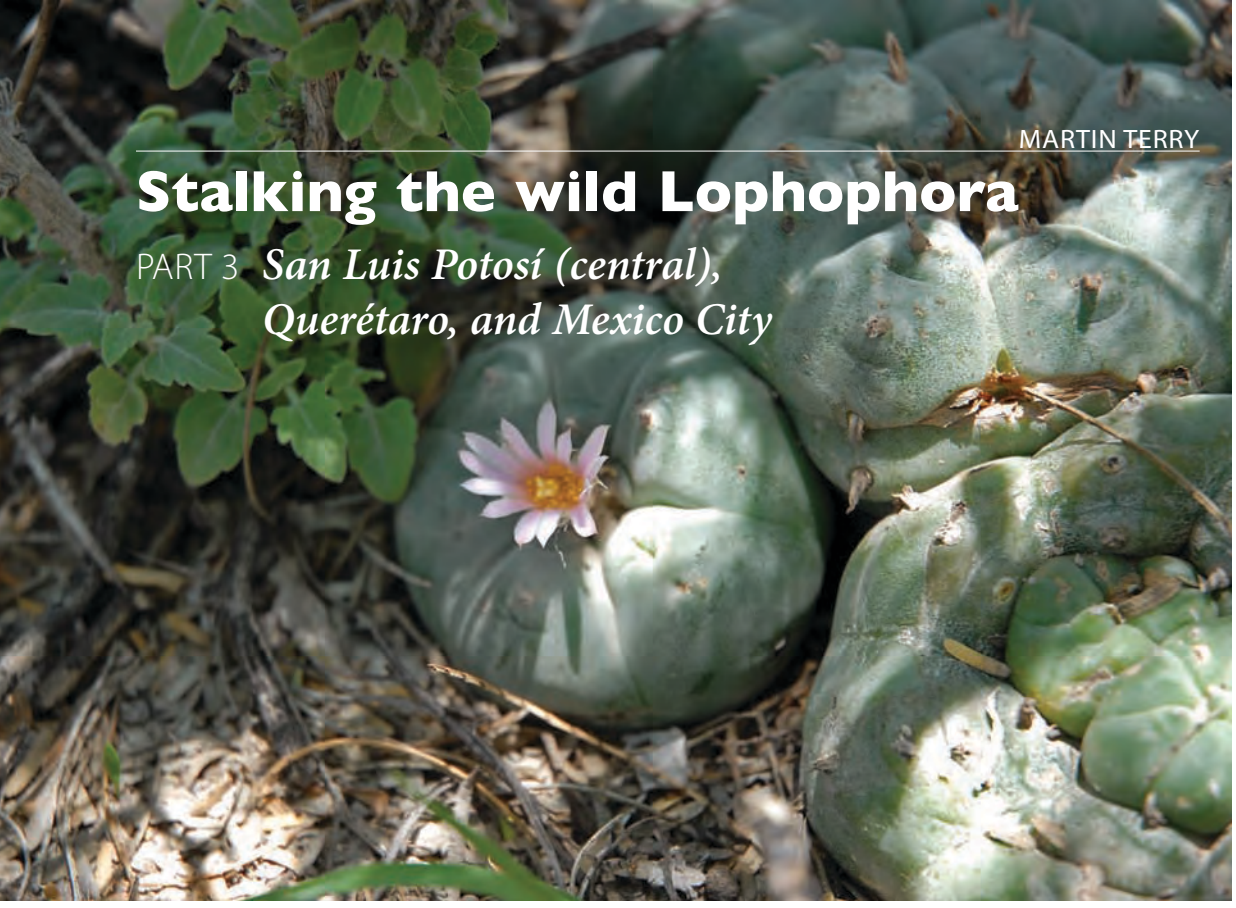


MARTIN TERRY

Stalking the wild Lophophora

PART 3 *San Luis Potosí (central), Querétaro, and Mexico City*

We continued south on Highway 101, leaving Tamaulipas and entering San Luis Potosí just before we hit Highway 80, on which we turned east toward El Huizache. The latter is a village at the intersection of Highways 57 and 80. It is also the landmark for the population that Ted Anderson selected as the source of his neotype specimen to represent the species *Lophophora williamsii*. I had visited this population in 2001, and it was immediately apparent, now six years later, that the population had undergone some changes for the worse. There was evidence that plants were being dug up entire (including the roots, as opposed to the sustainable practice of removing the "button," or aboveground portion of the stem, and leaving the large subterranean portion of the stem to resprout (see sidebar *Where's the goods*) and the average size and density of the plants had visibly decreased compared to what I had seen six years before, with the clumps of caespitose plants being similarly reduced in size. There was also new agricultural activity in the middle of the *Lophophora* habitat, where fields plowed for marginal agriculture had replaced Chihuahuan Desert. An undernourished burro brayed at us—or perhaps it just brayed, at no one in particular—before retreating into the brush. It was not an appealing environment to spend time in, and as soon as we had collected our samples and taken our photos, we left, heading further eastward on Highway 80.

We stopped after a short distance to check a friend's GPS record of what was reported to be "*L. williamsii*." And we did indeed find *Lophophora* there, on both sides of the highway, but it was *L. koehresii*, not *L. williamsii*. This was another mud-flat population, and while the plants were not exactly abundant, we were able to find enough to meet our quota of tissue samples without difficulty. Here again, there was no evidence that the *L. koehresii* had been harvested, despite the fact that it was a heavily trafficked area with much human activity.

Robert noticed that just a short hike up from the highway was a limestone ridge that looked like typical habitat for *L. williamsii*, so we decided to check it out. Bingo! On the lower slopes, in alluvial limestone soil, we found just a couple of specimens of *L. williamsii*, but a few meters farther up in a limestone outcrop we found classic *L. williamsii* habitat and what *had* been a fairly dense population of the species. Unfortunately we arrived a few weeks too late to see the population in its full glory. The landscape had been devastated. Massive quantites of whole plants had been dug up and removed. Seedlings and

◄▲ Near El Huizache, San Luis Potosí, *L. williamsii* may be solitary or caespitose. This is the neotype locality for *L. williamsii*. Its fame and easy accessibility, at the junction of two major federal highways, render it an obvious target for commercial cactus harvesters, and we found a number of their familiar excavations where entire plants had been dug up and removed. The plants here are expected to be genetically different from the *L. williamsii* that occur in the US, because the Texas plants are apparently 100% self-fertile, whereas the plants from El Huizache are reported to be obligate outcrossers (that is, a given plant can set viable seed only if it is fertilized by another plant). That means the Texas plants are highly inbred with minimal genetic diversity, while the El Huizache plants are expected to show far more genetic diversity within a given population.

We do not know the nature of the market the destroyers were supplying with these plants. We do know, however, that it was a mescaline market.

small juveniles had been dug up, discarded, and left to die. The poachers had been careless and dropped a few of the uprooted adult plants along the trail on the way out. We replanted as many of the uprooted plants as we could find and collected the tissue samples we needed, but this scene of destruction was sickening, and we left without delay. We do not know the nature of the market the destroyers were supplying with these plants. We do know, however, that it was a mescaline market. We know this because the poachers walked right through the population of *L. koehresii*—without touching them—on their way to the ridge where they found and thoroughly pillaged the population of *L. williamsii*. They knew exactly what they were looking for, and it was not pellotine (see sidebar *A cactus at the pharmacy)*.

The positive aspect of the situation was the clear finding of two populations, one of *L. koehresii* and one of *L. williamsii*, separated by no more than 500 meters, but completely distinguishable morphologically, ecologically, and phytochemically (the difference in alkaloid profiles is reported in the analytical work of Štarha[6] and confirmed commercially by the poachers' accu-

WHERE'S THE GOODS?

The concentration of mescaline (the hallucinogenic chemical) in peyote varies among populations. It also varies with time of year, plant age, and tissues sampled. Some investigators have found considerably less mescaline in the roots of plants from some populations, for example, but others have found mescaline concentrations in the root and stem to be similar. I suspect that this disparity is attributable not so much to variation in the methods of analytical chemistry, but rather to widespread misunderstanding of how much of the subterranean portion of the plant is actually stem, how little is actually root, and where the thin transition region between these tissues is. Specific tissue concentrations of alkaloids constitute another one of those questions that needs careful and comprehensive evaluation, taking into account geography and time of year, as well as tissue type. And the answer to this question is not merely academic, as harvesting the tuberous subterranean portion of the plants hampers new vegetative growth and therefore jeopardizes the population.

rate, selective behavior in the field). I predict that our DNA data will show an equally clear distinction between these two seemingly sympatric, but in fact ecologically allopatric, species.

We spent the night in Ciudad del Maíz, where cooked food, a shower, and bed were welcome amenities. Next morning, refreshed, we hit the highway heading south on a good gravel road, stopping to sample more *L. koehresii* populations near Las Tablas and San Francisco. The Las Tablas population is one that has been known for many years—but not as a population of *L. koehresii*. Ted Anderson included Las Tablas among the populations he sampled for his PhD thesis, but he did not recognize that the specimens there were anything other than an unusual form of *L. williamsii*[7]. And I confess that when I first saw these plants in 2001, my reaction was similar: They're just *L. williamsii* plants with a different flower color, living in lowland alluvial soil instead of upland calcareous soil. But these are not taxonomically significant differences in such a highly polymorphic species as *L. williamsii*...or so I thought. Once one's eye has learned to recognize

▲ *L. koehresii* east of El Huizache, growing mostly in mud near the highway. The large specimen was found growing beneath a large *Opuntia leptocaulis*. ▼ Scene of destruction east of El Huizache. *L. williamsii* was uprooted *en masse* by commercial cactus harvesters, who dropped these plants on the trail between the highway and the peyote population. Interestingly, they walked right through a population of *L. koehresii*, confirming that species as a non-drug plant. Please note: peyote can be sustainably harvested. It is not necessary to remove the root of the plant to harvest the "button." If left behind, the subterranean portion of the stem will often sprout new stems that eventually grow to become harvestable crowns.[2]

▲ *Lophophora koehresii* near Las Tablas, San Luis Potosí. Ted Anderson and I both mistook these plants for *L. williamsii* on first sight, but we would not now make the same mistake. Morphological differences include the relatively small size of the mature adult stems of *L. koehresii* and the relatively large size of its flowers, which may have tepals twice the length of those on *L. williamsii*. The fruits of *L. koehresii* are essentially spherical, in contrast to the cylindrical fruits of *L. williamsii*. The seeds of *L. koehresii* are larger than those of *L. williamsii*, and the two species have markedly different topologies of their seed surfaces as viewed under scanning electron microscopy. Other differences include stem color: generally a dark green in *L. koehresii*; blue green to gray green to butternut-brown green in *L. williamsii*. Large specimens of *L. koehresii* may develop a conspicuous "double-chin-like" horizontal fold of tissue at the base of the crown, similar to those seen in large specimens of *L. diffusa* that cannot support the weight of their own upper stem (especially during drought), but such a fold of tissue is never seen in *L. williamsii*, which has much more rigidly constructed ribs.

A CACTUS AT THE PHARMACY

Pellotine, which was marketed as a sedative/hypnotic about a century ago by Boehringer & Sohn in Germany, was obtained by isolating the alkaloid from an extract of *Lophophora diffusa* (at that time confusingly known as *Anhalonium williamsii*. What we now know as *L. williamsii* was then known as *Anhalonium lewinii*). When the Bayer company discovered how to synthesize barbiturates (starting in 1911), the drugs proved so cheap to manufacture—and so effective—that the extraction of pellotine from a field-collected Mexican cactus of unpredictable availability was no longer commercially competitive, so pellotine disappeared from the pharmaceutical market. Eventually Späth[4] synthesized pellotine, and Brossi and others[5] later discovered an improved procedure for synthesizing it, but the drug was never brought back into commercial use. It is interesting that pellotine is the second most abundant alkaloid (after mescaline) in *L. williamsii*, but it is by far the most abundant alkaloid in the other species of *Lophophora* (accounting for 70–90% of total alkaloid content), and in those species mescaline is present in only trace concentrations—not high enough to have pharmacological effects from ingestion of the cactus.

the differences between *L. koehresii* and *L. williamsii*, the two taxa remain indelibly demarcated and impossible to put back into the same conceptual taxonomic container (see sidebar *It's in the ribs)*. Particularly conspicuous is the *diffusa*-like rib morphology of *L. koehresii*, characterized by shallow, sinuous sulci separating adjacent ribs. Successive tubercles within each rib are connected with each other in such a way that repeated tandem hourglass shapes radiate from the center of the crown, and the tubercles of any given rib are in conspicuous alternation with the tubercles of the two adjacent ribs. Such differences cannot, however, be discerned from desiccated herbarium specimens, even by the most experienced cactus experts. One has to see the plants alive in the well-defined ecological niches of their natural habitats to appreciate how different they really are.

Querétaro

From the southernmost population of *L. koehresii* near Río Verde in San Luis Potosí, we faced a long afternoon of driving—south down Highway 89 to Jalpan, and then south toward Vizarrón on Highway 120—to reach the land of *Lophophora diffusa* in the state of Querétaro. We went to the first roadside population indi-

▲ *L. diffusa* in the northern portion of its range. Note the shallow, "diffuse," sinuous grooves between the ribs, especially toward the base of the crown.

cated by our GPS coordinates and immediately found the plants just fifty meters from the highway. *L. diffusa* has an affinity for gravelly alluvial soils of coarse sand, in or near major creek beds (which were all dry when we were there in May). It seemed surprisingly easy to collect our tissue samples from what I had anticipated to be a difficult species to find. Of course it helps if you know where to start looking.

We spent the night at a hotel in Vizarrón within walking distance of an obsolete GPS location for *L. diffusa* on the eastern edge of the town. The location was now an urban vacant lot filled with trash and a few opuntias, but no lophophoras. We talked to a few of the townspeople about peyote in the area, and none of them seemed to know of anywhere in the immediate vicinity of the town where the cactus could still be found.

GEOGRAPHIC DISTRIBUTION OF *LOPHOPHORA*

This map is the most accurate (based on a rigorous requirement for documentation of localities) and phylogenetically complete distribution map for the genus Lophophora now available. It is based on documented voucher specimens (brown dots) from the UNAM database supplied by Héctor Hernández, Billie Turner's Atlas of the Vascular Plants of Texas, personal communications from Gerhard Koehres, Jaroslav Bohata, and Jürgen Menzel, my own field observations, and herbarium specimens I have personally examined. Older maps tend to portray the range of *L. williamsii* as being more extensive, particularly with regard to the placement of its northwestern boundaries. Such marginal regions are indicated by question marks in the present treatment due to the lack of voucher specimens. All these areas merit further exploration but are

So the next day we went up the highway a few kilometers to a "fresh" location indicated by a friend's GPS coordinates for a population that had been visited recently and confirmed to exist. This population was also on both banks of a large dry creek, but most of the plants were obviously on private land. The owner's dog barked at us from a distance until the owner came out to see what was going on. I walked down a broad, open arroyo to talk with him. He did not tell us to remove ourselves from his ranch, nor did he say that he preferred that we not take tissue samples from his peyote plants. But he did want to see the written *permiso* from the Mexican authorities authorizing our research activities. So I told him I'd go back to the truck and get the papers, but when I was about 100 meters away, he shouted

PEYOTE AND THE LAW

Drugs are placed in the DEA's Schedule I because they are deemed to have "high potential for abuse… no currently accepted medical use… [and] lack of accepted safety data for use… under medical supervision."[8] Although such scheduling may seem unjustified with regard to what is actually known of its effects, unlicensed possession of any part of *L. williamsii*—including its seeds—carries non-trivial criminal penalties in the US. Our British friends, and many other cactus growers around the world, are welcome to grow peyote, and it is frequently found on seed lists of our sister societies and foreign nurseries. For reasons which are not entirely obvious, peyote has now been banned in France, Italy, the Czech Republic, Russia, Poland, and most recently Australia, much to the consternation of cactus enthusiasts in those countries.

▲ *L. diffusa*—a population in the central portion of its range with large, all-white flowers similar to those seen on *L. koehresii*. ▼ We stayed at the Motel Santa Rosalía in Camargo, Chihuahua, en route from Mexico City to the Texas border, only because my student's full first name happens to be Rozalía (Lía for short, though it is unclear whether she would identify with the title 'Santa'). The limestone mountains visible in the background are suspected (not confirmed) to constitute habitat for the elusive *L. willliamsii* of Chihuahua.

and waved "never mind"—or at least I interpreted his wave and shout in that sense. In any case, we finished gathering our samples without delay, to avoid any further complications. The plants at this location tended to be caespitose, forming clumps up to 30 cm in diameter, and many of them were in full bloom (even in the apparent absence of recent rain), their large white flowers contrasting with the distinctive yellowish green hue of the crowns of the plants.

Mexico City

Having sampled all the populations we were going to include in our DNA study, the next phase of the trip was to proceed to the National Autonomous University of Mexico (UNAM) in Mexico City and extract DNA from the tissue samples in the laboratory facilities provided by my friend and colleague, Héctor Hernández. That little maneuver was designed to eliminate the non-trivial problem of transporting peyote tissue (a Schedule I controlled substance—see sidebar *Peyote and The Law*) from Mexico into the US, which has not legally been done in the last 35 years, and which would require *permisos* involving new and untested regulatory pathways on the Mexican side. The solution to the problem was to separate the DNA from the psychoactive alkaloids (particularly mescaline), and to wash the latter down the drain in the lab in Mexico City, so that we would be transporting only pure DNA back to the US. The laboratory phase of the trip in Mexico City was a mixture of hard work and great company, as we found a warm reception from Héctor Hernández and family and from his colleagues at the molecular biology lab of the Instituto de Biología at UNAM, where in about ten days we were able to develop and apply a viable way of making commercial DNA extraction kits work on our samples without the use of liquid nitrogen. But that is a technical story for

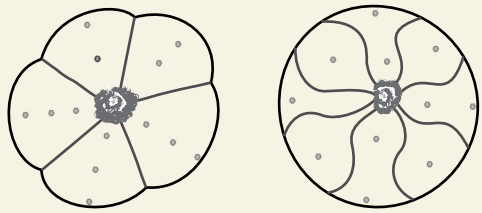
cactus-DNA nerds—the sort of stuff you'll read in *Haseltonia* when the DNA study is completed.

Border Epilogue

The last vignette of our experience on this cactus trip involves an incident that occurred upon our reentry into the US at the Presidio Port of Entry in Far West Texas. Because I had among my DNA samples a few grams of non-mescaline-containing tissue from the three *Lophophora* species not included in the legal definition of peyote, I had consulted on the phone with my DEA contact in the El Paso office to get his guidance on how to avoid problems at the border. He kindly put me in touch with the Director of the Port of Entry, who in turn alerted the USDA person on his staff, who would be expecting me to pass through the Port of Entry on a specified afternoon to help with the inspection of my cactus tissue and to avoid unpleasant encounters "of the third kind." Unfortunately, the USDA person so-informed was ill that day, and the only other person who could carry out the "Aggie" inspection function was not coming in until four o'clock in the afternoon. So what actually happened was that I duly declared the cactus tissue and the cactus DNA as required, and the random inspector I talked to thought this was the most exciting thing that had happened in Presidio in weeks. Soon I had a half dozen young men in dark blue uniforms standing in a semicircle at the back of my pickup, staring at the samples and firing questions at me. When their routine questions failed to elicit anything more than a boring response from me, one of them puffed up his chest and asked, "Do you have FDA authorization to be doing research with this DNA?" To which I responded, "Well, as a matter of fact, I do, but FDA authorization is not required to bring plant DNA into this country." And he responded, most wonderfully, "It is if you want to bring it in through *this* Port of Entry." About that time a supervisor showed up and broke up their sport, and the dialogue returned to a more rational plane. The senior officials were cordial and as helpful as they could be, given the uncomfortable uncertainties that evidently, in their minds, surrounded plant DNA. In the end, we were able to clear customs in a mere two and a half hours, including the time it took to radiograph my entire old truck. "Just as a formality."

IT'S IN THE RIBS

There are conspicuous differences in crown morphology between *L. williamsii* (left) and *L. koehresii* (right). Ribs of *L. williamsii* are raised and clearly divided by straight, deep sulci (grooves). Each rib



resembles a pie slice. Tubercles, denoted by areoles bearing tufts of hairs, may be individually raised, forming a radial row of elevations along the already raised rib. Ribs of *L. koehresii* are flat and subtly divided by sinuous, shallow sulci. They show an alternation of widening at each tubercle and narrowing between tubercles, forming a radial series of connected figure-eights. Tubercles, denoted by areoles bearing tufts of comparatively few, shorter hairs, are relatively flat. The tubercles of adjacent ribs tend to be offset, so that a wide tubercle in one rib is situated between the narrow intertubercular portions of the two adjacent ribs.

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