Chasing *Canotia:*

Story and images by Benjamin T. Wilder

Science Expedition

As we pushed up the final meters to the highest ridge, Isla Tiburón finally revealed itself as an island—the largest in Mexico and homeland of the Indigenous Comcaac (Seri People). Only then could I see the waters of the Gulf of California on all sides. The mountainous spine of the Baja California peninsula loomed far to the west, and the mainland and Sierra Seri rose just to our east, separated from the island by the narrow Canal del Infiernillo (Channel of Little Hell). I had ventured to the highest points of the island to fill in a long-standing gap in the flora of the island—a rigorous treatise of all the plants that occur in a defined area. What plants occurred at nearly 900 meters above the desert coast on this 1,200-square-kilometer island? No one knew, so in collaboration with my mentor Dr. Richard Felger, I ventured forth to find out. Little did I know that what we would find would send me on journey to the far corners of the North American deserts and then back again to the place where it all began at the top of the island, seeing it as if for the very first time.

After taking in the view for a couple minutes with my companions—botanist Brad Boyle and Comcaac bighorn sheep guide José Ramón Torres—we got back to the task at hand. We were there to carefully examine, record, and document the plants we found at the top of the island by collecting specimens, and our time was limited. Generally, the tops of mountains are cooler and moister and, accordingly, more vegetated than the portions down below. At 29ºN, just a couple hundred kilometers north of the southern edge of the Sonoran Desert, I expected that the top of Tiburón would hold a large array of more tropical species. As we climbed through the canyons leading to the high ridge, we had come across several, adding nearly a dozen new species to the flora of the island. Yet, the top of the island was surprisingly marked with bare ground and more shrubs than trees, many of these the same desert shrubs and trees as on the desert floor. Soon, a patch of short, green, spine-tipped shrubs drew our attention. They looked remarkably like the crucifixion thorn of northern and central Arizona, *Canotia holacantha*. But

A quest for a landscape's past reveals time embedded in a desert shrub

that wasn't possible, was it? All doubt was erased when José Ramón found the unmistakable woody capsules still attached to the plant. *Canotia*, here at the top of the island, hundreds of kilometers from the closest known population? The intrigue was too much to ignore. As in any good science expedition, one question and discovery leads to the next. The hook for my dissertation had been set.

Four years later found me driving up the endless switch backs of mainland Mexico's Sierra Madre, or God's Middle Finger, as Richard Grant's exploration novel calls this range. I was with my friend Abram Fleishman in a Ford F-150 belonging to the University of California, Riverside, the institution at which I was now at pursuing my PhD. We were on our way to Coyame, Chihuahua, at the far

PAGES 30-31: The rugged interior of Isla Tiburón. The author collecting *Canotia* on Isla Tiburón (image by Servando López Monroy).

ABOVE: Looking toward the Baja peninsula in the west (image by Brad Boyle). *Canotia* at an island high point.

edge of the Chihuahuan Desert and over 700 km east of Isla Tiburón. Since returning from the top of the island I had decided to pull on the thread of the *Canotia* enigma and try to get to the bottom of what was it doing on the top of Isla Tiburón, and to see what that could that tell us about the history and origin of the Sonoran Desert. The tool I would employ is known as population genetics, which is based on the idea that genetic signatures—in this case slow-mutating chloroplast DNA sequences—capture the relationships between different populations back in time, revealing past geography. I was now on a quest for widely scattered populations of *Canotia* across its range, and Coyame has one of the rarest of all.

Tucked into the rolling limestone hills of the Chihuahuan Desert are the only locations of the other species in the *Canotia* genus, *Canotia wendtii,* first identified in 1975. Our journey took us up the moist tropical slopes of the Pacific side of the Sierra Madre, through the pine forests of Yécora in the highlands of the Sierra, into the deep barrancas outside Madera, Chihuahua, then down the gentler grade of the eastern side of the Sierra and into the Chihuahuan Desert. This is the land of sotol, or desert spoon—an agave relative used to produce a delicious distilled beverage of the same name, which we met on our journey and with which we quickly became well-acquainted.

Unlike the Sonoran Desert, in its northern stretches the Chihuahuan lacks columnar cacti; it is a landscape of low stature with vast landscapes of creosote bush, shindagger, agave, sotol, and other shrubs. This high-elevation desert is too cold in the winter for columnar cacti, and in general shares relatively few species with the Sonoran Desert on the other side of the great Sierra Madre—except, that is, for *Canotia*.

After several days' travel and multiple side trips that familiarized us with this new desert land, we reached the coordinates noted on herbarium sheets of *Canotia wendtii* at the University of Arizona herbarium by those who first collected and named this species. Not sure what to expect, we walked a short way from the truck—and immediately found a dwarf *Canotia*, nearly identical to what I had seen on Isla Tiburón, but shorter, around knee-height. Remarkably, an area of less than one square

Flagstaff
Tonto Basin
MOGOLLON HIGHLANDS
GILA NATIONAL FOREST
Phoenix
KOFA MTS.
Sonoran Desert
TABLE TOP
Tucson
U.S.A.
MEXICO
SKY ISLANDS
DEMING GAP
Chihuahuan Desert
Tubutama
Magdalena
Gulf of California
BAJA CALIFORNIA
SIERRA SERI
Coyame
Hermosillo
Bahía de Kino
ISLA TIBURÓN
SIERRA MADRE
Pacific Ocean

LEGEND

- Collection points for *Canotia* mentioned in this article
- In pursuit of *Canotia*
- Continuous range of *Canotia*

Map by Roseann Hanson

Canotia holacantha drawing by Lucretia Brezeale Hamilton.

kilometer, in the middle of the Chihuahuan Desert indiscernible from the surrounding areas, is the only place this species is found. The plot was thickening. We made our collection of stems from about 30 individuals, each tucked into individual bags, dried and preserved with silica gel, to hold until I could extract the DNA and then analyze a selection of sequences back in the laboratory.

Having gone to the geographical extremes, it was now time to fill in the middle. The distribution of the much more widespread crucifixion thorn *Canotia holacantha* is intriguing in itself. A series of isolated and discrete populations in the states of northern Sonora and southern Arizona give way to a near-continuous population in central and northern Arizona, where the species is often dominant on the landscape.

The isolated populations are often on desert peaks with similar elevations to Isla Tiburón—around 900 to 1,200 meters. These summits are far shorter than the towering sky islands of the greater southwestern United States, where you can travel from desert to conifers in an hour, the biotic equivalent of Arizona to Canada in 2,500 meters elevation gain. However, they share an important similarity: the higher elevations of these desert mountains also harbor vegetation distinct from what is found on their lower slopes. They are

mountains in a sea of arid lowlands. When the cooler and wetter environments of the last glacial maximum—about 21,000 years ago—began to transition to warmer and drier conditions, species once widespread in the lowlands followed favorable habitat and moved up in elevation as well as latitude. Novel communities replaced them in lower-elevation habitats, such as the Sonoran Desert we know today.

It was time to climb those mountains.

The desert peaks where *Canotia* is found, as well as the majority of its range, are within a day's drive of Tucson, Arizona. I was able to undertake day trips or short camping trips to these sites scattered across southern Arizona and northern Sonora. I started closest to home in the Waterman Mountains, just 45 minutes northwest of where I was born and raised in Tucson. My father, Janos Wilder, joined me as we drove to the base of the rugged limestone outcrop, a rare occurrence of limestone in the Sonoran Desert and a favorite soil type of *Canotia*.

Again, based on coordinates from an herbarium sheet of *Canotia* collected here years prior, we set out to see if we could find our target plant. On the higher portions of the north-facing upper slopes, they soon became common. We cut off individuals stems, scraped away the waxy cuticle, and made strips of the green photosynthetic bark to make the DNA extraction easier. My father was a quick study whose knife skills as a chef came in handy.

Similar trips began to fill in pieces. Rather than simple collection points on the map, each site revealed itself to be a unique window into the past. It was not just *Canotia* that occurred on these desert peaks, but full communities of plants that are extraordinary, notably distinct from the more prevalent desert vegetation at their slopes or through much of the desert lowlands. Table Top Mountain hosts a relic grassland at its flat summit. Drivers going east and west on Interstate 8 would never suspect that flat-topped mountain to host a gallery of species from the last ice age. Farther west, near the Colorado River, the deep, sheltered canyons of the Kofa Mountains likewise support a bevy of extralimital species (that is, oustide normal range) species. These include oaks, desert almonds, the California fan palm—and our friend *Canotia*. Not

LEFT: Hundreds of miles to the east of Isla Tiburón on the mainland, *Canotia* lives in an isolated pocket in the Chihuahuan Desert.

ABOVE, TOP: Collecting *Canotia* in the Kofa Mountains near the border of California and Arizona (image by Rebecca Wilder).

ABOVE: *Canotia* on the rugged slopes of the Waternan Mountains, looking east toward Tucson, Arizona.

too far north and east, near Bagdad, Arizona, is a magnificent forest of joshua trees, rivaling the most beautiful and well-known stands of the California deserts. This anomalous community of *Canotia*, joshua tree, and creosote speaks to remnant plant associations from another age.

Next up on the list of locations were a couple of isolated populations in northern Sonora. Each of these occurrences are at the upper elevational edge of the Sonoran Desert as it grades into more woodland-like communities of juniper and oak. A robust population had been reported around the Pimería Alta mission towns Sáric and Tubutama, founded by Father Eusebio Kino between 1687 and 1690. The town names derive from words of the Indigenous Tohono O'odham, and reflect the long-standing presence of O'odham in Sonora.

Unfortunately, these towns are also right in the center of territory contested by drug cartels and plagued by extreme violence. A week prior to my departure, a convoy of some 50 vehicles from El Chapo's Sinaloa cartel was ambushed by the Beltran Leyva cartel in the hills in the exact area where *Canotia* occurs. When I drove past the turn off toward Sáric, just south of Nogales, I passed dozens of Mexican military armored vehicles trying to impose some order. The situation has remained volatile for over a decade, keeping the plants out of reach, upending the lives of the O'odham and Mexican citizens of these towns, and further sliding toward chaos as the shadow of the cartels expands.

After collecting from other locations in northern Sonora that I was able to reach, just one thing remained—samples from where the quest began in the first place. From the top of Tiburón I had seen the even higher Sierra Seri on the opposite mainland, just across from the island. I figured that if *Canotia* is here, it must be there. I set out to find out in one of the driest years of the decade (a dissertation does not wait for good rain years). Nonetheless, these perennially green-stemmed spiny characters are more or less drought-proof, and off I set with my friend and teacher Humberto Romero Morales and his nephew Maximiliano Damian López Romero. We climbed up the north face of the tallest part of the range, Pico Johnson, aiming for its upper portions.

In a seemingly trivial pre-trip task, I had replaced my empty sunscreen with a Walmart product I picked up in Guaymas, Sonora. Now on the mountain, it became clear this sunscreen had a scent that water-starved Africanized honeybees could not resist. (Many favorite desert camp sites are now quite challenging in dry times due to established colonies of Africanized honeybees.) Soon dozens of bees lined the edges of my shirt on my arms and neck, and on my face drinking my sweet sunscreen-laced sweat. I am not afraid of bees and know they are just looking for water and to let them do their thing. Luckily I was not allergic—or so I thought.

We continued to climb and to my exultation there she was, a stand of *Canotia* just where I thought it might be. I quickly began the careful preparation of the samples by scraping the wax off and creating the thin photosynthetic strips. I entered a remarkable Zen-like state of focus, working the stems with my knife as the bees crawled over my skin, drinking my water. The second day in, working on my tenth plant, I went to brush sweat off my ear and inadvertently swiped a bee instead, which instantly stung me—quickly followed by another, and another, with more following suit. I dropped everything and somehow ran down a steep talus slope for several hundred feet as the bees chased and continued to sting. Finally beyond the bees, my whole body began to aggressively itch, my face and limbs swelled, and my heart began to race. I sat in the shade and calmed my breath while the itching and heart rate diminished, though the fat head lingered for hours.

With the goal in hand, it was time to head home, though the additional mysteries higher on that mountain beckoned—and still do.

I decided not to push my luck again that season and waited until the following year to go back to the top of the island and make the population collections needed for the genetic analyses. When I returned, I was rewarded with a generous rainy summer and plants in peak condition for exploration. I arrived at the Comcaac village of Punta Chueca and Humberto's house. The challenges and impediments that had hindered the previous field season had vanished and we quickly arranged to go to the island and back to the high peaks. That first moment of being in the panga (a fiberglass open-air boat with an outboard motor) on the water of the Gulf of California is one of those feelings I wish I could bring up on demand. All of my senses felt alive as the motor revved up and we cut through the damp, brisk morning air on a new adventure with each coming moment undetermined. I closed my eyes, breathed in

the moment, and felt gratitude for where I was and whom I was with.

Isla Tiburón has a small network of roads that were first established in the 1960s when the island was decreed a Wildlife Refuge and Nature Reserve. Today they primarily serve the bighorn sheep and mule deer hunting that is intended as a revenue stream for the Comcaac. There is a revolving fleet of secondhand SUVs, most likely stolen and finding their final uses here. They're in a constant state of disrepair, each being cannibalized to support another that is in slightly better condition, until it too is beyond function. This time we were in a "new" red four-door Ford Explorer that sported broken door handles (inside and outside) and a cracked windshield, though it ran well. We drove along the coastal *bajada*, a broad slope of eroded material found at the base of mountains. The plants were denser than I had ever seen, lush with growth from the summer rains. Our spur road turned inland and headed up the *bajada* and straight into the Sierra Kunkaak. The road paralleled a large arroyo draining the interior of the Sierra. We wound our way into the base of the mountains and parked not far from a giant rock fig towering some 15 plus meters above the wash, what we call a dry river bed in the Southwest. We left the cars behind, hiked up a canyon, and soon turned up a ridge to begin the climb. After a couple hours of hiking we reached our upper base camp, and from here the high ridge began to present itself.

The next morning Humberto led us up across numerous ridges that wound to the higher elevations. Soon we had gained the upper ridge and *Canotia* reappeared, more numerous than where I had seen it on the island before, and notably short-statured. It also became apparent that this upper ridge was disconnected from the summit ridge we had climbed last time, separated by a deep intervening canyon. We used our limited time diligently and made a robust collection of about 30 individuals,

enough samples to capture any intra-population genetic variation that may exist. After five years since our first encounter at the top of the island, it was a surreal experience to be back and accomplishing a goal I had so anticipated and sought. All too often exploration can push us constantly on to the next, searching for that discovery around the corner, the next moment. I paused to reflect on what had been accomplished and all that had led to being back at the top of the island.

With the fun part successfully realized, it was time for the months of lab work to unravel the code. DNA extractions segued into PCR amplifications and then sequences of the 83 individuals I'd collected across 16 populations and two outgroups. It was all worth it. Analyses of the sequences revealed a story even stranger than I could have imagined.

The Isla Tiburón population of *Canotia holacantha* proved to be most closely related to the Chihuahuan

PAGE 37: Sunset over Isla Tiburón as seen from Sierra Seri on the mainland. The author and Humberto Romero Morales (image by Servando López Monroy), and the *Canotia* that started it all, with its telltale woody capsules.

ABOVE LEFT: During the 2012 expedition to Tiburón for a final collection of *Canotia* for DNA analysis, the landscape was lush from abundant summer rains. At other times, the land can be almost barren, the plants senescent from drought.

ABOVE: Hiking up into the rugged Sierra Kunaac of Isla Tiburón.

PAGE 41: Sun setting behind Baja California and the Gulf of California as seen from the Sierra Seri.

Desert micro-endemic *C. wendtii*, rather than to the adjacent Sierra Seri or any other location. That unlikely pairing, or sister relationship, that bridges the farthest edges of the map, has significant genetic differences from all other populations. In addition, the populations in Sonora and the Waterman plants form their own cluster, followed by all the rest of the populations in Arizona. Another surprise was that the next closest species to *Canotia*, *Acanthothamnus*—another green-stemmed spiny shrub from southern Mexico—was shown to nest within the Arizona and Sonora plants.

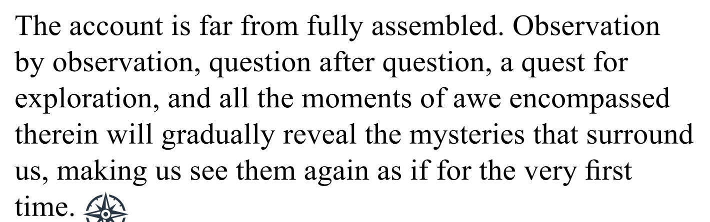
So, what the heck did all that trekking across the desert show and what does this all mean?

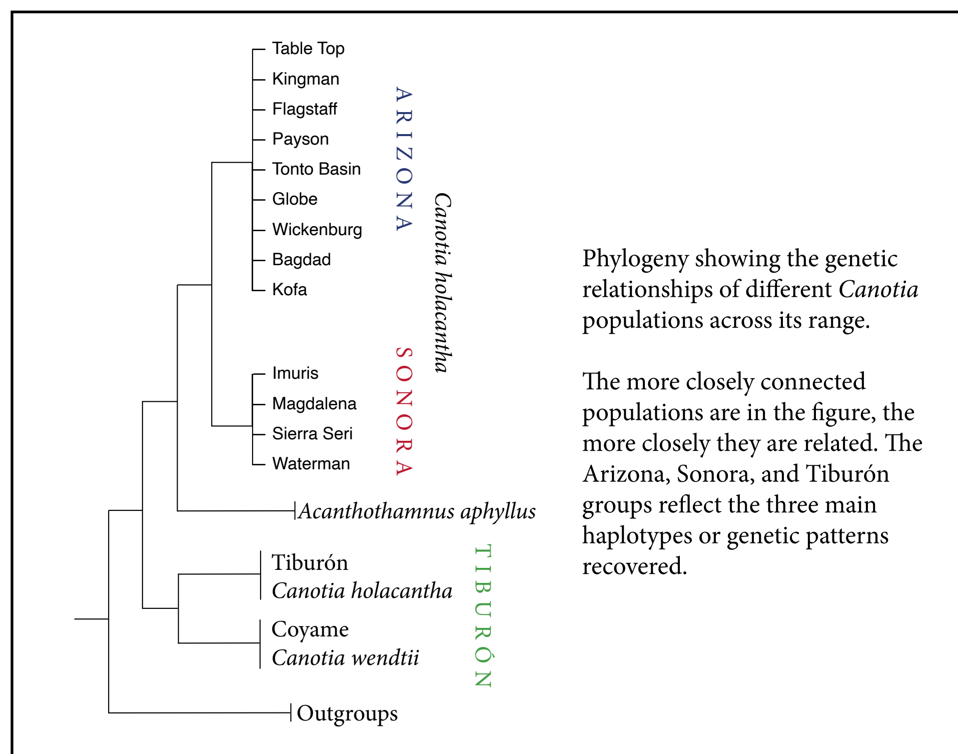
The data suggest that *Canotia holacantha* and related taxa have had a long and likely much more widespread presence across the region than seen today. The disjunct connection between the northern portion of the Chihuahuan Desert, Isla Tiburón, and the southern Mexican deserts home to *Acanthothamnus* hints at a fascinating story of past distributions, refugia, and connections long vanished. It is possible their common ancestor was once widespread across the landscape, and as climates changed the range retracted, leaving populations confined to the insular refugia of Isla Tiburón, hundreds of kilometers away in the limestone hills of the Chihuahuan Desert, and more amply in the arid valleys of central and southern Mexico. Rather than a connection across and over the 23-million-year-old Sierra Madre, the throughway was likely up and around the north end of the range, through the Deming Plains where the Continental Divide drops to its lowest elevation in southern New Mexico. The timing of this is not clear and could date to the current or previous interglacials. It is possible that we are observing the remaining "tips of the branches" of a *Canotia* common ancestor, the "trunk" of which has been eroded by time through contraction and extirpation.

The imprints of time are embedded in the landscape in so many different ways. In this case, the history of the desert is written by plants, some almost fully erased by changing climate over thousands of years.

Yet there they are, with their stories preserved in the letters of their genetic code. On the top of the largest island in Mexico. Tucked in a nondescript corner of the extensive limestone hills of Chihuahua. Sprinkled across desert peaks and scattered throughout the northern edge of the Sonoran Desert.

The account is far from fully assembled. Observation by observation, question after question, a quest for exploration, and all the moments of awe encompassed therein will gradually reveal the mysteries that surround us, making us see them again as if for the very first time.





Phylogeny showing the genetic relationships of different *Canotia* populations across its range.

The more closely connected populations are in the figure, the more closely they are related. The Arizona, Sonora, and Tiburón groups reflect the three main haplotypes or genetic patterns recovered.