climate region (albeit at the southwestern-most part), while the other two are found in California's deserts: the *A. deserti* complex from the Sonoran (aka Colorado) desert and the *A. utahensis* complex from the eastern Mojave desert. Shaw's agave is California's largest agave, and I have no trouble placing it amongst our "charismatic mega-flora"—elements of California's native flora that are widely recognized by the public. However, in this particular case, many would recognize the plant only as an "agave" or "century plant" without realizing that it is a native species.

The Regional Parks Botanic Garden has three accessions of *Agave shawii* var. *shawii* in its living collection. Two of them are direct representatives from the only two known native localities for the species in the United States, while our third (and oldest) collection is from Baja California, Mexico. When the garden's first director, James Roof (along with Rod Kirk), collected at least six plantlets (pups) off reclining stems of this agave, along with some seeds, on November 28, 1962, about 40 kilometers north of Ensenada, he thought that the species was extinct in California. Soon after, he realized his error and, in 1970 and 1974, added plants from the two native California populations to the garden.

The two known Californian populations are from San Diego County: the first at the US Naval Supply Center, San Diego, Point Loma Annex, around the midpoint on the Point Loma peninsula on the west side; and the second at Lichty Mesa, literally along the international border at Border Field State Park—the southwestern-most point of the continental United States. While Roof collected 3 or 4 pups and seeds from the Naval Supply Center population on May 9, 1970, he collected only a single pup from the larger Lichty Mesa population on November 22, 1974. Why only one pup from Lichty Mesa? Roof didn't directly say, but he did note that the Lichty Mesa population had few pups available at the time he made his collection. It is quite unusual for an *Agave shawii* var. *shaw*ii population of that size to have few pups, and could indicate that this population was unusual or that others had previously collected the young pups.

Shaw's agave (*Agave shawii*) both photos by Pattie Litton

Shaw's agave (*Agave shawii*)

Unfortunately, all but one clump of the Lichty Mesa population was removed in May and June, 2008, to make way for the construction of the US–Mexico international border fence. At the

Shaw's agave (*Agave shawii*)

time of construction, a nearby nursery, Recon Native Plants, Inc., salvaged about 1,000 rosettes of these agaves, athough the majority of them were later sold commercially (Vanderplank, 2014). How could such a thing happen to such a rare and beautiful plant in the United States? By unanimous vote of the US Senate, and by a House of Representatives vote of 368 yeas, 58 nays (3 republicans, 54 democrats, and 1 Independent), and 1 vote of "present" (democrat), the 109th Congress passed, and President George H.W. Bush signed into law, a bill that specifically permitted the construction of 17 miles of border fence in San Diego County without having to comply with any state or federal environmental laws. Thus, the largest of only two known US populations of *Agave shawii* var. *shawii* (and the only US population of palo blanco, *Ornithostaphylos oppositifolia*) were removed by our government.

The garden's Baja California collections form the bulk of our living material of Shaw's agave, and these are the plants that have been blooming over the past three years: one rosette in 2014, two rosettes in 2015, and presently one rosette in 2016. (Roof noted that the first of these bloomed in 1980, and that it was one of the pups he had collected, not one of the later, seed-grown individuals.) It has been estimated, though it is not definitively known, that seed-grown plants may produce their first inflorescences (presumably from their oldest rosettes) when they are between 20 and 40 years old. As with all agaves, each rosette that flowers subsequently dies (regardless of whether it has produced viable seeds or not).

The primary pollinator of Shaw's agave throughout its native range in Mexico is thought to be nectarivorous bats, due to the size, shape, and disposition of the flowers, though this has not been proven. Viable seed set in the native California plants has been poor at best, and indicates that there are pollination problems in these small, geographically-isolated northernmost populations of the species. (The nearest Baja California population is 25 kilometers south of the international border, well beyond the typical foraging range of most pollinators.) Contrary to what researchers expected from a bat-pollinated flower, nectar production is highest during the afternoon and early evening, which may indicate that a pollinator shift (perhaps to large bees and hummingbirds) may be underway. However, regardless of flowering and seed production, one of the defining characteristics of *Agave shawii* var. *shawii* is that it typically produces pups at various times during its life, such that a single clonal plant can consist of dozens (hundreds? thousands?) of rosettes over its very long life span. No one really knows how old some of these agave clumps are or how many genetically different individuals a population may contain. This is yet another example of how little we know and how much we still have to learn about the basic biology of these rather well-known common (in Mexico) plants.

As in California, Shaw's agave continues to be cleared and eliminated from vast swathes of its natural habitat in northwestern Baja California, Mexico. Hundreds of thousands of mature rosettes have been eliminated from Baja's coastal terraces. There are still innumerable mature rosettes living in relatively undisturbed tracts of land in Baja California, but without more basic knowledge about this species, one cannot properly assess the threats to the long-term survival of this beautiful species in the wild.

Liveforevers continued from page 1

the soil may stay moist for a few weeks, but in the summer the soil bakes. Santa Cruz Island dudleya (*D. nesiotica*) is one of the easiest to grow of the summer-deciduous species. Lance-leaved (*D. lanceolata*) and chalk dudleya (*D. pulverulenta*) grow mostly on soil. Other species grow in small cracks in rocks or in shallow mats of moss, lichen, spike-moss (*Selaginella*), or even liverworts, in sunny or shady canyons. In Joshua Tree National Park and other desert areas, *D. saxosa* subsp. *aloides* is found in desert washes near seasonal streams or on rock. Greene's liveforever (*D. greenei*) and other island species grow on a variety of substrates, including both soil and rock. Few are epiphytic, although there is a patch of the candleholder liveforever (*D. candelabrum*) growing on Santa Cruz Island oaks and a few Baja California species that rarely grow on cacti. Serpentine-endemic species and subspecies tend to be difficult to cultivate.

Dudleya was probably first called liveforever because of its ability to survive in plant presses during long boat rides back to Europe. In order to better understand plant classification in any group, it is often useful to go back to the specimen for which the species was named and to the original collection location. However, where the early plant collections of liveforevers came from is not well known. The first *Dudleya* brought back to England for science was collected in 1794 by Archibald Menzies, who mistakenly stated it was collected at the Cape of Good Hope. Haworth corrected this error with the less than precise locality of "California." Reid Moran guessed that the plant, later called *Dudleya caespitosa*, was collected near Monterey. There is so much variation from one plant to the next in *D. caespitosa*, probably due to hybridization, that I throw up my hands trying to identify individual plants in some parts of its range. Knowing where the first one was collected would help define it.

Another early collection of a species developed for horticulture that was growing in Europe in the 1850s was *Dudleya cymosa*, thought to be either from Mexico or California. Unfortunately, an early painting, later designated as the basis for identifying *D. cymosa* subsp. *cymosa*, depicts a yellow-flowered plant that does not match well with the rest of the mostly orange-flowered subspecies. In both of these species with imprecise collection information, there are no preserved specimens to help elucidate what plants were originally named.

Although Moran (1978) has written that "most species of *Dudleya* are distinctly undistinct," there are actually some that stand alone. *Dudleya pachyphytum* is unmistakable and on some bucket lists of the most important plants to see in the wild. After an unsuccessful trip to see *D. pachyphytum* several years earlier, in 2014 Gary James, a former community college administrator, tour guide, and succulent enthusiast, took a trip with four of us to Cedros Island, Baja California, to try to see it. We drove 400 miles, then took a taxi, plane, truck, and panga boat before we even started the enervating hike up a steep canyon to a high ridge where we saw the liveforever. (After finally seeing *D. pachyphytum*, Gary was excited to visit the spiral aloe, *Aloe polyphylla*, in Lesotho in southern Africa, the next plant on his bucket list.)

Cedros Island liveforever (*Dudleya pachyphytum*)

CONSERVATION

Although most everyone knows the iconic native manzanitas, the California liveforevers are far less known. Both genera have their dedicated fans and many features in common. Members of each can be rare or common, seeders or sprouters after damage, rampantly hybridizing or not, and extremely difficult for the uninitiated to identify in certain localities. Each can be pollinated by hummingbirds and bees without being too specialized for either. Each has had species declared extinct and then refound, and each contains rare species that flourish in small, prime habitats.

In 1986, Ted and John Kipping brought me a single plant of San Benito Island liveforever (D. linearis). After that I heard that rabbits later released on the island ate most or all of the liveforevers. I started propagating my single D. linearis from cuttings, fearing it was extinct in the wild. Fortu-

nately, the rabbits were removed, and D. linearis is recovering from the seed bank and possibly a few remaining plants. Rabbits similarly decimated the Santa Barbara Island liveforever (D. traskiae) before the rabbits were removed.

The Laguna Beach dudleya (*D. stolonifera*) is the only liveforever that produces stolons. It was rare enough that conservationists managed to get parks set aside, partly to protect it. I have been particularly involved in the restoration of the rare Verity's dudleya (*D. verityi*) after the Camarillo Springs Fire of May, 2013, burned through all populations of an already endangered species. These are just two of more than 30 species threatened in the wild. (*Dudleya stolonifera* is the t-shirt logo of the Orange County chapter of the California Native Plant Society. Similarly, the Channel Islands chapter has

Britton's liveforever (*Dudleya brittonii*) against Agave 'Blue Glow'

D. verityi on the backs of their sweatshirts.) Many dudleyas, including *D. stolonifera* and *D. verityi*, have a very narrow range of conditions in which they can grow well and not get out-competed by other species. Several of those habitats, such as on hilltops with spectacular ocean views, have been disrupted by development. Rock climbers have removed from cliffs dudleyas they deemed to be in their way.

CULTIVATION

By California standards, liveforevers have been cultivated for a long time. Many are short-lived, but Britton's liveforever (*D. brittonii*) of the Arizona Garden at what was once the Del Monte Hotel in Monterey, California, may be from the 1920s or from the original planting in the 1880s.

The big white-leaved plants are not that easy to tell apart out of flower. Britton's liveforever grows near Ensenada and is prized for the white-leaved form, not its more difficult-to-grow green form. The pale yellow flowers are held upright on the spreading flower stalks. Chalk dudleya is the California one with pendant red flowers and white wax on almost all parts of the plant. It does grow almost as far south as the very similar Anthony's liveforever, which is found on volcanoes near San Quintín and on Isla San Martín. Anthony's averages slightly larger rosettes and taller flower stalks with flowers held variously, but not pendent as in the chalk dudleya. What you find in nurseries these days with any of the above three names may be hybrids of two or three of the above, but they are still attractive and may be slightly better suited to cultivation than pure plants straight from the wild. I was given an old Anthony's liveforever that I believe was from wild-collected seed and told to put it out in the garden. It looked glorious, but we had a rain in May followed by warm weather and the liveforever was dead in a week from a warm-weather fungus. Some of the large white-leaved plants do best if planted with the rosettes at an angle where they won't collect water in the leaves.

Too many liveforever plants are collected in the wild, including by people who work in the fields of plant and animal conservation. In keeping with the hardiness of the species, *Dudleya* that have fallen out of a cliff can simply be put back in a crack in the rock where they may well survive, and this simple act may help counteract the effects of over-collecting. I have seen liveforevers that were burned to the ground and kept dry during a drought, sprout a year and a half later from their roots when good rains finally came. Munchkin dudleya (*D. gnoma*), knocked completely upside down by cattle, sent roots down into the ground, creating odd upside-down plants. So the thought that "Oh, it fell off the cliff. It will never survive. I should take it home," is not necessarily true.

Liveforevers are exceptionally easy to start from seeds, though getting them through to adulthood takes some patience and TLC. I have often taken flower stalks off plants, and weeks later, hybridized them or collected self-pollinated seed. When sowing the seeds, do not cover them at all. They need less water than many cacti or *Aloe* seedlings, but they do need to be kept from drying out too much.

Liveforevers are generally easy to care for in pots. The seldom-seen Santa Cruz Island dudleya is one of the summer-deciduous species that are better left unwatered in medium shade over the summer. The evergreen species may be watered all year, though care should be taken not to overwater during hot weather and during the summer. Weak fertilizer may be given several times a year starting in October. Mix in some sharp gravel, pumice, or perlite to provide drainage. The *D.* 'Frank Reinelt', *D. attenuata*, *D. virens* subsp. *hassei*, the large white-leaved species, and some others can be grown in full sun in the ground, but many species benefit from some light shade most of the year.

Among the pests are mealy bugs, root mealies, aphids, moth larvae, and butterfly larvae. It can take a year or two for a plant to grow out of the distortion caused by a mealy bug infestation. In every population that I have looked for it, I have found larval damage to the liveforever stems. The snout moth and Sonoran Blue Butterfly are two species known to cause some of this damage. This is another reason to avoid collecting large plants in the wild, as you may bring the pests hidden deep in the stems to your collection. It is best to go after the larvae with a knife or the wire end of a surveyor's flag. Chemicals and Bt have little effect, perhaps because the *Dudleya* seem slow growing enough that they may not take up systemics in time to have an effect, and the larvae are inside the plant, not feeding on Bt-sprayed leaves. Leaf roller caterpillars damage, but do not kill, liveforevers. Remove them with a small tool or by hand as soon as possible. Waxy plants are less often affected, at least by the leaf rollers. Two species of jewel beetle feed on dudleyas in Baja California, including one with a species name of *Chrysobothris dudleyaphaga*.

If you want to grow multi-branched plants outside, try *Dudleya* 'Frank Reinelt' or *D. virens* subsp. *hassei*. 'Frank Reinelt' is a hybrid of a Tilden plant called at the time *D.* 'Anacapa.' That parent was collected on Anacapa Island, where *D. caespitosa* is the only species of liveforever. The label on the original hybrids said "Dudleya Anacapa X." The rest of the label was broken off. I am guessing that the other parent was Orcutts' liveforever (*Dudleya attenuata* subsp. *oruttii*). Wayne Roderick said that we had to name the hybrid after the hybridizer, so we each named it 'Frank Reinelt' in our respective garden publications (Roderick 1991). The creatively named *D.* 'Son of Frank' is not one entity but attractive seedlings of 'Frank.'

Palmer's dudleya (*Dudleya palmeri*) in bloom

The three large white-leaved species and their hybrids mentioned above make stunning statements in a garden staged against dark plants, pots, or walls. The sticky-leaved liveforever (*D. viscida*) does well in rock gardens and in cracks in garden walls (McCabe 2006). It has the added bonus of having aromatic leaves, pink flowers, and the ability to catch a few white flies. Among the most sought after liveforevers for pots or gardens is *D. pachyphytum*, named in 1978 by Moran. The first ones in California public gardens were stolen almost immediately. People from five or more countries have been implicated in collecting too many of these fat white-leaved beauties from the wild. I have some attractive hybrids of *D. pachyphytum* with other white-leaved species. So far they rarely branch and have not been distributed. Perhaps the tissue cultures that friends are trying for me will lead to hybrids that are suitable for distribution to gardens.

One of my hybrids of *D. anomala* X *D. attenuata* subsp. *orcuttii* has been distributed as *D.* 'Edna's Echidna'. It has narrow, soft pointed leaves and forms a sort of sea anemone or echidna-like mound. When I want to be certain of parentage, I do all of the hybridizing in my living room, where I can keep out the birds and the bees. Like the *D. anomala* parent, the branches of the hybrid will droop if left dry for too long. I am fairly far along in developing a very red set of hybrids

Dudleya cymosa subsp. *ovatifolia*

using the Santa Monica dudleya (*D. cymosa* subsp. *ovatifolia*) as the main source of genes.

RESEARCH

Finding the plants in the wild can be an adventure. I have looked for them by car headlights, flashlight, and headlamp. They are guarded at times by steep cliffs, possible killer bees, poison oak, barbed wire, actual guards, hotel security, and sharks. Ralph Hoffmann, an avid plant collector on the Channel Islands in the early 1930s, died when he fell off of what later was named Hoffmann Point, reaching for a plant that botanists speculate was a liveforever.

As part of my research I have made many artificial hybrids. Having seen the hybrids in the greenhouses helps me recognize hybrids in the wild. One of the mysteries is why there are distinct species in the wild when they hybridize so readily in captivity. Habitat differences, pollinators, timing of flowering, and geographic isolation are just a few of the possible reasons why plants that can hybridize don't do it successfully more often. Some of the hybrids I have produced grow and flower, but may not be as fit as their parents, as they may succumb easily to fungal and other pathogens.

Little is known about natural dispersal in liveforevers. The tiny seeds are not specialized, but may be blown around and up slopes and canyons. The *Dudleya* on El Capitan and Cathedral Spires in Yosemite provide circumstantial evidence for this possibility. Do Santa Ana winds blow seeds from the mainland to offshore islands? And does water transport seeds down streams? Some seeds in other groups of plants may travel in bird feathers or on the mud on birds' feet, explaining how plants might get from one island to another. It seems clear that bees and hummingbirds effect pollination, but it is not known if butterflies or other invertebrates that visit the flowers successfully pollinate them.

The discoveries among liveforevers are ongoing. I have submitted an article naming a new species and am working on a few more new candidates. I have begun using DNA with other researchers to try to decipher relationships among the species. We have learned about what some of the early branches of the liveforever family tree looked like, although so far the end branches of those trees are confusing. Moving forward, I will use modern and classic methods to name new species, some of which are severely endangered. At this point, field work and measurements have proved most useful.

Dudleya pachyphytum is a desert species on an extremely dry island. However, the only place it grows is on the windswept, fog-shrouded ridge apex near where the Cedros Island pines grow. This distinctly distinct species will rot if too well watered, but won't thrive if treated like the drought tolerant agaves several paces away on the drier side of the ridge. The contradictions and mysteries are not a frustration, but a source of fascination for me. I want others to enjoy the dudleyas in the wild or in their gardens. By spreading the word about dudleyas, naming new species, and making them available to gardeners, I hope that even if all the species don't live forever, at least they are given the best chances they can have in my lifetime and in that of my children.

Stephen McCabe has been studying Dudleya *since 1983. He is the Emeritus Director of Research at the UC Santa Cruz Arboretum, where he was employed 1985-2015. He is working with Jeremy Spath and Kelly Griffin on a book about liveforevers. His conservation research was featured in a cover story of Science News (October 3, 2014).*

Photos by the author.

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How CAM Photosynthesis Helps Succulents Conserve Water *by Alicia Springer*

Succulents avoid desiccation in hot, dry conditions through many strategies—fat, water-retentive leaves and stems are only the most visible. Many succulents, including dudleyas, have evolved a water-conserving variation on that most fundamental of plant processes, photosynthesis. Called CAM photosynthesis—for Crassulacean Acid Metabolism—this method of converting sunlight into sugar enables CAM-acting plants to do some of the metabolic heavy lifting, so to speak, in the cool dark of night when less water is lost to transpiration.

Named after the family Crassulaceae (which includes dudleyas) in which it was first observed, CAM photosynthesis is found in roughly five percent of plant species, including representatives in at least 30 plant families. This water-conservation strategy evolved independently in many families adapted to desert-like conditions, such as cacti, agaves, and aloes, but is also employed by some epiphytic 'air' plants, such as bromeliads and orchids, that rely on ambient condensation for their water supply. CAM photosynthesis differs in the details among CAM-acting families, but the general outline of the process is shared.

You'll remember that standard photosynthesis (also known as C3 photosynthesis because the first organic product is a three-carbon compound) is all about using the energy of sunlight to convert carbon dioxide and water into carbohydrates, which are stored in the plant as fuel, and oxygen, which is released. (Consider this a vastly oversimplified summary of an astoundingly complex set of processes.) In all photosynthesis, gases and water vapor need to move in and out of the plant. These transfer points are the stomata—pores in the leaves that open and close in response to temperature, humidity, and other conditions that affect the plant's functions. A plant standing in arid ground in the full sun of a hot, dry, windy day with its stomata wide open would soon be one dead desiccated plant—so all plants, CAM or not, modulate the movement of water by controlling how and when the stomata open.

If water vaporizes from the plant when the stomata are open, why open them in the daylight at all? Transpiration, for one thing. Water moves in an unbroken molecular chain through the plant, from the tiniest capillary at the root tip through each stomate on every leaf. The evaporative action at the stomate end of the water chain sucks up water from the root end and keeps it circulating, cooling down the plant in the process. Without transpiration, there's no water movement; without gas exchange, no photosynthesis. If you're a mighty oak, you need to keep a huge volume of water moving, and you need to synthesize a lot of sugars, so you require lots of transpiration and photosynthesis in the light and heat of day.

Now say you are a dudleya growing on a sunbaked rock wall. Your low-surface-area leaves are coated with thick waxy cuticle. With your stomata sealed up tight, evapotranspiration is minimized. Water is stored within your retentive tissues, plus you are short and squat, so you don't require the constant upward movement of an unbroken water chain that depends on daylight transpiration. You can keep your stomata closed during the day—but you still need to photosynthesize using the energy of sunlight. You can't put off all your metabolic obligations to the dark of night.

Alicia Springer

Dudleya cymosa

Here's where the CAM variation comes in. CAM plants evolved the ability to store CO2 in the form of an organic acid that non-CAM plants don't synthesize. CAM plants open their stomata and take in carbon dioxide at night, storing it for photosynthesis during the day when the leaf pores are tightly closed—thus losing about one-tenth as much water per unit of carbohydrate synthesized as plants using standard C3 photosynthesis. Ambient temperature plays a role: cooling temperatures increase acid formation and CO2 storage, and rising temperatures stimulate CO2 release—a great strategy for the cool nights and hot days of arid climes. In times of unrelieved drought, CAM plants can shut down and seal up altogether until better conditions prevail.

There is a trade-off, however: CAM photosynthesis happens at a much slower rate, so CAM plants are slow growers. But you're a dudleya, not an oak, so slow growth is not a disadvantage.

To read more about CAM photosynthesis, please see the thorough explanation found in *Plant Ecology of the Sonoran Desert Region* by Mark A. Dimmitt (scroll down to "Succulence") on the Arizona-Sonora Desert Museum website: https://www.desertmuseum.org/books/nhsd_plant_ecology.php

Alicia Springer is a writer and editor with an interest in California ecology. She is a member of the UC Master Gardener program of Butte County and is a recent and welcome addition to the Manzanita *editorial committee.*

The Other Crassulaceae, the Family of Stonecrops *by Glenn Keator, PhD*

Sedum obtusatum

Photo by Emerald Canary, inset by Glenn Keator

Besides California's iconic dudleyas, the Crassulaceae family is widespread and divided into many other genera, some easy to identify, others difficult, many inhabiting other parts of the world, particularly Mexico, the Canary Islands, and South Africa. Some like the houseleeks in the genus *Sempervivum*, the hen and chickens (*Echeveria* spp.), the jade plant (*Crassula ovata*), or the aeoniums are familiar sights in California gardens; others are poorly known.

California is home to several other genera with fascinating diversity and varied habits. All share fleshy, succulent, simple leaves, often star-like flowers with five petals and five or ten stamens, and several separate pistils that ripen into follicles filled with tiny dust-like seeds.

My favorites include adaptations to extreme conditions—thin stony soils that dry in summer—annuals that despite their tiny fleshy leaves cannot retain enough water to carry them through long, dry summers. The genus *Crassula*, which assumes more robust perennial or even shrubby forms elsewhere, contains the world's tiniest succulents among the few native species, minute annuals with red-tinged leaves and one or two axillary green to whitish flowers, the entire plant standing no more than two inches high. Look for these "pygmy weeds" in temporarily moist spots, sometimes edging vernal pools early in the year.

The other genus *Sedella* (little sedum) contains a few species with bright yellow star-like flowers (the flowers like small versions of *Sedum*) that favor thin volcanic or serpentine soils in the foothills.

The tuberous, winter-dormant perennial from high-mountain rock outcrops—*Rhodiola integrifolia* aka roseroot or rosecrown—sprouts just after snow melt. The sturdy stems support many fleshy, toothed leaves topped with cymes of deep-red four-petaled, male or female flowers. Although difficult to grow, rosecrown is a famous adaptogen (an energizing or enhancing substance) widely used in herbal medicine; the species is found all across the Northern Hemisphere.

The largest "other" genus in California is *Sedum* or stonecrop, a genus consisting of hundreds of species worldwide, most seeking rocky slopes from the foothills to the high mountains. Sedums vary widely in stature, life span, and variability, making

identification difficult for the beginner, but fortunately, many of the native species are rare, paring down the possibilities for identifying the widespread kinds. Among the mostly perennial species, the annual *S. radiatum* crops up in many foothill woodlands with tiny narrow leaves and pale yellow flowers in early to mid-spring. Locally it occurs on Mt. Diablo and Oathill Mine Road in Napa County.

Among the perennials, *S. spathulifolium*, broad-leaf stonecrop, is found from coastal bluffs to middle elevations, always on rocky slopes with perfect drainage. The tight basal rosettes of the spatula-shaped leaves may be bright green, silvery gray, or deep red, giving rise to various cultivars. All feature short cymes of bright yellow flowers in mid-spring. Locally, look for this one on coastal bluffs at Pt. Reyes and in dry woodlands on Mt. Diablo.

Here follow a few other commonly encountered sedum species:

S. stenopetalum is a common sight in sandy or rocky soils in the high mountains, easily recognized by its narrow red-tinted leaves and yellow flowers; it blooms shortly after snowmelt.

S. obtusatum is widespread in similar montane habitats but is a more upright plant, often forming clustered branches with plump leaves narrow at the base and broadly rounded at the tips. The flowers are creamy white to yellow.

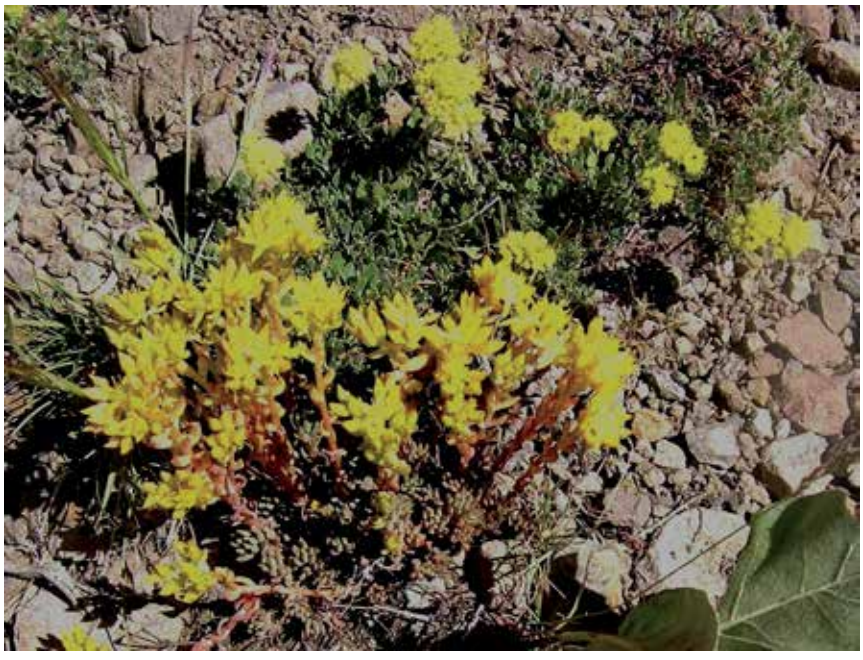
S. laxum, also widespread in montane habitats, is a close sister species to *S. obtusatum*, noted for the usually pinkish flowers. Studies are currently under way on both species complexes, and splitters have enlarged the number of species; but to my mind, only a specialist in the group can readily sort out the different kinds.

Of these other California stonecrops, sedums are the best choice for gardens and the most available; the annual genera are seldom encountered in horticulture, and the rosecrown is difficult to grow.

Glenn Keator is chairman of the Friends *Advisory Council. He is a popular instructor of botany and field trip leader in the Bay Area, and he teaches the docent training course at the Regional Parks Botanic Garden. He is the author of a number of books on native plants.*

Emerald Canary

Rosecrown (*Rhodiola integrifolia*)



Glenn Keator

Sedum stenopetalum growing in subalpine rock rubble.

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