Monarda fistulosa: Making Good Scents in Colorado

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Sometimes you just have to stop and smell the wild bergamot, and that is exactly what I have been doing for the last four years as part of my Ph.D. dissertation research, conducted with Prof. Yan Linhart at CU-Boulder. Like many species in the mint family, *Monarda fistulosa* L. (Lamiaceae), commonly known as wild bergamot, bee balm or horse mint, produces small volatile chemicals called monoterpenes in tiny sacs (trichomes) located on leaves, calyces and even flower petals. When one rubs bee balm leaves, these trichomes are broken and almost immediately one detects the scent of escaping monoterpenes. Also known as essential oils, monoterpenes have been used by humans for thousands of years as fragrances and flavors; however, plants use them for a variety of functions, including: suppression of plant competitors, repelling herbivores or attracting pollinators and seed dispersers (Harborne 1993). Monoterpenes are widely distributed among a variety of plant families and their variation in natural plant populations has been extensively studied. Many labiate species contain individuals with distinct chemical phenotypes, called chemotypes, which are controlled by simple Mendelian genetics (Vernet et al. 1986, Vokou et al. 1993). Plants of a particular chemotype usually produce one monoterpene that dominates their total essential oil composition. This means that individuals of the same species can have very different smells, tastes and interactions with other organisms, such as herbivores and pollinators. Prior to my work, three chemotypes had been identified in *Monarda fistulosa*, containing either geraniol, carvacrol or thymol as their main monoterpene (Marshall and Scora 1972, Weaver et al. 1995, Johnson et al. 1998). The smell of geraniol is sweet or lemony - it is a major component of lemon oil, whereas carvacrol and thymol remind one of thyme or oregano, both of which have these chemotypes. While the existence of these three chemotypes in *M. fistulosa* has been known since the early 1970s, only one study presented detailed information on the distribution of chemotypes in the species (Marshall and Scora 1972). I have discovered that two of the known *M. fistulosa* chemotypes, carvacrol and thymol, occur in Colorado in pure and mixed populations. Additionally, in one population in southern Colorado, I have found a previously unknown chemotype for this species with essential oil composed almost entirely of the monoterpene linalol. With the support of a Colorado Native Plant Society research grant from the John Marr Fund, I have been characterizing the chemotype variation of *M. fistulosa* over the landscape and trying to understand how these patterns arose and how they are maintained.

The first step to understanding chemical polymorphism in *M. fistulosa* was to map chemotype patterns of populations. The methodology I used was simple. Using historic herbarium records, information from locals and by just driving around, I located about 50 populations of wild bergamot throughout the state. At each site I randomly collected a single leaf from an average of 20 plants, soaked them in pure ethanol for one week to extract the monoterpenes and then analyzed the solution by gas chromatography, a technique that allows separation, identification and quantification of monoterpenes.

Chemical analyses of over 900 Colorado plants revealed variation ranging from populations comprising only carvacrol plants to populations comprising only thymol plants, as well as populations comprising various mixtures of the two. So, what factors are responsible for these patterns? One explanation may be temperature. In Boulder County, where almost half of the populations analyzed occur (Figure 1), it appears that populations high in thymol plants are found at higher elevations or in colder areas, such as deep canyons. These micro site differences may be important in *M. fistulosa*, since in Colorado it has a large geographical range over most of the state with diverse habitats from prairies to high mountain meadows. Also, the idea that plants of a particular chemotype are excluded from an area due to temperature has been shown for common thyme (*Thymus vulgaris*) in the south of France. In the case of thyme, certain chemotypes were absent from the floor of an enclosed basin that regularly experienced much colder temperatures than the surrounding uplands (Amiot et al. 2005). To unravel this question in *M. fistulosa*, I plan to monitor temperature, humidity and other abiotic parameters at sites with different chemotype compositions.

Another factor that may shape the chemotype composition of populations is herbivory. At a few sites, I have found plants being fed upon by a small tortoise beetle (*Physonota unipunctata* Coleoptera: Chrysomelidae) that specializes only on *M. fistulosa*. The larvae of this beetle have a curious defense mechanism; they accumulate their feces on two projections on the rear end of their bodies, which they curl upward, holding the "fecal shield" over their bodies. Since their diet consists exclusively of *M. fistulosa*, the fecal shield is rich in plant monoterpenes, adding a chemical dimension to their defense strategy. While the beetle larvae will readily feed on both chemotypes, my preliminary data show that when fed only carvacrol foliage they have lower survival and longer development times. Thus, in populations where these herbivores feed, thymol plants may experience more damage and reproduce less than carvacrol plants.

Another interesting find along my chemical odyssey was the discovery of what appears to be a new chemotype of *M. fistulosa*. On a lonely stretch of highway west of Trinidad, Colorado, I spotted an isolated roadside population. Initially, the plant leaves I collected all seemed to have the familiar smell of carvacrol or thymol chemotypes found at many other sites. Suddenly, the scent of one plant was completely different from any other I had previously encountered. Upon returning to my laboratory, I immediately started my gas chromatograph and eagerly watched the monitor as the sample ran. The results

showed one main peak, which was the monoterpene linalol. While linalol has been identified in a closely related species, *M. didyma*, no one has ever reported this compound in *M. fistulosa*. As grandiose as it may sound, I felt I was witnessing an evolutionary event, where a new mutant phenotype had appeared, and if it had some heritable advantage over the resident chemotypes, the linalol chemotype may increase. Then again the plant may get mowed by the road maintenance crew before setting seed, a fate for which its new mutation would be useless. Anyway, the next time you are hiking and encounter wild bergamot in the wild, don't forget to stop and give it a sniff. You may not find a new chemotype, but you will sample just a little of the olfactory genetic diversity that makes up *M. fistulosa* in Colorado.

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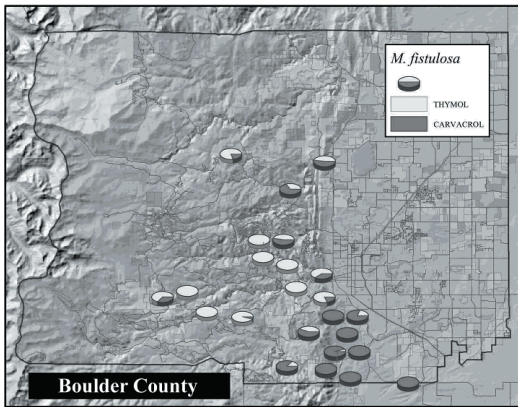

Figure 1. The chemotype distribution of 24 populations of *Monarda fistulosa* in Boulder County, Colorado.

"*Field Trips*" continued from page 2

Shale Barrens of the Laramie River Valley
Date: Saturday, July 29
Leaders: Rich Scully, Georgia Doyle and Mary Jane Howell

The upper Laramie River Valley is located in extreme northwest Larimer County. Along slope breaks among the sagebrush-covered uplands, there are calcareous shale barrens that host several rare plant species, including *Penstemon laricifolius ssp. exilifolius*, *Eriogonum exilifolium* and *Phacelia formosula*. The shale barren plant community contains elements of both Colorado and Wyoming floras, including the only Colorado state record of *Oönopsis wardii*. We will make an easy four-mile day hike starting in mid-morning and finishing mid-afternoon. For details and to register for this field trip co-sponsored by the Fort Collins Chapter, contact Rich at 303-823-0766 or richwscully@msn.com.

Cameron Pass
Date: Friday - Sunday, August 4-6
Leaders: Johnny Proctor and Denise Culver

Enjoy a weekend on the trail of the elusive moonworts. Get ready to look hard for *Botrychium lunaria*, *B. lanceolatum*, *B. echo* (G3S3), *B. minganense* (G4S1), *B. simplex* (G5S1) and hopefully *B. lineare* (G1S1). Meet at 6 pm, August 4 at the Aspen Campground for festivities, or meet at 9 am on August 5. Free camping will be available Aug. 4 - Aug. 6. To register for this field trip co-sponsored by the Fort Collins Chapter and the Medicine Bow-Routt National Forest and Thunder Basin National Grassland, please contact Denise Culver at 970.491.2998.

South Platte Park
Date: Saturday, August 5, 9 am - 12 pm
Leader: Ray Sperger

Surrounded by Denver metropolitan suburbs, the South Platte Park unit of the South Suburban Parks provides an important site for wildlife habitat connectivity, as well as functional riparian, wetland and upland ecosystems. This trip will highlight various restoration projects undertaken at this park site. We will meet at 8:45 am at South Platte Park, Carson Nature Center, 3000 West Carson Drive in Littleton (north of Mineral and west of Sante Fe). To register for this field trip co-sponsored by the Horticulture and Restoration Committee, please contact Steve Yarbrough at syarbrough@e2m.net.

Winter Botany at White Ranch
Date: Saturday, January 13, 2007, 1:00pm
Leaders: Carol English and Leo P. Bruederle

This trip will emphasize identification of plants in their winter condition. White Ranch is a Jefferson County Open Space Park located in the foothills northwest of Golden. As such, we will be hiking (or possibly snowshoeing) through open meadows and forested foothills, while identifying the prominent shrubs and trees dominating the landscape. We will also use our understanding of basic botany to identify weeds and other herbaceous plants using characteristics of their growth form, inflorescence and fruit. Why put our hand lenses and field keys away in September with winter botany still ahead? To register for this field trip co-sponsored by the UCDHSC Department of Biology, please contact Leo Bruederle at 303-556-3419 or leo.bruederle@cudenver.edu.