Prairies Make Good Scents

BEE BALM, A PRAIRIE NATIVE
by
Ken Keefover-Ring

When most people think of the plants found on the prairie, they usually think just of grasses. However, prairies are filled with many other plant species, including some in the mint family, known botanically as the Lamiaceae. This family is well known to us through species such as thyme, lavender, and rosemary. While all of these familiar mints are native to the Mediterranean, the North American prairie has its own mints.

One such species is *Monarda fistulosa*, commonly known as wild bergamot, horse mint, or bee balm. Bee balm is easily identified by its large spherical head of dark pink to purple flowers, which are apparent beginning in mid-summer and sometimes last until the end of September. Like other mints, bee balm produces small volatile chemicals called monoterpenes in tiny sacs (trichomes) located on leaves and flower petals. Upon rubbing bee balm leaves, these trichomes are broken and almost immediately the scent of escaping monoterpenes is detected. Also known as essential oils, monoterpenes have been used by humans for thousands of years as fragrances and flavors. Plants however, use them for a variety of functions, including: suppression of plant competitors, repelling herbivores, or attracting pollinators and seed dispersers. In addition, many labiate species contain individuals with distinct chemical phenotypes, called chemotypes, which are controlled by simple genetics. Plants of a particular chemotype often 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.

Bee on Bee Balm
Ken Keefover-Ring

M. fistulosa is known to have three chemotypes, with individual plants containing either geraniol, carvacrol, or thymol, as their main monoterpene. Geraniol has a sweet, floral smell, whereas carvacrol and thymol remind one of thyme or oregano, both of which contain these chemicals. 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. I have sampled and measured the essential oils of *Monarda fistulosa* populations on the prairies (and foothills) from southern Colorado to southern Manitoba in Canada. I have discovered that two of the known chemotypes, carvacrol and thymol, occur throughout most of the plant's range, in pure and mixed populations. Geraniol plants are limited to a small area in southern Manitoba. This chemotype is thought to have arisen relatively recently due to some sudden mutation.

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, the chemical that give lavender its characteristic smell.

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 100 populations of bee balm throughout the states of Colorado, Wyoming, the Dakotas and Manitoba. 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.

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Chemical analyses revealed variation ranging from populations comprising only single chemotypes, to those with various mixtures. So, what factors are responsible for these patterns? One explanation may be temperature. In Boulder County, where many of the populations analyzed occur, 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. To unravel this question in *M. fistulosa*, I am currently monitoring the temperature, humidity and other abiotic parameters at sites with different chemotype compositions.

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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 end up as significantly smaller adults than those who were given only thymol foliage. 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.

So, prairies are more than just grasses. Other plants, such as *Monarda fistulosa*, are important components of these ecosystems. In addition, the different chemotypes of bee balm and their interesting distributions demonstrates the genetic diversity of prairie species, which in this case is only evident to your nose. So, the next time you are hiking on the prairie and encounter bee balm, 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 rich plant diversity that prairies have to offer.

Coneflower, courtesy of Ruth Baranowski