15

PLANNING THE JOURNEY OF A LIFETIME

RICHARD WENDELL MANKIN

Content warning: n/a

Would you pack up a trunk of microphones, vibration sensors, amplifiers, recorders, petri dishes, notepads, and a laptop and then fly to a remote part of the Ecuadorian Andes to study fruit fly courtship? Well, if you're doing research to control insect pests by managing their mating behavior, you might jump at a chance to join this expedition.

In this case, the pests were tephritid fruit flies, which are economically important agricultural pests worldwide. Females of many tephritid species lay eggs on developing fruit, and the hatched larvae burrow in and eat or damage the fruit before the grove owners can harvest it. Before the females lay their eggs, they mate with courting males on the undersides of the leaves of a fruit tree. If farmers had economically viable means of interfering with fruit fly courtship, the cycle of adult mating, egg laying, and larval damage to fruit would be disrupted and the currently heavy use of pesticides with potentially harmful human and environmental impacts could be reduced.

Unfortunately, there is no one-size-fits-all solution to disrupting tephritid mating. Each species has a different pattern of courtship, during which males gather into groups on the undersides of leaves, displaying and buzzing their wings in distinctive patterns while interested females fly up, land on the leaves, and pick a favorite. The better we understand these courtship patterns, the better we can develop methods to disrupt them.

Ecuadorian forests are very biodiverse. One cloud forest includes a "hot spot" that contains a cluster of fifty closely related tephritid species in the genus *Blepharoneura* that feed on melon fruits such as watermelon. Unfortunately, much of the cloud forest region is threatened by climate change and human population growth. The stakes are high to examine the mating behaviors of the tephritid species in this diversity "hot spot" before the forest changes forever.

It's not easy to do research in a remote cloud forest in Ecuador, however. First, relationships must be established or strengthened with researchers at Ecuadorian universities and persons familiar with the local geography and wildlife. Then governmental permissions must be obtained to conduct the research in a specific area. Finally, the researchers must plan out and fund the lodgings, equipment, and supplies in advance. I was one of eleven researchers who carried out the project in 2019.

The research is even more difficult when one has limited mobility.

Let me backtrack to the 1950s, when I was living near an air force base in New Mexico. I developed an intense curiosity about the deserts and wooded mountains ten or twelve thousand feet high, as well as their insect inhabitants, nearby farms, jets, radar, and other technology. I remember spending time outside watching airplanes, birds, and insects flying above and staring down at ants and insects on the ground, thinking, "There are patterns here." I wanted to understand how these aspects of technology, nature, and animal behavior fit together. That desire to understand remains with me today, seventy years later.

I grew up before the passage of the Americans with Disabilities Act, and access for those with disabilities was not required at schools. Missing muscles in my legs and arms impaired my mobility, and the school system provided "bedside teachers" who schooled me at home until the end of the second grade, when my teacher convinced my parents and my school principal that I belonged in regular classes. Her helping hand started me on the path through grade school, college, graduate school, and a postdoctoral associateship.

As a child, I was unsure whether limited mobility would affect my ability to succeed as a researcher. Although surgery at age eleven to straighten my legs allowed me to walk with braces and crutches, my mobility remained limited. My legs did not bend while walking, so I moved them out and around on each step, and it took a few years to learn how to travel over rough ground and to climb steps. I had to prepare ahead and set up workarounds to access buildings or deal with longer times for traveling between classes. Along the way, I learned that school and career success depend on careful planning, aided by support from parents and family and later from friends, colleagues, and helpful bystanders. Planning helps me break barriers, especially when visiting a new environment.

By the end of my postdoctorate, I was initially focusing on specialized technologies for studying insect behavior and neurophysiology, and then the focus expanded to insect pest management and environmental conservation. Toward the end of this period, Rachel Carson published her book on the broad and harmful environmental impacts of DDT—the famous pesticide that was used during the World War II era to control insect damage on crops and to protect humans from malaria and other insect-vectored diseases.

I was fascinated with how we could use new technologies to learn about insects in ways that would improve our agricultural and public health practices. After being hired as a research entomologist in 1980 at the USDA Center for Medical, Agricultural and Veterinary Entomology, I became interested in its insect acoustics research laboratory, which focused on detecting hidden insect infestations in stored products, trees, and soil, as well as on disrupting the mating of insects that locate one another using acoustic signals or vibrations carried along leaves, stems, and branches. With colleagues and students, I have developed and tested instrumentation and signal analyses that detect and interpret sounds produced by hidden insects moving (which sounds like scraping) and feeding (which sounds like snapping plant fibers) in distinctive patterns.

Many insects use acoustical or vibrational communications for mating behavior, some of which, like fruit flies, crickets, cicadas, and stink bugs, are familiar to many of us. We collected data on both the sounds that Mediterranean and Caribbean fruit flies made and their temporal patterns and then analyzed their mating communications. We often had to collect signals at remote field sites because the insects could not always be reared in the laboratory or transported to it.

Fieldwork is necessary to ensure that one is not working on the wrong problems, to understand the important processes that help or hinder one's pest management goals, and to make sure that lab experiments work in the real world. I have eagerly collaborated with colleagues in several field studies. And even though I've always had limited mobility, I've exercised regularly and learned to prepare for hazardous terrain at field sites. Depending on the field environment, such as Florida citrus groves, I may have to construct lightweight benches to flatten the working surfaces and keep the equipment dry.

The researcher Marty Condon has been studying the neotropical *Blepharoneura* genus for decades. These flies feed on diverse *Gurania* plants—cucumber relatives. Very little is published about the mating behaviors of *Blepharoneura* species and how they compare with the behaviors of important documented fruit fly pests. Marty enlisted the aid of Sonja Sheffer, a molecular biologist, to genetically identify several species because they could not be distinguished morphologically, and she also asked Sonja to examine the mating behavior of *Blepharoneura*. Sonja called me about the equipment and procedures needed to record and analyze the mating calls, but after some discussion, she recommended that I come along and assist in person.

Soon I was flying to Quito and heading to a lodge near the Sumaco volcano in the cloud forest where Marty, Sonja, and nine other ecologists, biologists, and students on the research team were searching for host plants, raising fruit flies, and collecting DNA for species identifications.

Upon arrival, there was an immediate change of plans because the cloud forest was too wet and noisy to use acoustic and video equipment that was only partly waterproofed. I'm used to holding my crutches vertically on rainy days in Florida to prevent the tips from sliding away, but the shadiest surfaces in the cloud forest were almost like ice—much more slippery than I'm used to. While we were disappointed at first, we quickly decided to conduct the observations in a quiet dorm room in the Sumaco field station lodge, away from most human activity.

Over a three-week period we studied the visual and acoustic mating signals of the different tephritid species that had been found in the forest and whose offspring had been reared on *Gurania* plants in the lodge's kitchen. Individuals of these species were about the size of a typical housefly and fit easily into a petri dish. A little bit of beeswax was used to attach the accelerometer sensor to the dish and pick up the walking and fanning activity of the courting pairs, as well as their low-frequency abdominal vibrations. The daily rains pounding the metal roof and the frequent bird calls made it difficult to collect acoustic recordings of fruit fly matings, but we could detect their vibrations with the accelerometer and observe the visual displays of the male calling from underneath the lid of a petri dish (as if it were the bottom of a leaf). We sat our small accelerometers next to the three-inch petri dishes, quietly waiting and watching for male and female pairs to perform courtship behaviors.

During most courtships, the female eventually declined the male and flew off to the side of the petri dish. However, after six days of observation, we finally observed the first mating. I excitedly called over everyone who happened to be in the lodge, and we all observed and cheered (the flies didn't seem to mind).

I came back to the lab with dozens of vibrational communication recordings, observational notes, and meaningful memories of working with other scientists and students in the cloud forest. Marty, Sonja, and other group members helped me plan the experimental details, set up the apparatus, and maneuver around the difficult terrain outside the lodge. Now I'm analyzing the visual behaviors and auditory signals produced by the different *Blepharoneura* species.

Science is so slowly planned out that only rarely does a person become aware of an important, imminent opportunity, head off to a remote cloud forest with colleagues, and then successfully collect data from just one summer field season. Our success was due to good luck and the collaborative efforts of many individuals. As anthropogenic development encroaches on the habitat of the *Blepharoneura* fruit fly, the data we collected may become a rarity. Looking back, I think this may have been one of the last possible opportunities to capture one of the first and possibly last recordings from all these threatened species with modern equipment. Soon the cloud forest habitat may be changing drastically due to the impacts of climate change and lead us further into unknown territory.

I feel honored to have been a part of this project and its success. The beauty and the diversity of the Andean cloud forest, its birds, and its insects are spectacular. While the forest remains, more people, including other scientists with disabilities, should be able to experience it. We all need opportunities to explore, ponder, and pass on the insights we have gained.