NECTANDRA INSTITUTE

Jun 2013, Vol. 13 No. 2

Musing from an Observer

Ask me "Which is the most impressive animal I have come across in Costa Rica?" You may be surprised to learn that my unequivocal answer would be "Ants". Of course, I knew of ants before coming to Costa Rica, but they were simply part of the urban landscape. As insects, they are tiny, they do not make noise; their bites are tolerable and they are not known to transmit human diseases. Ants simply did not cause my mind to lock on and appreciate them. As an average observer, my infrequent conscious thoughts about ants were associated only with their occasional invasion of my California kitchen.

Yet, I did learn a few things from those annoying encounters. For example, it was not difficult to deduce that ants are highly organized. Otherwise, how else could they stay in the unbroken columns that were no more than a few ant-widths thick—the ones that zigzagged across my kitchen? Ants must be able to receive cues, respond, communicate—and are highly disciplined. Otherwise, how do they know where to go, what to seek, when to stick together and which kitchen to invade? While on their march, their togetherness and single-mindedness were hard to miss. Until they reached that piece of sweet or suet on the kitchen counter, short of my killing them, they could not be persuaded to leave the column, no matter how hard I tried to disturb them: scatter them with vibration, they would only regroup and march on.

Then I moved to the rural neotropics. My exposure to ants skyrocketed. I don't know how many species are found locally but there are some 900 species known in Costa Rica. Right off, the effect of high biodiversity hit home, literally. Inside my home, different ant species prowl in the kitchen, nesting among paper piles, tending their young in my potted plants, and setting up housekeeping wherever it suits them. My house now sits on a gigantic ant nest. Outside, I do my gardening side by side with millions more of them. Each exposure kicked my curiosity up a notch higher, motivating me to learn more about them. With each new discovery, my eyes opened wider and my jaw dropped lower.

Let's just take the ants around my house. The tiniest ants are barely visible, at less than 1 mm, the largest are about 2.0 cm. I quickly learned to give one particular microscopic species the widest berth (assuming I can see them). Their stings are by far the most painful of many ant bites, disproportionate to their size. I have since learned (*For love of Insects*, by Thomas Eisner) that what I felt was not simply the force of mandibles sinking into my flesh, but also a well-aimed application of potent formic acid either injected or sprayed from its rear end. The potency of the formic acid varies with species, some up to 50% formic acid. Interestingly, Eisner showed that if the mandibles were prevented from executing its bite, the ant refrains from spraying—not a practical piece of information. My most startling discovery about bites occurred one day while leaving the house. As I was opening the garden gate to let my vehicle through, I saw underfoot a large wave of red ants, marching shoulder-to-shoulder across the entire driveway, heading out toward the street. Gingerly but hurriedly, I stepped across its path, opened the gate, re-crossed the ant column to get back into the truck, then drove off. Several miles and many minutes later, I was just self-congratulating for having missed a painful encounter with the ants, when I felt their *simultaneous* sting, from ankle to thigh inside my pants. That was a most memorable introduction to the native common tropical fire-ants. Unbeknownst to me, they are famous for their stealthy crawl up people's legs and for their synchronized fiery sting. (I can almost imagine them poised with their mandible wide-open and waiting for the signal "Now"!)

Scientists are slowly beginning to understand the many ways the ants communicate. They do it with a combination of touch, sound, chemical signals (pheromones) and even visual cues. The touching is readily discernible. Ant columns are two-directional, with the load-bearing ants going toward their nest whereas the empty-mandible ones march toward their forage target. They can be readily seen to stop, touch each other, then move on. As they forage, they leave behind a trail of complex pheromones as cues for their fellow workers. At least 18 different pheromones are now recognized, some with very long half-life and others very short-lived, each undoubtedly serve as specific signals for various tasks, including tribe identification, territorial marking, enemy defense etc.

In general appearance, adult ants vary little from red brown to black. They all have antennae, six legs, a three-segmented body with a cinched "waist" appearance. All walk on their feet and are wingless (except transiently for queens and males). In behavior, however, ants are as varied as there are species. For example among my house ants, some species are solitary, other forage in groups, some always in single files, others in multi-files, some I see at all times of the day,

others are active during the night. Some even have predictable working hours. Outside the house, millions of tiny feet of one species would wear a clear 3-inch rut across my lawn. Another species' highway is a continuous trough, with the lawn grass left intact to form a covered highway (to stay inconspicuous from predators?), yet another would build an inch-wide dirt "tube" above ground to traverse. Some species forage singly and lug their prize with their mandibles, others do it as a group effort. There is nothing quite as entertaining as watching many dozens of tiny ants together "walking" a crumb across the floor and trying to get it out of the house underneath a closed door. The questions that cross one's mind are "How do they individually coordinate to get the whole mass moving in one direction? How do they know which way is out? Is there a leader? How are field decisions made? Will they figure out that the crumb is too big for the crack underneath the door? "

Nothing in my prior education, however, prepared me for the size and sophistication of leaf-cutter ant societies. The spectacular sight of thousands of these endemic ants bearing leaf cut-outs or flower petals are a continuous source of wonder for visitors to the neotropics (Fig.1). There are more than 40 species in two genera of leafcutter ants (*Atta* and *Acromyrmex*), all of them found in the American tropics and subtropics. Leaf-cutter ants are one of four animals that farm for a living (beside humans, termites and bark beetles). Long lines, up to 300 m long, of foraging ants with bits of vegetation weighing up to 50 times their body size are a common sight, although some species are solitary foragers. Back at the nest, the plant materials are cleaned, masticated and further processed (with a mixture of saliva and feces) into a substrate to grow the fungus on which the ants subsist. Different ant species cultivate different monocultures of fungal species, all belonging in the Lepiotaceae family. Fossil analyses revealed that this obligate mutualistic relationship between primitive ants, fresh vegetation and fungus have existed for at least 100 million years in the Neotropics, culminating with the modern leaf-cutters ants as the most recent arrival (8-12 million years ago). Just as any farmers, the leaf-cutter ants have to contend with serious invading crop pests. To combat the parasitic fungus (*Escovopsis*), which can devastate their food supply, individual worker ants carry inocula of antibiotic-producing bacteria (*Streptomyces*) as microbial controls. During the formation of a new colony, the queen takes along both an inoculum of the food fungus as well as the antibiotic producing bacterium, thus maintaining their mutualistic association for million of years.

The leaf-cutter ants practice sustainable agriculture—they rotate and continuously change leaf crops to avoid decimating the very crop that they depend on. However, due to their sheer numbers and industriousness, the dominant herbivores of the New World tropics are leaf-cutter ants, not cows! Whereas cows can chew off plants on the ground, leaf-cutter ants strip entire trees overnight. They literally carry off 20% of the tropical plant mass between their tiny mandibles each year.

The leaf-cutter ant colony itself is an architectural marvel. Mostly underground, the ant metropolis consists of a central mound (up to 16 m in diameter) connected to hundreds of radiating outer chambers (80 m away) by tunnels, housing up to 8 million ants per colony. These immense structures have air intakes and hundreds of openings to control temperature, maximize air circulation and minimize CO_2 build-up, as well as miles of ant highway leading in and out of the colony (Fig. 3). The main central chambers are used as brood chambers, whereas the smaller peripheral chambers are the food farming chambers. (See YouTube video *Ants Build Something Amazing, Global Duty, 6:38* for a spectacular view of an excavated colony in 3-D). Each nest is also optimally designed for waste management. Debris and unwanted waste are moved to the special bottom chambers, away from incoming leaf crops and larvae growing chambers before being hauled out of the nest through designated tunnels.

The leaf-cutter caste system is nothing short of astounding. It is based primarily on body size and responsibilities. At the bottom of the social scale are the tiny minims (≤1 mm head). They tend to the brood, clean the larvae, do housekeeping and cultivate the food crop. The slightly larger (2.0 mm) minors are the infantry, they patrol and defend the foraging column against predators (army-ants, parasitoid wasps and flies). The media (>2.5 mm) are the actual leafcutters; they forage, harvest and bring back the harvested plant bits. The largest majors (7 mm) are the soldiers; they defend the colony from invaders and do tasks that benefit from their larger size. All of the ants described thus far are sterile daughters of the mother queen, which is by far the largest in size (up to 2cm long). Whereas worker ants have short life span (< 3 yr), the queen may live for 20 years and lay an average of 50,000 eggs/yr, once a year between May and June in our cloud forest. The queen determines the caste of every single egg hormonally. She also determines the sex of the next generation through fertilization using the 300 million sperm (most likely from polygamous mating, with up to 10 males in a single nuptial mating flight) that are stored within her to last her lifetime. Fertilized eggs become females, unfertilized eggs become males. Thus female ants are diploid and have a copy of genes from both parents, while male ants are haploid and received genes only from their mother. Once a year, a small fraction of the fertilized eggs develop into winged future queens, while the unfertilized eggs become winged males. The winged females and males fly off, and mate during their species-specific

nuptial flight, after which the males die. Mating is strictly polygamous. Males mate with many females and vice-versa. After each of these annual nuptial flights, the sky and ground are literally darkened by these flying ants. In spite of their immense numbers, less than 2% of the females survive the orgy, then find a suitable site for the new colony, break off their wings, burrow into the soil, and start to lay eggs. She fertilizes only a small portion of the first eggs laid, to turn them into workers. She uses additional unfertilized eggs as a food source for the first generation of workers since she herself does not forage, but must feed all the larvae. After hatching, the fertilized eggs develop as larvae, and after molting several times, develop into pupae, then into adult workers, which can then forage for plant material to initiate the cultivation of the fungal gardens to expand the worker population.

Scientists are just beginning to collect basic information on ants, barely scratching the surface of all there is to know about them. Each new piece of information is more stunning than the last, only confirming the infinite complexities of these tiny creatures. For example, consider that ants have only a single pair of chromosomes and no centralized nervous system (*i.e*. brain). They are among the smallest of animals, yet they can achieve what we humans cannot: energy-efficiency, effective communication, sustainable agriculture, pest-control, stable economy, optimal environmental control, population management, comprehensive health-care, social housing, efficient division of labor, functional municipal waste management, just to name a few. There are infinitely many more of them than there are humans, yet they have existed for more than 100 million years with little detriment to our planet. If that does not humble us as humans, nothing will. How can I not admire ants?

*** *The Editor* ***

.

Fig.1 Leaf cutter ants carrying off treasured house plant (leaf, flower). The ants often attempt to carry off items (e.g. small fruit) that are disproportionate to their size and build.

Fig. 2 Often the only visible portion of the vast underground leafcutter ant nest, these mounds serve as either entrances or exits, but never both. The author experimentally used a stick to connect an IN mound to a nearby OUT (waste mound). Not a single ant was fooled —none crossed the artificial bridge during the 15 minutes observation period, even though there was steady traffic of leaf bearing ants using the entrance and waste bearing ants coming out of the exit.

Fig 3A It took 3 solid days of cement pumping to fill all the underground chambers of the above abandoned leaf cutter ant nest. After the cement was allowed to set, the team led by Brazilian investigator Luis Forgi carefully excavated the surrounding dirt to reveal the central the auxiliary tunnels.

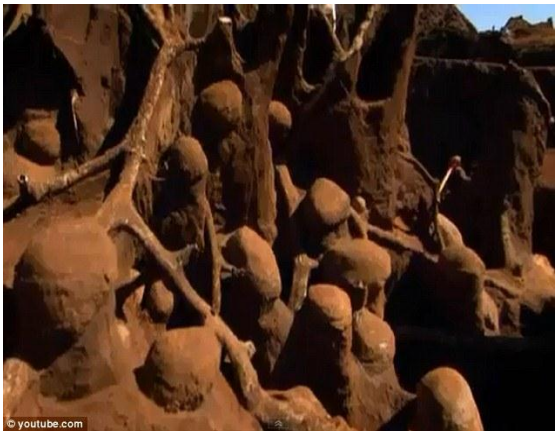

Fig 3B Close-up of the inter-connected chambers radiating from the central larger chamber which serves as the larval nursery.

Other News Highlights 2013

*** *Reported by Luis Villa* ***

Jan Residents from the the community of San Antonio de Barranca, a 2011 eco-loan beneficiary, participated in a series of Nectandra Institute's (NI) birding workshops given by a staff biologist. Besides receiving instruction in the proper use of binoculars and sighting techniques, participants also learned about avian morphology, species found locally, feeding and mating habits, and migration patterns. Classroom instruction was followed by actual bird watching sessions on the restoration property purchased by the community water management association with eco-loan assistance and along the Espino River, tributary of the Balsa River.

Feb As they did one year ago, local leaders from La Palmita, a NI partner community, organized a field trip by more than 100 local residents to the headwaters of the Espino River to tour a block of contiguous properties that have been purchased and set aside for restoration and conservation purposes. This time, participants were able to see even more protected land thanks to the eco-loan financed acquisition of a 36-acre property in September, 2012 by a local hydroelectricity co-operative. Communities that acquire watershed restoration lands using eco-loans from NI pay "eco-interest" on these loans, in addition to repaying the principal. All restoration work and time spent monitoring restoration progress on these community-owned protected areas count as eco-interest. These educational field trips, considered as eco-interest "payments", increase the general public understanding of the importance of forest and watershed protection

Mar Staff biologist Manrique Esquivel traveled to Granada, Nicaragua to participate in the 2nd annual "Nuestra Agua" conference, which brought together delegates from all over Central America and Mexico, representing community-based groups and non-governmental organizations working in the area of water resources management. Manrique presented Nectandra Institute's eco-loan model, our strategic partnership with community water management associations and promoting the protection of watersheds and water resources as a way of achieving forest conservation.

Mar For some time now, LightHawk has contributed valuable support for Nectandra Institute's work by donating flights over the Balsa River Watershed, our priority action area. Our flight in March marked the fifth consecutive year of our partnership with LightHawk. The obtained photographic and video footage has been instrumental in helping us promote a watershed view of the world within and beyond our partner communities. LightHawk is a non-profit organization that "champions environmental protection through the unique perspective of flight."

Apr The need for local water protection is NI's linchpin to achieve our ultimate goal: the conservation and restoration of tropical montane forest ecosystems. These highland forests act as sponges: they absorb precipitation, diminish surface runoff, increase ground water absorption, and replenish shallow aquifers which feed the area's springs, streams and rivers. During this month, eco-loan beneficiaries performed the biannual water flow rate measurements of springs and rivers located on or downstream from the properties acquired with eco-loan financing assistance. These longitudinal data will help us understand how spring and surface water flows are influenced by the restoration taking place on these protected properties.

May For the past two months, NI staff members Randall Varela and Manrique Esquivel conducted a series of workshops to teach participants about watersheds, the relationship between montane forests and water flow, as well as macroinvertebrate organisms. The differential presence of the latter is a practical means to assess contamination levels and stream water quality.

May The newest 11th and 12th eco-loans are unusual for NI in that the borrowers were two, not just one, community water management associations (CWMAs). The loans were used to purchase jointly a 12-acre former cattle-grazing property. The livestock will be removed to regenerate the forest and to protect the two communities drinking-water supply (combined population of 3000 residents). There are plans to install trails and an educational center for local school children to learn about conservation and watershed protection.

Jun Together with a group of women who provide community service in exchange for the assistance they receive through a public welfare program, NI staff collected seeds from local native tree species to produce seedlings in a small nursery set up by the Municipality of Zarcero for the area's forest restoration projects, including those that are being carried out on properties financed with eco-loans.

Visit us at: www.nectandra.org