The Rainforest Connection

Resource Book

Introduction

When the Chagres River was dammed as part of the Panama Canal construction, a large area was flooded to create Gatun Lake. As the water rose, from 1910 to 1914, hilltops were slowly separated from the mainland. One of those hilltops became Barro Colorado Island. The island covers 1,564 hectares and has an irregular coastline of about 48 kilometers. Its highest elevation is around 145 meters above the level of the lake.

Among the biologists who came to the Isthmus of Panama to study the Anopheles mosquito (the carrier of malaria) during the construction of the canal was James Zetek, an entomologist. He and two of his colleagues, William Morton Wheeler and Richard Strong, recognized the potential of an undisturbed island where scientists could study the tropical flora and fauna. They selected Barro Colorado as that site. The island was declared a biological reserve by the then-governor of the former Canal Zone on April 17, 1923, nine years after the official opening of the Panama Canal to shipping traffic.

A laboratory was built, and the island became one of the first protected rain forests in the Western Hemisphere. The laboratory/reserve was administered by a committee of the National Academy of Sciences until 1946, when Congress gave the responsibility for maintaining it to the Smithsonian Tropical Research Institute (STRI), a bureau of the Smithsonian Institution in Panama. In 1977 (when the treaty to turn over the canal and the Canal Zone to Panama was signed), STRI signed a contract with the government of Panama that gave STRI status as an International Mission operating in Panama.

Barro Colorado Island has become an international center for tropical research. Each year, more than 200 scientists come to study the ecology, evolution, and behavior of the island’s flora and fauna. More than 2,000 research projects have been completed and their findings published in international scientific journals.

Jackie Giacalone Willis and Gregory E. Willis go to Panama every January to do a long-term monitoring project supported by the Environmental Studies Project of the Smithsonian Tropical Research Institute. They carry out a walking trail census of mammals on Barro Colorado Island, located in Gatun Lake in the former Panama Canal Zone. Using standardized techniques for recording sightings of mammals, Jackie and Greg record data for at least 100 km of census for one month during the dry season. They also have used automatic cameras to take photos of animals that are elusive, used videotaping to record behaviors, and have radiotracked animals to learn more details of their daily activities.

When the field station on Barro Colorado Island was recently equipped with e-mail connections to the rest of the world, it became feasible to run an on-line project with classes that are also connected electronically. Jackie, during most of the year, is the director of an NSF-supported school reform project in New Jersey called Great Ideas in Science. When partner schools of the project in East Orange and Jersey City began to come on line in rapidly increasing numbers, Jackie saw the potential to develop a relationship with students that might help make science more real, more exciting, and more friendly to students than the traditionally-held views of science. Working with Jane McMillan-Brown, who was the project manager of Great Ideas in Science, a set of strategies and goals were laid out for THE RAINFOREST CONNECTION. Jackie and Jane designed a plan, made initial contacts, and then hoped for the best. Teachers who had participated in Great Ideas Institutes were notified that, if the connection from Barro Colorado proved to be reliable, then they could send their e-mail addresses and expect regular correspondence from a scientific team studying mammals in a rainforest.

As it turned out, the lines remained open, the teachers and their classes responded, and Josh Baron at Stevens Institute helped us along by expanding our network of classes and constructing a website. The project succeeded beyond our dreams! Greg provided a major part of the legwork in collecting data on mammals and reporting
crocodile activity. Jane kept the communications running along smoothly and discovered a most unusual convocation of sloths. Jackie wrote a lot in between census walks, collated the data, and contacted expert friends who helped with the responses to the floods of questions from students. It was a major collaboration by people in different countries and different walks of life.
Acknowledgements

Thanks to the following:

* The little folk of the forest-- all those animals of various species, and the trees and other plants, and all the rest, for letting us visit and enjoy their home and company.

* The Smithsonian staff people who provided us with an internet connection and a pleasant place to live while we worked. The support of the Smithsonian Tropical Research Institute has been essential to the entire Mammal Census Project. (And in years when STRI didn't have the budget money, then Greg Willis funded the work!)

* Pat Detamore for her literary contributions and regular encouragement and for bringing Jackie to the rainforest and to BCI for the first time, and teaching her how to find her way.

* All our teacher friends who took time to read to their students, and talk, and to listen to them. It isn't easy being a good teacher!

* Barry Koffler, who kept us guessing what he could find in our writings to turn into a joke, and kept us entertained. Barry is a biologist with a most unusual website about chickens. You can enjoy it yourselves at: the FeatherSite at http://www.cyborganic.net/People/feathersite/

* Gregory Adler, Matthew Gompper, Katherine Milton, and Betsy J. Mitchell, who provided us with animal profiles.
The Mammal Census Project

Jackie and Greg are running a project to collect long-term (15 years) data on the numbers of individuals of different species of mammals on Barro Colorado Island. People used to think that because there are no sharp changes in temperature in the tropics, and no severe winter weather, that everything stays the same all year round and from one year to another. Yes, they knew it rained a lot for part of the year, and was dry the other part, but folks didn't figure that affected the mammals much. They certainly didn't think that mammals in the tropics had big changes in their numbers like the lemmings do in Alaska and Scandinavia or the voles do in New Jersey. The theory was that the tropics are extremely stable places to live and that life is fairly easy for mammals. So we checked some of that and found quite a lot of evidence that mammal numbers do change a lot and that some years they have trouble getting enough to eat. Early researchers in the 1930's reported that some years there was famine in the forest on BCI and many mammals died. More recent observations in the 70's showed that famines occur periodically. We found that the end of the rainy season and the early dry season (November - March) are difficult times every year because fruits tend to be scarce. We also thought there might be a somewhat irregular cycle of good years and bad years. Our long-term data will be analyzed to look for such patterns.

And now we are trying to find out why things change in this forest. We have, for example, been measuring fruit production by some trees that are important to some mammal species. Fruit production (and therefore food supply), varies from year to year. Rainfall and sunshine are both important for trees to produce fruit, so these are logical factors to look at. We received e-mail messages asking if the El Niño was causing the recent drought on BCI, and, indeed, the El Niño weather pattern might prove to be very important in understanding our data on mammals.

We have a specific routine for collecting data to determine the changes in numbers of mammals from one year to the next. We do our census in early dry season. We walk at a rate of one kilometer per hour. We look around, up, and to the sides, etc. We record all mammals except bats. For every animal we see, we record identity of the species and an estimate of:

1. the distance between the animal and the observer,
2. between the animal and the trail, and
3. the height of the animal off the ground.

That sounds like a lot of stuff to write down, but if you practice estimating distances (in meters) and then develop a routine, it's not hard to do. These numbers will later be used to estimate:

1. the ease with which animals will allow observers to approach,
2. the width of the strip of land that is being censused (different in different parts of the island where vegetation may be very open or very dense), and
3. the levels of the forest being used by different species.

We also trap and mark squirrels to get a mark-and-resighting estimate of the size of the squirrel population. We put little ear-tags (like having pierced ears) and necklaces with colored beads on the squirrels in one 10-hectare area, and later look to see what proportion of the squirrels have markings. (This is similar to a mark-and-recapture study of goldfish crackers that can be done in the classroom to estimate the “population” of “goldfish”) These data on individual squirrels are interesting because we have learned that squirrels may live to be 10 years old, something biologists didn't suspect before, but that Greg and I guessed at a few years ago. This means that one very knowledgeable mother squirrel might build up a whole inventory of information about a variety of food sources in her territory and raise lots of babies to succeed in her place. This is another reason why long-term studies are important to do.

Our basic data, however, are in the form of numbers of animals seen per kilometer. For example, in 1996, we did about 120 km of census and saw about 4 agoutis per kilometer, on the average. This was down from 5 agoutis per km in a previous season. We planned to look at fruitfall data too and compare to see if there was an obvious reason why agouti numbers were down.

We have to do our census in the morning between 7am (when it's just light enough to see clearly in the forest) and noon, when many animals take a siesta for the rest of the day, coming out to feed again in the late afternoon. And we do about 20 km of night census too, which is more tiring and time-consuming for each animal we find and
identify (it takes longer to be sure of an identification when working at night). We do day and night censuses because different species are active in the dark when other species are sleeping. We take headlamps (like the ones that miners wear) and a 500,000 candlepower spotlight. It's harder to see animals at night, but the equipment gives us a special advantage. Most animals that are active in the night have a special part of their eye in the back of the eyeball (tapetum) that reflects light and so intensifies their ability to see in low light levels. The light of a spotlight is also reflected back to our eyes (you must hold the light at or just above your own eye level) and so we see bright "eyeshines." Different species also have characteristic eyeshines: bright yellow, brilliant green, dull red, etc. We record all the mammals we see (except bats) and where we saw them, as well as the time.
Life on BCI

While on Barro Colorado Island, we stay at the field station of STRI on the island. This facility was established to provide living and working quarters for scientists to study tropical plant and animal life. It is strictly a study and research area, located within a large wildlife preserve. This is not a resort area.

There are six buildings which were built to house visiting scientists, researchers, assistants, and some staff. Although we refer to these buildings as houses, they are different from typical houses in that they have only bedroom, bathrooms, closets, desks and chairs and lamps, and ceiling fans. So, we don't need tents because we come back to our rooms after we do our field work. It is very important that we change clothes and shower soon after returning from the forest in case ticks and chiggers are clinging to our clothes.

Most of the houses have beds for eight people, usually two to a room. Sometimes, if students are visiting, cots are moved in to accommodate extra people. We share bathrooms with showers. Warm running water is a luxury we are fortunate to have for cleaning up after a day's work is done.

Food is served cafeteria style in a large screened-in dining hall where we sit at long tables. This gives scientists a chance to talk with each other about their projects. The cook is Panamanian and lots of our meals include delicious Panamanian dishes that Jane was enjoying for the first time, such as fried yuca, sancocho, and baked plantains. And the cook also prepares chicken, rice, beans, salad, and sometimes turkey or roast pork, spaghetti, or lasagna. Lots of fresh pineapple and papaya. Jackie especially misses ice cream, however.

While we don't have to cook our own meals, we do have to do lots of laundry and keep our rooms clean. (It's not like a hotel.) A laboratory building is air conditioned to protect the scientific equipment, computers, books, and other supplies. Every bedroom has a "dry closet" with a small heater inside that stays on all the time to keep our clothes, shoes, and books dry and free from mold and mildew, which can be a real problem in humid areas.

The buildings are fairly close to the lakeshore. Many have balconies where we can sit and watch the birds and monkeys in the trees. There is no sand beach area. Some people take a canoe out to a raft anchored in the cove and swim out there, since there are nesting crocodiles along some parts of the shore and it's best to leave them alone. Gatun Lake is part of the Panama Canal. It is a fresh water lake, and provides water for the canal locks, as well as drinking water for the Canal Area and much of Panama City. Our water for drinking, cooking, bathing, and so forth is pumped out of the lake and up to a small treatment tank where it is treated with chlorine to make it potable.

Other than the living and working area described above, there is no town or community and no store on the island. In fact, the one "road" on the island is only about six feet wide and several hundred feet long. It is used to transport supplies and equipment from the boat dock to the kitchen loading dock or to the houses. The only vehicle on the whole island is a small elderly jeep that the workers use for hauling stuff. Otherwise, we get around the island on foot, walking the many kilometers of trails (and there are 40 km of trails!) through the forest.

The nearest town, Gamboa, where some of the Panamanian workers and their families live and where there is a very small, sparsely stocked store, is a 30 minute boat ride away across the lake and canal. To buy regular and household items, people have to drive or take the bus from Gamboa to Panama City, which might take 45 to 60 minutes more. You can see that it's necessary to plan your shopping trips carefully because there's no such thing as running to the corner store for something you forgot to buy.
What We Wear

First and foremost, we must protect ourselves. There are lots of ticks, chiggers, mosquitoes, ants, and a few snakes that could bite or sting. So, we always wear long pants tucked into our socks and hiking boots that come well above our ankles. This helps to keep the ticks and chiggers and ants from getting inside our pants! We inspect our clothing periodically to see if any critters have tried to hitch-hike. We don't want them attaching themselves to our clothing and ending up back in our houses, in our beds and chairs. Of course, we watch where we're stepping; we don't want to disturb a snake that may be hard to see because of its color blending with the forest foliage. The boots we wear have heavy soles and good ankle support, and are thick enough so that spines from trees can't pierce our feet or ankles.

We carry strips of masking tape stuck on the outside of our pants. This can be used very effectively to remove ticks that find their way onto us. It really works. Jane says she will use this technique the next time she goes hiking back in New Jersey where there might be ticks.

We usually wear a cotton T-shirt tucked into our pants. The pants are 100% cotton painter's pants in a light color so that brown ticks are easy to see on the light background. Around our waist we wear a fanny pack in which we carry a bottle of water, a light snack like granola bars or fruit, some tissues, maybe a small flashlight, a pen and small note pad for noting the animals we see, where we are when we see them, and what time it is. We also carry a compass and a map of the island. Because the forest growth is so dense, we can't see far distances so we must rely on skills other than looking into the distance for landmarks in order to get where we want to go. The trails have markers to help hikers locate their position. We always carry binoculars or field glasses to help us identify animals in the trees. For example, it could be difficult to tell for sure what kind of monkey you were looking at in the tree tops without binoculars. And Jackie has marked some squirrels with colored beads that are hard to see without binoculars.

Sometimes Jane wears a sweat band. Jackie pulls her hair back. Greg usually wears a cap. The bottle of drinking water is probably the most crucial item in our packs. We sweat a lot in the heat and very high humidity. Our bodies won't function adequately without enough water so we must drink every hour or so to replace what we are losing.

Panama’s dry season lasts from late December to April, although this varies somewhat. The trails are quite dry then, but in rainy season they are very muddy. In rainy season we would also use electric boot dryers each night. We don't usually wear raincoats because it's too warm to wear them. We just get wet. It still rains some days in the dry season, but not every day, and we don't mind it much – we just need a hat so that we can see. However, if we are carrying equipment like a camcorder, we also bring either a plastic bag or a poncho to protect the equipment. Jackie always carries a camcorder.

Some people use bug spray, hoping to keep the insects away. We haven't found it makes much difference. Jackie found herself itching a lot from numerous tick bites she got when crawling around under a fruiting tree to set up an automatic camera. Many animals used that tree for feeding and must have dropped off bunches of ticks that laid eggs. The baby ticks hatch at the beginning of the dry season and are about as big as the period at the end of this sentence. They usually hatch in clusters of a few hundred!

Oh, and in case any of you are wondering, nobody worries about makeup much. You'd just sweat it off anyway.

And then there's the “bathroom problem.” There are no bathrooms out there, just in our houses, where we do have flush toilets! (That's quite a luxury, since pit toilets are the best there is in most faraway places. Most of the world has no bathrooms! Or you could think of it as just one huge bathroom!) When you gotta go...just be sure to carry your own toilet paper. And the sanitation crew of the forest takes care of clean-up and recycling – the dung beetles use poop to raise their families.
Why Do We Do This?

A typical trip from New Jersey to Barro Colorado Island often begins with the alarm clock getting us out of bed at 3am on a cold December day. We dress in light cotton clothing topped with sweaters.

The temperature in New Jersey might be around 25° F, and the temperature in Miami when we change planes there at 10 AM could be about 68°. The temperature when we land in Panama City at 2pm usually hovers around 88° F. Imagine what that change feels like as we walk out of the airport in Panama! We certainly don’t want to be wearing the same clothing we started with earlier in the day.

By 4am, a taxi will be taking us on a one hour ride over ice-encrusted road to Newark Airport, where we’ll stand in several lines before boarding a plane at 7am. After waiting another hour for takeoff, we’ll fly three hours to Miami, rush through miles of Miami Airport to make a flight connection. The flight to Panama will take about 2½ hours. After going through Customs and Immigration, we’ll drag 150 pounds of equipment to a taxi; spend another hour in Panama City’s traffic before we reach the boat dock. We might wait two hours in 86° F heat (and 90% humidity) for the boat to take us to Barro Colorado Island. That’s another hour’s ride. We’ll finally arrive on BCI in time for the 6:30 dinner. Why do we do this? And when did it start to be fun?

Greg and I go through this routine every year, and we have a lot of reasons for making this journey, returning to BCI. We think the point at which it became fun on this trip was when:
- we rode the taxi past the big ships in the Panama Canal, and first saw them gliding as if they were sliding over the land
- we saw our first lizards with pebbly green skin snoozing next to the dock
- old friends, biologists and other workers on BCI, began to show up at the dock and welcomed us while we all waited for the boat
- the forest fragrances – a complex mix of flower perfume, ripe fruits, rotten vegetation, and leafy things growing – floated down to us on the boat
- we passed the first fat cinnamon-colored agouti feeding beside the walkways on BCI
- a velvet-skinned gecko ran up a wall when we opened the door to our room
- small, smooth white jelly beans in a desk drawer were really gecko eggs
- another drawer contained a complete ant nest with eggs, larvae, and pupae, all carefully arranged and packed to fill the shallow drawer
- a brocket deer stood in the evening shadows near the door to the dining hall
- the next morning we saw the first squirrel friend from last year, still looking stylish in his green and white beaded necklace.

We do it because this forest is so beautiful and so unlike anything back in New Jersey, so very strange – but also like being home again.

We are so enamored with tropical forests that sometimes we even spend vacation time there. In February of 1999, we took a break from BCI to go to the cool highlands of western Panama, where we were joined by our friend Pat Detamore. Pat wrote a story about that trip.
A CLOUD FOREST BIRTHDAY
by Patsy C. Detamore

What does a biologist who is working in a tropical rainforest do with a few days of vacation time? The answer is simple – go to another kind of rainforest. And that is exactly what Jackie did to celebrate her birthday. This forest was a lot different from the one on BCI, however. While the altitude at BCI is nearly at sea level, Panama has another wet forest, called “cloud forest,” that reaches at least 8000 feet in altitude. Both forests are very humid and full of interesting plants and animals. But there the similarity ends.

Temperatures in the BCI forest usually range between 72° and 86°F, while those of the mountain cloud forest are more like a winter's day in Georgia, with temperatures in the 50's, even when the sun is shining. Instead of wishing for air conditioning, a new arrival is more apt to wonder if the woodpile is large enough to keep the fire going all night. Most of the trees on the mountainside wore thick coats of moss and lichens, as though they, also, were trying to keep warm. Actually, those mossy coats were nurtured by the constant dampness of this forest. Cloud forests are found on mountain slopes in many tropical areas, where low-hanging clouds keep the habitat constantly cool and wet. We had visited other cloud forests in Costa Rica and Guatemala. Similar mossy coats may also be found in temperate zone rainforests in the United States, such as on the Olympic Peninsula in Washington or in several areas of Alaska.

The “birthday” forest is on the slopes of El Baru, an extinct volcano not many miles from Panama's border with Costa Rica. To reach it from Panama City, one can drive six hours on a concrete highway to the city of David (pronounced Dah-veed), or take a one-hour flight to the same destination. Jackie chose the quicker way. From David, the road to a hotel called Los Quetzales (pronounced ket-sahl-ehs) half-way up the volcano is navigable by ordinary passenger car, although progress is slow because of many hills and curves – and lots of potholes. The journey does not end there, however. At the hotel, a switch to a four-wheel-drive vehicle is necessary to reach several cabins perched higher on the mountainside. Even then, you're not right at the door; there is a steep trail about 100 meters long to be climbed first. It can be a tough hike if you're carrying luggage or groceries!

As a switch from counting mammals while slogging through the hot forest on BCI, Jackie, her husband Greg and friend Pat Detamore spent several days in one of the Los Quetzales cabins with a main goal of glimpsing the spectacular birds after which the hotel was named.

The quetzal is one of the world's most beautiful birds, with a shiny red breast accenting the iridescent green of its head and back. Its size is about that of a domestic pigeon, but the male bird seems much larger because of its long tail, which is several times longer than its body. When he flies, the male quetzal's tail floats behind him like the train of a bride as she walks slowly down the aisle. When he sits on eggs in the nest inside a hollow tree, his tail bends and a foot-long length of it may hang out the entrance. Female quetzales are beautiful too, and spend time incubating the eggs, but do not have the long tail.

Although quetzales are the national bird of Guatemala, and at one time they were very numerous in that country, it is likely that Panama now has more quetzales than Guatemala because of extensive hunting there. When the Spanish conquistadores arrived in the Americas, they found the Mayan Indian chiefs and priests wearing costumes elaborately adorned with quetzal feathers. It is known that the Maya kept birds in large aviaries, and that it was a capital offense for a commoner to kill a quetzal. It is said that the Maya tried to catch the birds alive, pluck the feathers they wanted, and leave the birds to reproduce, thus maintaining healthy populations. Subsequent European invaders did not follow any conservation practices. Hunting combined with habitat loss proved to be a deadly combination for quetzal populations. The rich volcanic soils of the slopes of Central American mountains made excellent land for farming, which led to extensive deforestation, and the consequent loss of many species besides the quetzal.

Local residents of the area claimed that pumas and ocelots roam this mountainside, but our group never saw even so much as a cat track during our stay.
In addition to the numerous birds, the group discovered a mystery that still remains unsolved. A strange, tiny greenish light glowed throughout each night on the branch of a tree near the cabin. It was too high to reach or touch. Inspection through binoculars in daylight revealed only a small, gray-brown blob that appeared to be fastening a few bits of moss or lichens together, suspended in what seemed to be a spider web. The steady light reminded us of glow-worms and other insects that produce their own light. Perhaps a visit next year will solve this mystery.

After a few days on El Baru, the group moved to another cloud forest on a nearby mountain, where plant and animal species were different because of a difference in altitude. A thousand feet in altitude can make a good deal of difference in daytime and nighttime temperatures – which influence the growth of vegetation and thus the animals that live in these different habitats. Nights there are quite chilly, but sunny days can be hot. Birds and small mammals were more easily seen; and it seemed almost a shame to leave the clearing in which the cabin was situated, because so many species of birds (more than 30) were readily visible from the doorstep. Most of those birds were insect eaters, drawn by the abundance of moths which had been attracted to the fluorescent lights which were routinely turned on at dusk.

One morning, a tamandua (a tree-climbing anteater) meandered through the backyard, then climbed a nearby tree, where he snuffled about amongst the bromeliads in search of his breakfast. A red-tailed squirrel had just finished checking out this same tree only moments earlier. And up the trail a hundred meters or so, a two-toed sloth had met an unhappy fate a few days earlier. All that remained of him was a few bones, an untidy pile of fur, and several of his long, curved claws lying on the ground.

Jackie's birthday having been celebrated in what she considered an appropriate manner, the little group of “vacationers” returned to BCI, with only a few days left before having to leave Panama until next year.
A Typical Day

This morning on Barro Colorado Island, we woke up before dawn and put on our hiking boots and field clothing, and packed water and notebooks. By dawn, the howler monkeys were already howling and roaring like lions and barking like dogs. They do this every morning.

We took a walk today from 7:00 this morning until 1pm. We traveled up and down hills, for a distance of 6 kilometers. As we walked, we saw a variety of mammals, birds, and reptiles. The kinds (or species) of mammals that we saw this morning were agoutis, coatimundis, brocket deer, red-tailed squirrels, howler monkeys, capuchin monkeys, tamarins, and peccaries. There are other types of mammals in this forest that we did not see today.

We walked very quietly and slowly so that we would not frighten the animals. Because the animals weren't frightened, they didn't run away, and we were able to watch them feeding; and we could see what kinds of food they ate. Many animals gathered under fruiting trees to pick up fruits that had fallen because monkeys had fed in the treetops and knocked fruit loose. At this time of year, there is very little food in the forest, so animals spend a lot of time searching for something to eat.

Yes, we do get tired – to answer another frequent question. We have a goal to do at least 120 km of mammal census per season, so we do at least 5 km each day. But if we walk out from the lab to do 5 km, then we need to walk home again. We have to census in the morning between 7am, when it's just light enough to see clearly in the forest, and noon, when many animals take a siesta for the rest of the day before coming out to feed again in the late afternoon. And we do about 20 km of night census too, which is more tiring and time-consuming for each animal we find and identify (it takes longer to be sure of an identification when working at night). We went out the other night and saw 5 pacas and one porcupine (prehensile-tailed variety) in 1.4 km of walking. We were a little disappointed not to have seen any brocket deer or opossums, but sometimes that's the way things are. And yes, sometimes things scare us at night. Sometimes we hear really spooky noises that are cries of animals – and we can't find the animals to see what they are.

When we get up in the morning on BCI, the temperature is usually between 73-75° F. As we walk in the forest and the sun gets higher in the sky, the temperature in the forest may rise to 80 degrees by lunch time. That doesn't feel so bad if there's a breeze blowing or you don't have to walk uphill or if the humidity is low. But the humidity is often at about 80-90% and that's pretty tough to take! We’re usually here in the dry season, so we get some regular breezes and some periods of lower humidity, so it isn't always awful. Keep in mind that much of the time that we are in the forest we are also in very dense shade. Photography in the forest can be very difficult because there isn't much light. (I will not come home with a tan, unless I make a point of finding a sunny place to hang out.)

But outside the forest, standing in the bright noon sun is another story. The lab clearing is about 88 degrees by lunch time and gets a little over 90 by mid-afternoon. That's why many researchers would just as soon take a swim in the lake and not worry about the crocodiles (who are just starting to nest at this time of year). Panama City feels much worse because of all the pavement and automobile fumes, but it doesn't seem to go much higher than the low 90's. It really isn't as bad as New Jersey in July! Night-time temperatures are very mild. On a night when it was 75 degrees when we set out on the trail at 7:30pm, it was still 75 when we went home at 10:30pm.
Night Walks

After one of the Rainforest Connection reports on night walks, Leslie Sokolow, who worked as my assistant on the squirrel research many years ago, wrote me describing what it was like for her to walk the trails at night:

“Jackie – Loved your last post as it reminded me of the countless nights that I spent waking trails all night. I look back and can't believe that I was so able and willing to spend 8 hours alone in the forest, often after a full day's work - but that's youth for you! The allure of BCI at night was tremendous for me. I felt that the forest was most private at night, that I was not an alien observer like I was during the day – felt more accepted by the animals because the night creatures seemed tamer. And the darkness under the trees was like a cloak around me. The nocturnal animals seemed more ‘rare and precious’ because they were visible only at night and away from the buildings, like brocket deer, kinkajous and their rarer cousins, olingos. And my favorite, the night monkeys – to view them was a privilege.

“The one time I saw fresh Jaguar print was the day after I walked that trail at night! Yow! I remember shaking to think that we might have easily met each other! Surprisingly I always felt so safe walking alone in the forest at night, sometimes quite far from the lab buildings. I have always maintained that people (strangers) were the scariest creatures to meet, and that on BCI that just wasn't likely.”

NIGHT WALK: Jane's Field Notes

There is only one way to KNOW what goes on in the rainforest after dark. You have to be there. A night walk is a very different situation from a daylight hike. First, there's the obvious. It's dark. Really dark under the canopy. Back to that in a moment.

We have to arrange with one of the guards who protect the island from poachers, to take us in a small boat to the other side of the island where we can pick up a trail-head and trek back across the island. That saves having to retrace our steps. Greg finds a guard able to do that and we agree to meet on the dock at 7:30pm. Daylight has long gone by then. For the next 30 minutes we check to be sure we have everything we will need: flashlights, headlamps, extra batteries and bulbs, high-powered spot light, drinking water, snacks, pen and paper for field notes, and insect repellent on clothing to ward off those predators that think you're an easy meal. Not only will they have a bite of you, they seem to signal their buddies to join the feast. And, when you're trying to identify the animal with the eye-shines picked up in the beam of your headlamp, there's no time to swat. We dress in field clothing. That means no matter how hot it is, we wear long canvas pants tucked into socks, field or hiking boots that come well above ankles, and a tucked-in T-shirt.

We wait while Andres, our guard, gathers life jackets for us and a walkie-talkie radio for himself (no, we don't have one). Finally, he directs us to climb down a ten-foot make-shift ladder into the small motor boat. The ladder is really a section of an old narrow radio tower stuck into the mud at the side of the dock. The “rungs” are the slanted cross bars connecting the uprights, making it difficult to place our feet, lower ourselves, and keep our balance. When the lake is at its normal water level, no ladder is needed. People can just step down into the boat. Right now (1998) the lake level has dropped about 6 feet below the usual level. In the boat, there is just enough room for the four of us – Jackie, Greg, and me, plus the driver – to sit. He backs the boat out of the inlet, turns it around, and heads for the channel leading to the Canal. His only light source is a portable spotlight he turns on and off at will to spot the channel markers. We wear life jackets and joke about how we're weighed down with our gear and will sink to the bottom if the boat tips in the wake of a freighter. (Cruise ships don't travel the Canal at night; they carry passengers who've paid lots of money to see the sights by daylight.)

For about 15 minutes, we zip over the water. We're far enough from any bright lights to really be able to see the starry sky. Andres slows the boat (from very fast to just fast), and begins searching for the marker indicating we need to turn again to enter the channel leading to the other side of BCI. He finds it, turns the boat, and in only a few minutes we're at the end of Armour Trail. Because of the unusually low water level, we have to jump off the boat
into squishy ground that's usually under water. Safely ashore, we wave goodbye to our excellent boatman and listen as he turns and heads back out into the channel. Now there is no choice but to walk back, all 4 ½ kilometers.

It is now 8:30pm. The moist heat from the 90+ degree day still hangs heavy in the air. Despite the cooling effect of the breezy boat ride, I'm already sticky with sweat just from the exertion of getting out of the boat, adjusting my pack and putting on my headlamp. The trees are still. The only sounds we hear at the moment are probably made by tiny tree frogs and katydids. The only things moving are us.

For the next four hours, we walk, pausing regularly to listen, inspect, signal to each other about a finding or talk a bit about anything really impressive. On a night walk, you depend on your lights. The sliver of a one-eighth moon provides no help through the thick canopy. Your range of vision is limited to the length and strength of your artificial light beam; so daytime landmarks such as very tall trees away from the path, or the radio tower atop the plateau aren't visible at night. Familiarity with the trails and where they intersect or cross the island is very useful. A sense of adventure and a sense of humor can help get you in and out of almost anything. We three certainly pack a supply of those on every trip!

The purpose of doing a night census walk is to establish a record of the mammals you see (or it might be insects, birds, or reptiles, for example) along with their location at the time you see them, and what they appear to be doing. If they are eating, can you figure out what the food is? Are the animals on the ground or up a tree? Look again; there may be more than one.

There are several clues that you may be near an animal. One is noise such as rustling in the fallen leaves or in the trees. Some animals seem to make no noise that I ever hear. Others issue forth warning calls, or let you know if they're upset. Another clue is odor. Some animals give off distinctive scents or odors that are easily noticed by humans. Strong scent may mean that a particular animal is close by or has passed through the area recently.

I'm learning that in the dark, the best indicator that an animal is close, is seeing their eye-shines. As we walk, we slowly move our heads from side to side and up and down, scanning the forest as far as our headlamps project light. When we see one or two small yellow circles of light glowing through the trees, sometimes seeming to stare back at us, we know we may have spotted an animal. We investigate further by using our binoculars and the spot light. Some animals have much brighter eye-shines than others. Sometimes we are fooled into thinking we have found a mammal only to discover the sparkle of light in the distance is reflection from a spider, waiting patiently for a potential meal to pass its way.

Although only the mammals we see will be recorded for the census, other creatures certainly catch our eye, stop us in our tracks, and deserve mention. Here is our list, not necessarily in the order we discover them.

Mammals:
11 Brocket Deer
1 Common Opossum
1 Woolly Opossum
2 Agouti
2 Paca
1 Peccary
A lot of Bats of several kinds. Out on the water, we saw large bats swooping down to the surface. There are fish-eating bats with claws capable of catching minnows. In the forest, large fruit-eating bats swoop into our light beams, as they're traveling the forest trails too. We are not what they're looking for.

Reptiles:
1 Cook's Tree Boa
1 Anole (very large *Anolis frenatus*), sleeping

Arthropods:
1 Grasshopper, 5½ inches long and one inch thick, wing span of 6 inches. Without a doubt, this is the biggest grasshopper I've ever seen.
Spider, spiders, spiders. Watch out for webs woven between trees with large hungry arachnids waiting for you.

Greg finds the eye-shine of a boa. At first thinks he has a spiny rat chilling on a branch. On second look, with the help of the spotlight, though, he sees a much longer body stretched along a slanted vine or downed branch. Whoa! A boa!

This is one of the largest snakes I have seen in the wild. I know it's the only boa I've seen here. Gorgeous. We estimate its length to be 4½ to 5 feet and its girth looks to me to be the size of a big orange. Its head is pointed toward the forest floor, maybe three feet from the ground. Its tail end is coiled slightly and draped over a higher branch. Its coloring is a combination of light brown, almond, darker brown (only a bit) with an iridescent pink tone. It really is light colored. We will check some sources when we get back, to identify it accurately.

At about 11pm, after walking about 2½ kilometers, we stop to have a drink of water and a snack of Fig Newtons and granola bars. We still have 2 kilometers to go, mostly downhill. By 12:15am, we can see the lights of our buildings in the distance. At 12:30am, we enter the dining hall, leave a note for Andres as promised, letting him know we're safely back, take a long, refreshing, cold drink from the water fountain, and head for the showers. That's it for night walk.

Note: We checked a reference book on snakes and determined that the snake we saw is a Cook's Tree Boa. It's important to check sources when there is room for doubt so that the record of which animals are seen on the island is accurate. Records have been kept here for at least 70 years that we know of, providing scientists and other naturalists an opportunity to check for trends and changes in the plant and animal communities on the island.
Dangerous?

The biggest dangers we might encounter in this forest all have to do with insects and mites that bite or sting. There are africanized honey bees, the so-called “killer bees,” but they usually nest high in trees. If we leave them alone, they usually leave us alone. Their individual stings are no worse than regular bee stings – the problem is that they tend to call their hive mates to help them sting the enemy. And you don't want them all thinking you're the enemy! The real problem with africanized bees is that they are not native to these forests and have pushed out many of the wild forest bees, some of which species may soon become extinct. What do you think might happen if little forest bees are no longer available to pollinate the rainforest plants that have tiny little flowers?

Ticks and chiggers are the most troublesome for us. We carry masking tape to pick the ticks off our clothing, and keep our pants tucked into our boot tops. This also helps keep the tiny mites called chiggers out of our clothing; otherwise they burrow into the skin and make a big itchy welt. We also stay alert for ants, some of which are very large and can give a very painful sting. I have not been seriously hurt by any insects, but some others have been badly stung by Paraponera ants, by wasps, and parasitized by botflies! Paraponera ants are black and long, between ¾ and 1 inch long. That's a big ant! The problem with them isn't their length; it's their stinger. Apparently, if they sting you, the pain is excruciating and lasts awhile. It isn't fatal but it is nasty. I do my best to stay away from Paraponera ants. They travel on vines and you have to pay attention before you grab onto a vine or a tree to see if anything that could harm you happens to be there. Also, Chagas bugs can give you a nasty disease called Lieshaniasis. There are also some trees and small plants that “bite” – they have sharp spines. We try not to touch things without looking first.

When asked what is the most dangerous creature I have encountered in the forest, I would have to answer, “A tree.” One tried to kill me in 1999 by falling down where I was about to walk. I jumped back and fell over, but managed to get out of the way of the trunk and all the branches. It made me feel very jubilant to realize that I was still alive, because in those moments when the tree was coming down at me, I was convinced I'd be killed. The tree had actually fallen over many weeks earlier but was leaning against another tree, and hanging directly over a major trail. Some wood-cutters had been hired to take it down, but their saw broke on the very dense wood and they had had to give up until they could come back with a better saw.

Maybe the greatest danger of all is dehydration. The heat here makes you perspire quite a lot. If your body loses too much fluid and if you don't drink enough you can dehydrate, which means your body has too little water. Then your body won't function properly, you'll feel terrible, and you can get very sick. So we carry water bottles (about a liter each) and drink frequently during our walks.

There are snakes and ocelots and jaguars in this forest. Many people think these animals are dangerous to humans, but they actually don't bother people unless we try to harm them or their babies. Maybe the most dangerous creatures in the forest are people who don't respect the animals who live here.

There is no quicksand here. Hollywood film-makers use quicksand in so many films that you might think it's all over the world. Actually, it's quite uncommon. I've never seen any. Some mud is dangerous in river estuaries where there's a tidal flow, but that's not quicksand.

Mrs. Grossman's class in Randolph, NJ asked what kind of weapons we have to protect ourselves. We don't carry weapons, unless a pocket knife counts – and that's really for repairing equipment, etc. Guns are not allowed on the island, except for the Game Wardens. What do we need to protect ourselves from that a gun would be useful for?

They also wanted to know what we do if a crocodile attacks and whether we had seen any on the shoreline. There are usually crocodiles on the shoreline during the time we are on BCI because they are starting to pick out nesting sites. They are very protective of their babies, so the staff put up rope fences to keep folks from wandering into the crocodiles’ favorite areas. Most of the crocodiles are fairly small, about 5 feet long. Only one attack has occurred in 50 years or more. The man who was attacked swam really fast to the shore and walked back to the lab.
Someone else was bitten by a small caiman in the middle of the plateau at the top of the island, but that was kind of a freak thing because he stepped on the caiman and it jumped up to defend itself!

We are not afraid to walk in the forest. We are careful where we step, and observant as we walk. We can often hear the animals before we see them, if we walk quietly and listen carefully. And sometimes we can smell them! We know they can smell us.

Third and fourth grade science students at the Washington Academy of Music in East Orange, N J, asked us how we protect ourselves from those deadly killer bees, other than just staying out of their way. These bees are not out looking for people to kill! Usually they are much too busy doing their own work (collecting nectar) to bother with humans. The cases where people are attacked is when the people either squash a bee near its hive or they actually shake or damage the hive itself. We carry some Benadryl capsules in our packs in case we are stung. The Benadryl helps to reduce reactions to the stings such as swelling and pain. Other researchers report on the locations of africanized bee hives so that it's easier to avoid them. They post reports on a chalkboard in the dining area. There's also an emergency bee kit to provide first aid, but that's in the office, not out in the forest.

Greg was the first person to see a jaguar on BCI since it became an island in 1914. This was about 13 years ago, however; and since then only one other person has seen a jaguar on the island. Others have found tracks and scrapes with claw marks in the soil where a jaguar had marked a territory – but not very often. The tracks included large and small prints, apparently a mother and kitten. The jaguars don't seem to live here all the time, but swim over from the mainland. When Greg saw that jaguar, it didn't see Greg at first because he was standing still on the trail, just writing in his notebook. He got a really gooood look at it, before it smelled him and walked away. Generally they just walk away without threatening people. And most people never see them at all.

I was also asked whether I had ever been attacked and/or bitten by an animal, like a panther? Yes! I was bitten by a margay cat! Margays are smaller than ocelots, about the size of a big housecat and are yellow with black spots. Her name was Margot and she had been rescued as a kitten that was for sale in the Panama City market. Her mother had been killed by a hunter in order to catch the baby Margot. Researchers on BCI tried to teach Margot to hunt and to be wild, but she liked people too much and never learned to kill prey effectively after her mother was gone. She was encouraged to roam in the forest on BCI, but came dancing down the trail to greet people when they hiked out in the forest. I think she got lonesome since there are no Margays on BCI. Anyway, one day she saw me and wanted to play. I tried to take her picture but she “play-attacked” my arm, wrapping her claws around my wrist and biting my arm. It hurt, but not badly. I played with her to keep her company. Later that month she was getting too thin from not being an expert at catching food, so she was sent to the US to stay in a zoo. Other than that, no one has been bitten by any cats here.
Trail Experiences

Only a few days after arriving on BCI in January 2000 for our annual dry season visit, Greg was walking down one trail that leads to the end of a peninsula. He was on the lookout for crocodiles that might be sunning themselves on some of the clear stretches of trail that are near the lakeshore. He usually sees one-meter-long crocs that are fun to see close-up and not dangerous if you keep your hands and feet out of their mouths! In one area, where the trail was about three-quarters of a meter wide, he saw a dark-colored obstruction, and thought it was a log. His search-image was for something fairly small, but this thing was as wide as the trail, and quite long. As he approached the log, his mind began to put together the fact that this wide, high object with jagged scaly projections on top, was starting to move. Indeed, it had a long tail pointed in his direction – and it was moving. A big head with numerous jagged teeth and large eyes was (fortunately) facing down the trail away from him. The big old croc was more than three meters long, very fat, and moving away from Greg, down the trail to the lake. Greg followed slowly, but the croc was interested in keeping some distance between them. We wondered afterwards if it might be a female that was fat because she was full of eggs that she would lay in a few weeks.

And that same week, I was walking along a well-traveled forest trail, when I heard several birds making lots of noise. Many bird species here travel and feed in “mixed flocks,” which are groups of birds of several species that move together to search for food. The different species usually feed somewhat differently, but can all keep a watch for predators, so it’s safer to be in the flock than to be alone. I turned toward the noises and saw two birds flying close together at my eye level, and about five meters from me. They were tiny and a vivid leaf green with turquoise near the tail. They seemed to be fighting; and I heard loud buzzing noises like a cicada. I thought maybe one had caught a tasty cicada and the other was trying to steal it. They both collided with a liana and fell together heavily to the ground. I ran over to where they were thrashing on the ground, a blur of green and turquoise and very loud buzzing. They saw me and flew up in different directions, and I lost sight of them as soon as they were in the foliage. They were two very small parrots, about the size of a pet store budgie, but rounder, and fat. There was no cicada: the noise was from the birds. They seem to be a species not seen before on BCI – a species from eastern Panama that has been slowly spreading westward toward Gatun Lake. They are spectacled parrotlets, and I never would have seen them if they hadn’t fallen right in front of me.

About half-way through our 2001 stay on BCI, I had another experience that was not nearly so pleasant. I found myself close to the moist red-brown clay that gives Barro Colorado Island its name. Close enough to see very small ants and spiders walking on their daily routines. Close enough to smell the moisture of the clay and the “rooty” odors of the soil. Regular step-like levels in the soil were formed by roots that crossed the trail and held back the clay. At the base of each “step” and under each ropey root were small tunnels where clusters of furry spider legs blocked the entrances. Perhaps they were sleeping, waiting for nightfall. Then they could safely come out to hunt for prey without being taken as prey themselves by tarantula wasps or coatis.

The reason I could see all this was because I had walked down the steep, muddy part of Lake Trail, and then had stepped on slimy mud and slipped. My ankle bent oddly and went “pop,” and I sprawled in the mud. After I calmed down, I cautiously poked inside my boot to assess damage. I wondered if I needed a splint, but saw no useful-looking piece of wood. I decided it was best to retie my boot lace snugly, and then try to stand up. But standing was not an option: the ground sloped too much and my ankle hurt too much.

Students have asked me in the past, “What do you do when you fall down and injure yourself in the forest?” I gave theoretical answers in the past, but now it had actually happened to me. Theoretically, you stay where you are and call out periodically until someone comes along who can help. But I was on a trail where people don't come by very often, and was too far from the main trail for anyone to hear me. Normally, Greg and I tell each other where we are going each morning, since we always do the census alone. I couldn't remember if I had told Greg that morning. It was 10am and no one would miss me until around 1pm. It might take many hours to find me. I knew that if I got onto the main trail before lunchtime, someone would walk by before noon. So, I needed to move myself 200 meters up to the main trail. That doesn't sound very far when both legs work well. Crawling 200 meters is another matter. Your knees feel every little pebble, and your hands get sore too. Spiny palm fronds lying across the entire width of the trail become treacherous traps, and large rocks are major obstacles.
I began the ascent. There were lots of sticks along the way, and I tried many, hoping for a ready-made cane. Every stick I picked up fell apart when I put pressure on it. Groups of big-headed, yellowish-white termites came out of holes in the sticks, and ran around in little confused circles. Decomposition processes were in full swing! After stopping several times to rest, to drink the last of my water, and to rub my knees, I came to the level part of the trail. That took me about an hour, and by then I was tired, sweaty, and very muddy. Then I started to get lucky. I found a stick that had only a small termite colony and was strong enough to hold my weight. By pulling myself up next to a small tree, I could stand. With the stick I could hop a little, limp a little, and get to the main trail. I arrived on the main trail and looked around and called out. But no one was there.

Since I thought I’d eventually have to walk down the slope of the plateau to the housing area anyway, I decided to move on. Searching among a pile of research equipment beside the trail, I found a length of narrow PVC pipe that made a great cane. With two canes, I could keep my weight off the bad foot. The main trail has cinder blocks laid on the soil to help prevent erosion of the trail surface, so it was going to be hard to step along with any speed. After a kilometer of limping slowly from one cinder block to the next, I felt exhausted, and had still another half-kilometer in the forest and another long walk on pavement. Then I heard footsteps behind me and Osvaldo, a botanical technician, showed up, on his way to lunch. He quickly saw what needed to be done and ran ahead to the dining area, where everyone would be eating lunch by now.

I kept walking. Twenty-five minutes later, Greg and Jose showed up – running, carrying crutches, water and some Ibuprofen for me to take. With the crutches, I could really move on a flat surface! But the surface changed to a long downhill slope with cinder-block steps. Then four more men showed up (Polo, Juan, Virgilio, and forgive me – I have left someone out!) with a board that has straps and handles, designed to be used as a stretcher in difficult terrain. They put a plastic inflatable cast over my boot and blew it up to make a good cushion all around the injury. Then they strapped me to the board, and the six of them carried me slowly down the trail. They tried to be careful not to bump me around, even though the trail was steep and narrow. But they often slipped or had to negotiate trees and rocks. I was scared, actually, because I knew someone else could get hurt, and I could feel how steep the slope was, and how great was the pull of gravity. It was strange to be looking up at the tree tops and sky while moving down the trail. I was extremely grateful to be carried out to the dock!

They took me straight to the dock, put me on a fast boat to cross the lake and called ahead to a hospital. When the boat reached Gamboa, Oris (scientific coordinator for BCI) drove me (and Greg) to the Emergency Room of a hospital in Panama City. We were taken in right away, and introduced to an orthopedist, who had my ankle X-rayed. The X-ray showed that no bones were fractured, but a ligament was torn. No surgery was required: I felt lucky again! I was released a couple of hours later, having paid with a credit card, with a cast on my foot, and with instructions to stay off the foot for a few days. I was told to expect a long recovery time before the cast could come off. Oris, who helped us along at every step, took us back to the dock to catch the evening boat to BCI.

That ended my days of trail census in the forest for awhile. I had to content myself with working on other projects, and cheering Greg onwards toward completion of the 100-kilometer census without any more help from me.
Sloth Stories

Many of the students we corresponded with in our e-mail reports asked “What is the oddest or strangest mammal species you have seen [on BCI]?” Well, we say it's sloths! So we sent back a profile of the two species of sloths that are on BCI:

MAMMAL PROFILE: SLOTHS
Two-Toed (*Choloepus hoffmanni*), Three-Toed (*Bradypus variegatus*)
by Jacalyn Giacalone, Ph.D.

Other than howler monkeys, not many mammal species on BCI can live and flourish on a steady diet of tree leaves, but sloths do very well on this food source, provided they are the right kinds of leaves. Tree leaves tend to be coarse and difficult to digest, full of tough cellulose and protected by toxic chemicals produced by trees to ward off their predators. In this war between plants and the animals that would eat them, sloths have succeeded through adaptations that enable them to be leaf-eaters, or folivores. Furthermore, they do their leaf-eating on the crowns of mature trees, only infrequently coming down to the ground, so they are called arboreal folivores. The story of their adaptation to the canopy of the forest and to leafy food supplies is an unusual one.

Two species of sloth are found on BCI, living in the same habitats, and sometimes on the same tree. Both species have shaggy fur that is slightly greenish, long hook-like claws on their front and hind feet, and they usually move very slowly and spend most of their lives hanging upside down. Three-toed sloths, which are very common and may be the most numerous species on the island, have been estimated by Dr. Gene Montgomery to number about 8,000. They can be active both day and night, and tend to stay in the same tree for a day or more and move short distances. They have a smiling face with a dark mask around the eyes, weigh up to about 6 kg, and have a short tail. Adult male three-toes have a large patch of short fur on their back that is golden orange with a dark brown stripe down the middle. The two-toed population may be as high as 1500. These sloths tend to be active at night, changing trees frequently and moving rather long distances in one night. They weigh as much as 8 kg, have two long claws on the front feet, no mask on the face and no tail.

It can be difficult to find sloths on BCI, even though they are numerous, because their camouflage is excellent, and they tend to spend most of their time high in the canopy. Their hairs have tiny grooves in which green algae grow, so they often look like masses of dry vegetation. Whenever possible, they move slowly from tree to tree through touching branches and bridging lianas, rather than come down to the ground. Information about the movements and diets of sloths was learned by capturing sloths and putting collars on them with radiotransmitters. Tracking of sloths revealed that their home ranges on BCI are usually less than two hectares. Drs. Montgomery and Sunquist reported that even with radiotransmitters on 42 wild sloths, it was difficult to observe them feeding, and very often it was impossible to see the sloths at all, even though their precise location was known. These researchers never did see a two-toed sloth feeding, and compiled only occasional records for three-toed sloths. Many questions remain about the biology of sloths. As these researchers noted, “We do not yet fully understand why each sloth was found where it was on a particular day.”

People used to think that sloths eat only one species of tree leaf, but as a population they feed on a great assortment of trees, using at least 25 tree species on BCI. However, each sloth family has its own few favorite tree species which are found within a small home area, and which are different from the preferences of their neighbors. Mother sloths appear to pass along their food preferences and their knowledge of the home area during a long period when they carry their young around their area. Sloths seem to have a matrilineal (transmitted through the mother) inheritance of home ranges and food preferences.

Sloth digestive processes work very slowly, because their food is difficult to process, and because their body temperatures fluctuate every day. Wild sloths have been found to have deep body temperatures ranging from 28° C to 40° C. They can raise their body temperature by basking in sunlight, but must also move to shade as they become too warm. Thus they practice thermoregulation in much the same way that lizards do. They depend on chemical processes used by bacteria in their gut to digest their food. Since chemical processes slow down as temperatures decrease, the night-time drops in temperature which usually cause a body temperature drop of about 7° C, reduce
their rates of digestion. Indeed, the rainy season weather is thought to present problems for sloth digestion, and most dead sloths on BCI are found in the October-December rainy period. Also, few trees have new leaves at this time, which means that although there are many leaves, they are difficult to digest. Sloths may starve at this time of the year, even with full bellies. Their digestion is so slow that it takes several days or longer for food to pass through their gut, and they eliminate waste only about once every 8 days, moving to the ground briefly to defecate. Compared with other mammal species that eat plants, sloths have the slowest rate of passage of food through the gut, a process that usually takes hours. The three-toed sloths use their short tail to dig a hole and then bury their feces, but the two-toed have no tail and dig no latrine hole. This is a very odd behavior for arboreal animals that otherwise rarely descend to the ground.

Sloths are adapted to problems of leaf digestion in a variety of ways:

1) Their stomach has complex pouches that are good for storing bulky food. The pouches separate batches of food that are in different stages of digestion and fermentation by bacteria. Three-toes have more complex stomachs than two-toes. This makes sense because three-toes are obligatory folivores (can live on nothing else), while two-toes can live on various fruits, flowers, and buds, as well as leaves.

2) Since leaves differ in digestibility, sloths may choose specific types. Active sloths swivel their heads to look around very carefully before deciding which leaves to approach for feeding. Female sloths that are pregnant or carrying a young one often choose to feed on leaves of Lacmellea panamensis, which is one of the most easily digestible to sloths. Pregnant sloths may prefer Cecropia eximia, but mainly in August through December. However, females with young do not very often use Cecropia, which is not as digestible as Lacmellea.

3) To speed up their life processes, three-toed sloths in particular will hang out in the sun in the morning, exposing their bellies for deep body warming, and will often choose trees to sleep in that will give them good basking sites in the morning.

Sloth mothers give birth to one baby once a year, after a six-month pregnancy. The young one is weaned from milk after about six weeks, but continues to ride on the mother for another five months. During this time the young sloth learns from its mother which leaves are to be eaten, where to find shelter, and where edible trees are located. Until six months old, the young one keeps at least one foot on its mother while reaching for leaves to eat, until finally the mother just moves away and keeps on going to another part of her home range.

Two-toed sloths like to sleep in tangles of lianas in trees, as do other arboreal mammals such as squirrels. These tangles provide concealed spaces but also act as early warning systems against approaching predators. A two-toed in a tangle is difficult to see, and when once located, hard to catch, because they wake up when the vines shake, and either start to move away or face the opponent, attacking by slashing with claws, grasping and pulling the offender closer to be bitten. Two-toes have two sharp pointed teeth in each of their jaws. These teeth look like, but are not, canines. The upper and lower teeth slide past each other and sharpen the blades so that they are always very sharp. They hiss loudly and make bleating noises when threatened. Three-toes have few flattened teeth and rarely bite, although they will slash out with their front claws if attacked. They are considered more docile than two-toes. However, I have seen a three-way fight among three male three-toes. They first called to each other from about 50 meters apart with loud, high-pitched screaming sounds (which some describe as shrill whistles). The sloths approached each other at top-speed-for sloths, and then engaged in slashing, arm-swinging battles. One male fell from the tree to the ground, about 25 m. Stunned, but apparently unharmed, he soon began the process of climbing the nearest sapling and scanning his surroundings, finally reaching for lianas that would get him back up to the canopy.

The anatomical and behavioral differences between these two sloth species support the idea that they descended from two very different sloth lineages, the two-toes being in the same grouping as the extinct giant ground sloths. Researchers speculate that tree-dwelling sloths were on the evolutionary scene before primates appeared and have competed successfully against monkeys that would eat leaves. They achieved their success in excluding all but howler monkeys by: 1) being able to use many different tree species, excluding monkeys that might specialize on a few of those species, and 2) evolving a matrilineal social inheritance of tree preference that allows sloths to avoid competing with their sloth neighbors. Indeed, their closest competitors are not mammals, but reptiles: iguanas are
arboreal folivores who have generalized food habits. However, iguanas do not have a social inheritance of food preferences.

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Jane had been on BCI only a few days when she had an encounter with, not just one sloth, but three, as mentioned above. She wrote in her report that day:

“This morning on our census rounds, we discovered sloths. Now, others have seen a sloth or two at the most at the same time, (not very often, though). Well, first I saw one. It took me a few seconds to be sure it was a sloth and not a monkey. He was about forty feet up in a tree. I checked him out with my binoculars and called for Jackie to look. She had been watching squirrels in a mating chase. All of a sudden, I saw movement in an adjacent tree and there was another one – also a male. The second one appeared to be moving after the first. Now, you know about sloths and how they move soooo slowly, right? So, when I speak of a sloth chase you can picture this slow motion action here. Just when the second sloth had about reached the area where the first one had moved to, we both saw a third male heading the same way. We watched for almost an hour. (Told ya they move slooowly.) We even heard them calling, which many here say they've not heard. They all converged on one limb and began flailing at each other. We saw a few punches connect, then one of them moved away to another tree, defeated. The other two kept slugging it out. We were getting stiff necks watching this event in the treetops. Suddenly, there was a rustle of leaves and the smaller of the two came crashing at least 60 feet to the ground, about 15 feet from where we stood amazed. We immediately rushed through the vines and around trees to get to him.

“He seemed not to be hurt and began to move toward the nearest trunk of a very small tree. I went right over to him, could have easily touched him, but didn't (don't want his cooties) and began taking pictures. Jackie got good video too. We watched until he figured out how to get himself from the small tree to the larger one using thin vines. He may be slow, but he sure wasn't stupid. Unless you call fighting 60 feet off the ground stupid. He seemed to be looking over his options, trying to figure out the right course to take.”

Another sloth story comes from Pat Detamore, who was living in Georgia at the time. Pat is a naturalist friend who lived in Panama for about 40 years and who introduced Jackie to the rainforest. Pat wrote the following to her grandson Tyler, who was a 5th grader in Florida and was online with the Rainforest Connection:

“[Our family] used to have a 3-toed sloth as a pet. Sometimes I would take it for a ride in the car. It rode clinging to my collar with its long, curved claws and looked like a fat, furry scarf around my neck. We kept the sloth (which we named Gertrude) in a big cage (about the size of your kitchen counter) in the back yard. Since a sloth's muscles are used mostly for hanging upside down, they are not strong enough to support it upright to walk on the ground. So I made sure our sloth had several branches to hang from in the cage. I put a box of kitty litter on the floor in one corner of the cage; and Gertrude always used the box as her bathroom.

“The diet of 3-toed sloths is mainly the young, tender leaves of one kind of tree, the cecropia (pronounced sa-crow-pee-uh) – a tree that is also home to a certain kind of very fierce ant. I had to go out nearly every day to pick leaves for our sloth. The tree can grow quite tall, and the leaves that the sloth likes are near the top or at the ends of the branches. So I had to look for young trees that I would not need to climb, because of the ants. There was another problem as well. The cecropia leaves wilted very quickly in the hot tropical sun, so I had to carry an ice chest partly filled with cold water in my car, so that they would be still fresh when I got them home.

“On the days that I did not take Gertrude with me to gather the leaves, she waited anxiously for me to bring them back to her. When she heard me coming, she would call out to me, making a sound like the whistle of a bird, and come swinging along her branch to the side of the cage where the door was located.

“She liked to eat, but she liked to be petted even more. She always hated to go back in the cage after I had had her out for awhile, and would cry and cling to my clothing when I tried to put her back inside. She would cling with those long claws on all four feet, and sometimes it was difficult to get them all pried loose at the same time!”
The sloths that Jackie and Jane saw fighting were also 3-toed sloths, but 2-toed sloths live on BCI too. The 2-toed sloths are not as common as the 3-toed.

Josh Baron, who heads the Stevens Institute NIE network for teachers (CyberTeacher) asked, via e-mail:

“Why do sloths move so slowly? Is it to prevent over-heating? Or maybe due to the food it eats being low in energy?”

Jackie’s answer:

“The best guess I have heard is that most of what sloths do is aimed at being invisible. They have greenish, trashy-looking fur that blends in with the forest debris that normally hangs from trees. They move so slowly that it’s hard for a predator to detect the movement. They hang up in tree tops – again hard to see. But you are on target also with the guess about their food: leaves are rather low in energy content, so conserving energy should be important to them. Not all the answers are in on this, however. There were some studies done to see if sloths’ nerves might transmit impulses at a slower rate than in other mammals, but the results of that study showed no difference in rate of transmission. They are slow for some other reason than the physiology of their nerves. And they do tend to have rather low body temperatures for mammals. I will find out details on that if I have the resources here.”

Josh also asked:

“I noted that sloths only eat the leaves of one type of tree. I find this very interesting since it seems that it would be a disadvantage to the animal. Are there any theories on why it has such a limited diet?”

To this, Jackie returned:

“Actually, detailed studies of sloths on BCI done with radio transmitters attached to the sloths showed that they have a very varied diet. They do like cecropia very much – it’s a species that grows quickly at the edges of forests and is located in places where people are likely to see sloths. And it’s easy for them to collect Cecropia because the trees are not very tall compared to many of the forest trees on BCI.”
Squirrels

Tropical Red-Tailed Squirrel

_(Sciurus granatensis)_

by Jacalyn Giacalone, Ph.D.

Temperate zone residents who visit tropical forests are often surprised to find familiar-looking squirrels amidst the exotic vegetation and strange animals such as monkeys, coatis, agoutis, and anteaters. While some squirrel species are very familiar in North American and European cities and forests, and have been studied extensively, the tropical species are not well-known to scientists. It would also be incorrect to assume that all questions about temperate zone squirrels have been answered.

The tropical red-tailed squirrel is the only squirrel species living on BCI, although two other species of squirrel are found on the nearby mainland. Pygmy squirrels (Microsciurus alfari) used to occur on BCI, but were last seen in the 1960’s. Variegated squirrels (Sciurus variegatoides), which are common in and around towns and pastures in the former Canal Zone, were never reported on BCI once it became an island. The variegated squirrel is larger than the red-tailed squirrel and has a black stripe down the back and gray sides in this part of Panama. The pygmy squirrel is tiny, dark brown, has a very narrow tail and secretive habits. Evidence from their feeding ecology supports the idea that these two species have rather different ecological roles from the red-tailed squirrel. Considering the great variety of squirrel species throughout the entire tropics, squirrels seem to be a highly adaptable group, living at high altitudes and low. Of all the tropical species, however, the species on BCI may be the best-known to scientists.

Tropical squirrels do not readily reveal the details of their lives. Even individuals who have been equipped with radio-collars, and who have been followed by scientists for several weeks, are reluctant to be observed entering or leaving their nests. When a squirrel detects a follower near its nest, the squirrel may sit quietly, waiting for the human to go away before the squirrel will enter its den. This is especially true of mothers with young in the nest. If disturbed by observers at the nest tree, some mothers will panic and immediately move their young to a new location, laboriously hefting their helpless youngsters one at a time down to the ground and over to the new den. Radiotracking on BCI has revealed that mothers establish several alternate nest sites already prepared for occupancy against just such an emergency. Since the main predators of nestlings (cats, tayras, raccoons, snakes, and monkeys) may find the nestlings by detecting the mother’s activities at the nest entrances, then suspicion and caution when being followed are highly adaptive behaviors.

Red-tailed squirrels are medium-sized tree squirrels with glossy red-brown to yellow-brown fur on the body and a rufous-orange tail usually tipped in black. The bright orange belly is often streaked or spotted with white or sometimes with a large patch of white on the belly. They can be noisy, making soft barking or loud squawking sounds. They may be located by the noises made when they gnaw on hard-seeded fruits. The head and body length is up to 24 cm with a tail about 20-28 cm. An adult may weigh from 400-520 g, with adult females averaging 5.5% heavier than males. This squirrel has a wide distribution from Costa Rica to northern South America and shows great variability in color, often being rather dull-colored in parts of its range. However, in central Panama, it is a very distinctive species with vivid coloration that is not easily confused with the coloration of any other species.

Diurnal in habits, these squirrels are most likely to be seen during their period of greatest activity, between about 6:30am and 11am. They are less active in mid-day, usually taking a siesta, and have a late afternoon activity period. They are most abundant in second growth forest, on ridge tops, and in forests with abundant Dipteryx and/or palms. On the mainland, where red-tailed squirrels occur in the same general areas with variegated squirrels, the two species show habitat preferences. Red-tailed squirrels prefer humid or wet forest while variegated squirrels are found more often in dry deciduous and disturbed forests. In mixed forests or at forest edges the two species overlap in distribution.

Red-tailed squirrels are readily seen foraging on the ground or perched within 2 meters of the ground. However, they also use the forest canopy and understory trees, traveling extensively on lianas. Sometimes they can be observed feeding in the crowns of tall trees more than 35 meters above the ground. This species is very common on BCI and is one of the most likely mammals to be seen. Density estimates on BCI over several years have varied
between one and three squirrels per hectare in some habitats. Females that become established on territories are the longest-lived individuals. One marked female on BCI is known to be at least 10 years old. Subadults are the most vulnerable group of individuals, and are the most likely to disappear during times of food shortages.

They can be trapped only with difficulty in the December to August period, when food is fairly abundant. They are caught more easily in the rest of the year, when their preferred foods are scarce. Live-traps set in vine tangles, on leaning fallen trees, or on logs that are one to two meters off the ground are effective. Their preferred bait is Scheelea palm fruit, which can be frozen for use when it is out of season. Dried corn on the cob is attractive to them, but not as effective as Scheelea. Squirrels on BCI have been marked with numbered metal ear-tags (like pierced earrings) and chain necklaces with colored ceramic beads.

Breeding usually occurs during the period of greatest fruit abundance, which on BCI begins in December and lasts until September. Mating bouts have been observed in all months from November to August. However, a sudden onset of vigorous breeding activity is most obvious at the beginning of the period of fruit abundance, in late December. Mating activity abruptly ends in mid-August in most years. On BCI, the fruiting tree species that seems to trigger squirrel breeding activity is Dipteryx panamensis, which starts to ripen fruit in December. This fruit crop is apparently critical to the breeding of squirrels on BCI, for when poor crops of Dipteryx have occurred, breeding activity has fallen off and the squirrel population has declined.

It has also been noted by William Glanz that in areas where Dipteryx does not occur, breeding may begin at other times of the year and may be related to the abundance of other food sources. For example, in Paraiso (30 km southeast of BCI), breeding starts in late March or early April and is correlated with the ripening of Scheelea fruit, while in the highlands of Costa Rica, Giacalone noted that the onset of breeding coincides with the peak of blooming of the highly edible flowers of Quercus (oaks) in March.

The list of foods used by these squirrels includes 58 species among the more than 1400 plant species on BCI. The bulk of the diet is composed of the hard-seeded fruits of Dipteryx panamensis, Scheelea zonensis, and Astro Caryum standleyanum, and the large oily fruits of Gustavia superba. Squirrels also feed on various smaller fruits, flowers, tree bark, tree gums, new leaves, fungi, insects, and frog eggs. Females and subadults have more diversified diets than adult male squirrels, who feed primarily on the four species named above.

When courting, squirrels are easily located and approached, being very noisy and careless during their mating chases. Females are ready to mate only briefly, so males visit around the neighboring territories, socializing and checking on the breeding status of local females. As a female approaches her time for mating, some males may congregate around her for a few days. On the day of estrus she may have attracted a large group of males to her territory. One female may be courted by as many as 10 or more males who compete to remain near the female until she chooses to mate. Males chase and fight each other, chucking and squealing, biting and wrestling, and often falling out of trees. The excitement may last an entire morning or even most of a day. The chase route is within the female's home range, often just a few trees where the female repeatedly runs up and down, alternately resting and running. Although a dominant male may stay near her for most of the chase, she may, in the end, choose to mate with a non-dominant male.

The males do not participate in care of the young. The gestation period is about 44 days. Females produce one or two litters per year. Two young is the usual litter size. The young are naked and blind at birth. Nests for young are located in tree cavities, often [in] abandoned woodpecker holes. They are lined with the soft, shredded inner bark of lianas and trees. Nests of males are usually outside nests built of leaves and twigs.

The home ranges of females do not overlap, or do so at places where desirable fruiting trees are shared. The sharing is grudging: females have been observed to chase other females at such trees, and resort to time-share strategies to avoid fights. These defended home ranges are termed territories. Territory size, determined by radio-tracking, varies from two to four hectares among females. The establishment of a territory that has sufficient resources (fruiting trees, nest sites, good cover) to raise a litter is probably fundamental to the success and longevity of a female. Males, however, have home ranges that overlap with those of both males and females.

Squirrels often make loud, hoarse, rasping alarm calls (chucking) at humans, but behave very differently when a tayra approaches. Tayras feed on the sweet pulp of Dipteryx fruits, but have a reputation as predators. Squirrels
quietly fade into the foliage and leave the immediate area if a tayra comes to feed at the same tree. Likewise, experienced squirrels leave fruiting trees when capuchin monkeys approach. Capuchins have been observed to feed on nestling squirrels and to lunge after unwary adult squirrels preoccupied with courtship activities. Large snakes and predatory birds also feed on squirrels.

Many important questions remain unanswered regarding the ecology of this species. The role of red-tailed squirrels as predators and dispersers of seeds is not understood. These squirrels hoard numerous seeds of several large-seeded tree species. They usually tuck seeds into crevices between lianas and tree trunks. While some seeds may survive to germinate, it seems to be a rare event. It is not known whether hoarding by squirrels facilitates or impedes seed survival. Squirrels are known to draw heavily on hoarded seeds (up to 20% of feeding observations during the lean months, and seem to destroy entire seed crops in some years. Likewise, they are also known to feed heavily on immature seeds of Astrocaryum in some years, possibly eating an entire crop before it fully ripens. How often does it happen that low squirrel numbers and heavy fruit production coincide to make seed germination possible?

The use of hard seeds by red-tailed squirrels has been shown by Glanz to be a preference that is not shared with the larger variegated squirrels. The larger squirrels prefer soft fruits and flowers. This finding is in contrast to the situation among African squirrels, in which increasing species size correlates with increasing hardness of foods taken. No one has investigated the jaw lever system and musculature of red-tailed squirrels which permits them to utilize seeds that are considerably harder than seeds used by the larger gray squirrels in northern forests.

Variations in fruit crops of critical food sources appear to affect the population levels of squirrels. These fluctuations have been under study for several years. Short-term (annual and several-year) fluctuations of 2- to 3-fold seem to correlate well with measured variations in fruit crops. However, some longer-term (25-year) fluctuations of larger magnitude (perhaps 10-fold differences) have been recorded, for which no correlated fruit crop studies are available. The current mammal census and fruit crop monitoring on BCI is aimed at finding causes for long-term population increases and declines.

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TRAPPED!
by Jane McMillan-Brown

Why would we spend a couple of days placing, baiting, and setting 80 traps along six-tenths of a kilometer of trail? What will we do with whatever is trapped? How do we know that only the animals we want will enter the traps? Will they get hurt when the trap springs shut? Will they ever be free again? When? How? Where?

These were some of the questions I had when I learned that this year we would be trapping squirrels. Maybe you have some of the same questions as you come along with me and learn some of the hows and whys of mammal trapping.

Now for some of those earlier questions: First of all, it is squirrels we want to catch for the purpose of marking them for future observation and study. Giving them each their own identification makes it possible to keep track of when they are seen again, where they are seen, (for example, have they moved to another part of the island or are they feeding around the same area?), how healthy they appear to be, and so on. Jackie and Greg have been doing this every other year and observing the squirrels every January, gathering and recording the data. Trapping and marking animals is a complex job that requires great commitments of time, patience, and diligence. Once the traps are actually set, they must be checked frequently to safeguard the well-being of the animals. But, here I am getting ahead of myself.

One of the first things we have to do in preparation is to check the traps to be sure they are in good working order. No sense baiting a trap if the door won't shut because the metal parts are rusted. Many of the traps have been left outside, wired to tree branches for several years. They are wired open so that no animals will get caught after we end the trapping season. This helps get the animals used to seeing them and smelling them in the forest so that they are not afraid of them.
When we go out to check the traps, we know we will be leaving the trails and walking through brush and vine tangles, so we remember to tuck our pants tightly into our socks and tie our boots securely to help protect our legs from the ticks and chiggers. Snakes usually feel the vibrations we make from walking on the ground or see us coming and they get out of our way. They really aren't very interested in us if we aren't a threat to them.

We also have a map that Jackie drew which shows where the traps were the last time they were used. (Have you ever drawn a map, and then given it to someone to find something?) That helps us locate the traps after we've been away from BCI for a long time. Traps sometimes get covered with vines or fallen leaves, and coatis can rip them off the trees and drop them on the ground. Or some traps get crushed by falling trees and need to be repaired or removed from the forest and put in the trash. We can mark on the map any new traps we put out or any that we move to different locations. Once the traps are set so that they will catch animals, it's also very important to have that diagram showing where the baited traps are so that we can be sure to check every one for animals and not miss any. (However, Jackie and Greg usually have all trap locations memorized by the second day!)

While there are no guarantees that other small animals, besides squirrels, won't get into the traps, one way to attract the squirrels is to put some of their favorite fruit in the trap, especially if it's a fruit that they can't get right now, like royal palm fruit. Jackie had some stored in the freezer for just such an occasion so that's what we used. The traps are about 50 cm in length by 20 cm wide by 20 cm high. They are made of steel wire and have a trap door at one end that will spring shut after the squirrel is well past the door. The door won't hurt the animal when it is closing. We place the bait at the far end of the trap so that the squirrel enters the trap to get the fruit, which smells very good to a hungry squirrel.

The trap is set so that once the squirrel walks across a small pan of metal on the bottom of the trap, the squirrel's weight causes the pan to tip, which releases a spring that closes the trap door. Some squirrels get more upset than others and will try to escape. That is why it is important to check the traps frequently once they are set. We don't want squirrels upset and trying to get through the small openings in the wire cage. They could bump their noses and get hurt if they were left too long. We also worry that a predator like a coati might harass a trapped squirrel and harm it. One of us must walk through the forest several times in the morning and again in the late afternoon when the squirrels are most active and likely to get into the traps. (They often nap in the afternoon heat of the day.)

By 11am on our second day of preparation, we've methodically checked, baited, and set every one of those 80 traps and marked our map indicating each location. After a refreshing drink of water from our portable water bottles, it's time to start back down the trail, wash up, and get to the dining hall for lunch by noon. We figure that we'll come back for the first check right after lunch. But wait a minute! What's that movement over by the trap near the big Dipteryx tree? Looks like something brown moving in the trap! Let's go over for a closer look. Wow, a squirrel has already found the fruit. Our lunch break will have to wait. Squirrel business has to come first now.

We hadn't expected to get one so quickly and we've been caught off guard. Usually, we'd be carrying an old shirt or towel to place over the trap after we remove the trap from the tree branch. (It's fastened on with thin wire.) The covering helps keep the squirrel calm as we carry it in the trap back to the lab for marking. Well, we all laugh about who will have to sacrifice their shirt for the cause. This time, Greg drew the short straw and agreed to take off his T-shirt and cover the trap for the remainder of our walk to the lab Jackie has set up in one of the buildings near the trailhead. I made a mental note to carry an extra, old shirt with me next time so I wouldn't have to...you know.

Once inside the lab, the squirrel is left in the covered trap on a work table while Jackie and Greg get the marking materials ready. This squirrel sits quietly and feeds on the bait while we prepare. I stand ready with my camera to photograph the marking procedure. The entire trap, containing the squirrel, is placed into a large plastic bag and a small cotton ball wetted with an anesthetic is added. Very quickly, the squirrel goes to sleep. This is the only safe way to handle the squirrel and keep from being bitten or scratched, while at the same time preventing the squirrel from being extremely upset. The sleeping squirrel is removed from the trap and placed in a mesh bag, like the ones often used in laundries. The bag is then gently laid on a scale. The squirrel's weight and length are recorded, along with its gender, and any significant markings. Now it is time to give the squirrel its own special identification marking. So guess what we use to mark them? Special jewelry! Yeah, really.

Designer jewelry. Nothing but the best for our BCI squirrels! Colored ceramic beads threaded onto a stainless steel neck chain – custom measured – is carefully fastened around the squirrel's neck and a numbered tag is attached.
to its ear. Each squirrel gets a different color combination and its own tag number. The ceramic beads won't crack and rot like plastic ones would and the stainless steel chain won't rust and cause problems for the squirrel. Careful notation is made of the tag number and color combination of the beads. From now on, for the rest of its life, this squirrel will be identifiable.

Almost before the tagging is complete, the squirrel begins to stir. We don't use ether, but instead an anesthetic that both acts quickly and wears off quickly, with few side-effects. This first one today is a young male who hadn't been previously caught. Before he is fully awake, he is placed back into the trap for his return trip to the forest. He will be taken back to the same location, the trap will again be attached to the branch, the trap door will be opened and the squirrel will leave it when he's ready. We reset that trap and check all of the others. Believe it or not, sometimes the same squirrels go back into the same trap another day. We only mark them once. After that, we just record their activity and location.

Several squirrels got caught before lunch, so Jackie and Greg have to finish marking and releasing the squirrels before they can take the time to eat. We always return squirrels to the exact places where they get caught, especially young ones that could get lost. I agree to go quickly to the dining hall to see if I can save us some lunch before the food is all put away or eaten by hungry researchers just back from their own morning adventures.

Now, you might ask, don't other species of mammals besides squirrels like royal palm fruit? And don't they get caught in these traps? Yes! But this is limited somewhat by using squirrel-sized traps, so big coatis and big monkeys can't fit into them. Occasionally a very pesky and determined coati will squeeze into a trap – then we have what looks like a cubical coati, all jammed in with its long nose mashed up against the end of the trap, fur sticking out in all directions, and no way to turn around. That's another reason why we check the traps frequently – trapped coatis want to get out NOW! We have caught a whole variety of mammals over the years: baby coatis and white-faced monkeys, and even a baby anteater (they don't eat fruit, but can just walk into a trap by accident). We have also caught 'common' possums, 'four-eyed' possums, pygmy possums, spiny rats, climbing rats, and a porcupine. Sometimes we catch doves. We let them go, take a picture sometimes, and record that they were caught, and where.

This year [1998], after 8 days of trapping, we caught more squirrels than we have in any year since 1979. We certainly don't ever catch ALL of the squirrels: some are too cautious to enter a trap. We left BCI this year with 23 marked squirrels living in an area of about 10 hectares. We saw many of those same animals in our census walks and are using those data to estimate how many squirrels live in the trapping area, and on all of BCI. We've also learned about the life spans of squirrels, that a female might live eight to ten years and raise many broods of babies, but males often live only three or four years and rarely make it to eight years. Mapping the locations where we have seen or caught a marked squirrel also helps us understand how big a piece of forest they need for their daily activities of feeding and raising a family.

Map of Barro Colorado Island, Panama, with trails marked.
Snakes

Many students seemed to be worried about our health and safety, for which we were grateful. However, we want to assure everyone that we are reasonably safe on BCI, probably safer than driving every day to work on a highway in New Jersey!

There are highly poisonous snakes on the island, such as coral snakes, which we see only occasionally. There are also many mimics of poisonous snakes, and they are often hard to tell from the real thing. We are very careful. The only case I know of someone being bitten by a coral snake on BCI was when a herpetology student decided to photograph a coral snake that he had caught and put in a cage. The snake tried to hide its head from the bright photographic lights and the big, scary man. The man poked the snake with his finger so that it would look up and make a better picture. The snake defended itself and bit him. A medical helicopter was called and the man was taken to a hospital in Panama City. He never showed any signs of poisoning, and it appears that the snake “chose” not to inject any venom. I have seen other people bitten by very dangerous sea snakes (not on BCI) with no ill effects except that the experience was really frightening! So being bitten by a snake is not necessarily the end. Most of the snakes on BCI are not venomous or only mildly so. There are vine snakes that look like green or brown vines and even move like vines shaking in the breeze. They are very well camouflaged. They eat lizards, especially anoles, and have a mild venom (not mild to the anoles!). I have been bitten by them and suffered no effect. The fangs are at the rear of the mouth, not the front. There are many other species of snakes including boa constrictors, rainbow boas, and spilotes (big rat snakes).

Another highly poisonous snake is the Fer-de-lance. These pit vipers are much feared by field workers because they are cryptic, quick to bite, and deadly venomous. They are very common on the mainland of Panama, but have been considered extremely rare or even extinct on BCI. There were several times when I or other non-experts saw what we thought were Fer-de-lance, but the expert told us that they were no longer on BCI, that we must have seen a non-venomous mimic. Since we didn’t bring any of these snakes back to the lab in our packs, we couldn’t convince the expert that we had seen the real thing!

This is where good field guides (books that aid in species identification) are very valuable. I read very carefully on the subject of Fer-de-lance and how to identify them by their keeled scales (with little ridges on top) and their head shape, sensory pits, and pattern. I was convinced we had seen several Fer-de-lance, and decided to be very cautious in brush piles and other places where snakes like to live. One of the snakes we suspected was extremely large, over 2 meters in length and several inches in diameter, but it was still hard to see until I had nearly stepped on it. I think some of us became frustrated by the expert who never saw what we saw, and so wouldn’t accept our observations!

In August of 1999, one of the field workers, Bonifacio, who knows wildlife very well, and had worked in the forests of Panama all his life, was working on a remote trail on BCI. He was kneeling on the ground, sorting fruits in a fruit trap, when he realized there was a Fer-de-lance coiled next to the trap. It was a great huge snake with a big triangular head, thin neck, and seven-inch thick middle. Bonifacio slowly backed away, convinced that this was the real thing. He found a stick with a forked end and carefully pinned down the snake’s neck. The snake uncoiled its more than two meters of body and started thrashing around – very strong, and very dangerous. It’s not permitted to kill anything on BCI without a good reason, and in this case Bonifacio felt he had a good reason: he was going to bring back this snake and make it very clear to all that we need to be careful when working in the forest. He wanted to settle this question of whether there are Fer-de-lance on BCI, but he wasn’t going to bring this one back alive! So he killed the snake and brought it to the lab. And the experts have agreed that there was at least one Fer-de-lance on BCI. The rest of us figure that this snake probably has friends and family on BCI.

When I told of Bonifacio’s encounter with the fer-de-lance in the Rainforest Connection reports, I received the following reply from my friend Leslie Z. Sokolow, who used to be a field biologist:

“[The snake story] makes me remember my own experience with fer-de-lances in Brazil (the Brazilian species, Bothrops jararaca, is different than the Panamanian, B. asper). In the early 1980s, I was studying small
mammals in a gallery forest near Brasilia. These forests are 1000-mile long fingers of the Amazon that stretch out into the open scrub cerrado of central Brazil.

“These forests were little studied prior to my work there – primarily because of the great abundance of fer-de-lances. These forests were treated as taboo by the scientific community because these snakes were so feared. I was fascinated and mostly a bit paranoid by the reputation of this formidable beast – an aggressive, highly venomous rattleless rattlesnake whose strong poison had no antidote.

“I came to the field equipped with my snake guards, my metal-tipped work boots, my tourniquet, my nerves steeled, and began my field work. I was so jumpy those first few weeks as my first task was to bushwhack trails in a dense forbidding forest where no one had stomped around before – I remember consciously trying not to stoop too low, thinking I might get my chin bit by an enraged fer-de-lance. It took me a while to see my first fer-de-lance; they camouflage so well, one has to either develop a good search image or be right on top of one to see it. In fact, I rarely did see them – either they were not as abundant as their reputation implied or they were darn hard to see.

“One day I came upon a huge fer-de-lance (over 6 feet long) basking right next to one of my live traps – I knew I had to kill it because I couldn't risk that this area where I traveled each day might be it's territory. I killed it with my small camping shovel, and being a “girl,” I had never killed anything so large and noble. I was surprised as how docile this deadly snake was that I had to kill. It must have taken me more than 5 full minutes to kill it and by the time it was dead, I was truly ambivalent about what I had done. This snake never assumed a threat posture towards me, even when I moved close enough to start pounding its brains out. Perhaps it was not the aggressive beast everyone claimed it was?

“My suspicions were confirmed a few weeks later when walking along a narrow muddy trail, I missed seeing a big old fer-de-lance until, too late, I STEPPED on its tail end!! This snake had been snoozing in a shady spot but instead of whipping around to bite me (I certainly was close enough), it woke with a start and zipped away at top snake-speed. Instead of fighting, it fled! This was sufficient evidence of this creature's docile nature – it's biggest secret as far as humans were concerned. After that episode, I packed my snake guards and work boots and wore comfortable sneakers the rest of my field days there. I saw many more fer-de-lances before finishing my field season but never did any show aggression to me.”

Another fer-de-lance showed up on BCI in January of 2001. Some workmen who were constructing a new building called out to Greg as he was passing by, and pointed out a small snake coiled next to the foundation of the building. The snake was three feet long, dark brown, tan and cream, with a pattern like a Turkish carpet, and a triangular-shaped head. It was a baby Fer-de-lance, and a very poisonous snake. Its middle was all swollen, as it had recently eaten a meal, perhaps a small bird or lizard. When Greg leaned toward it for a better look, it reared up and struck out with open mouth and fangs exposed. The workmen clearly didn't want to be working around that site if the snake was allowed to remain, and insisted that it be taken away. Greg agreed that it should be moved.

He found a stick of the right size and shape, pinned the snake securely behind the head and then carefully transferred it to a sack. Then the sack went into a bucket with a lid. Now we had another problem: the workmen wanted the snake to be killed. They didn't want it to show up again; and this was understandable. More people die from fer-de-lance bites than from any other kind of snake in the New World. However, the basic rules of a preserve like BCI are that we do not annoy, harm, remove, or kill resident animals. On the other hand we are very lucky that there are not many more dangerous snakes residing on BCI. In some parts of Central America, one can see several fer-de-lances or other poisonous snakes in one day. On BCI it is an uncommon occurrence.

If someone on BCI were to be bitten by a Fer-de-lance, however, there might be a very strong opinion that the species should be eliminated. So Greg put the bucket in our office while we decided what to do with this snake. If it was to be released, no one would want it in his or her study area. These snakes have excellent camouflage, so they are usually not seen until very close, often too close. A botanist creeping around on the forest floor collecting seeds or measuring seedlings is very vulnerable. This baby snake needed to be released in a location removed from most human activities, where it could eat rats and grow up to live out its normal life as a predator of small mammals, and an important part of the natural ecosystem.
But the animal with the worst venom – that will kill you fastest and deadest (if it ever bites you and chews on you enough to inject the venom) – is the coral snake (*Micrurus nigrocinctus*). I had a collision with one on the trail one morning! I was walking along gazing up at treetops, looking for monkeys, when I felt something lash at my boot. I knew “SNAKE!” and levitated forward at warp speed. When I came down and looked around, I saw the snake zooming off at least as fast in the opposite direction. It moved so fast it was a blur of colors that blended into a bright, almost fluorescent orange. The snake stopped and looked back at me with his tiny little eyes and tiny little head. He was about two feet long and was banded with red, cream, and black, in the usual pattern for real coral snakes (as opposed to those that are false corals, or mimics, and not venomous). He quickly found a hole in the ground and zipped down it before I could start up my camera. I'm sure his version of the encounter was much more exciting – after all, he had my boot come down on top of him! This is the first coral that I'd seen in about three years, and nobody on BCI has ever been bitten by one – unless they pretty much put a finger in the snake's mouth! It's really quite safe in this forest. Some rainforests have bushmasters and many fer-de-lance, and that's another very serious problem. But not on BCI. This place is not a tropical paradise, what with the ticks and chiggers, but it's also not dangerous. No one has ever died on BCI and the worst illnesses and injuries were appendicitis and some broken ribs – someone fell out of a tree and landed on a boat.

Greg and I had a friendlier encounter with a snake back in camp – in our room. One morning when we were getting ready to go out and check the traps, Greg noticed a snake in the room, with its body coiled against the door and its head underneath the door. Since it wasn't moving, he worried that he might have squished it when he came in the night before. He recognized that it was the same snake he had seen on our steps two nights ago – not just the same kind of snake, but the same individual, because it had a distinctive scar on its tail, and the tail seemed to be partially paralyzed.

Now it wasn't moving at all, so we thought it was dead, even after we cautiously opened the door and tried to move the body. It was such a pretty snake – about twenty-two inches long, with a slender body and a long, somewhat pointed snout, brown with black “saddle” markings on its back, and a row of dots below the saddles.

But it was alive! And now it wanted to hide somewhere. So it slid back under the door. We peeked around to see where it would go, but it wasn't visible on the other side of the door! We were trying very hard not to catch a part of the moving coils of snake in any part of the doorway. It took us a while to figure out that the door is hollow and the snake was moving upwards into the interior of the door (I said it was a slender snake). We quickly took photos on our digital camera, and went to the laboratory where there's a photo collection of BCI snakes. We found a matching picture – looks like *Leptodeira annulata*, a frog-eating snake.

The book said that they hunt around frog ponds, but we don't know of any near our room. A friend said that he heard they eat the tadpoles of red-eyed tree frogs. We wonder if this one eats geckos from our room instead of frogs.

We saw him again on other nights, when he came out to hunt at about 9pm, and sometimes again at dawn when he came home again to the hole in the door. Perhaps his tail injury was from the door closing on him. We put a sign on the door to warn other people to be careful.

My friend Pat Detamore (who also had the pet sloth) wrote about an experience she had with a snake many years ago, while she was living in the former Panama Canal Zone:

**Alfred's Story**
By Patsy C. Detamore

A friend and I were exploring a small island in Gatun Lake when we came across a large boa constrictor (about 6 ft. long and unusually fat) lying on the ground. Although we had spent a lot of time in Panama's forests, we had seen very few snakes, as they usually hide when they hear human footsteps approach. This one just lay quietly as we stood over it, and my friend suggested we take it home and eat it. (He had just been through a course at the Jungle Survival School and wanted to demonstrate to me that it was possible to “live off the land” if one was willing to eat some unusual foods.) “Besides,” he said, “snake meat really is delicious.” He sent me to cut a forked stick with my machete while he watched the snake.
As I turned away, my movement made the snake decide it ought to leave as well and it began to slither down a hole under some leaves. “Hurry up,” my friend called, “it's getting away!” He grabbed the tail and held on while I searched frantically for a branch of the right size. (I want you to know that this happened many years ago, before I learned about conservation of our environmental resources, or even about avoiding danger in the jungle. I wouldn't agree to removing a snake – or any other wild creature – from the rainforest now!)

By the time I got back with a forked stick, the snake had turned around in the burrow and poked its head out to see what was holding its tail. My friend, unwilling to let go of the tail, now grabbed the snake's neck with his other hand so as to keep from getting bitten. The stick was no longer necessary, and we put the snake into a large cloth bag that we always carried in case we found something we wanted to carry home.

By the time we reached home, it was too late in the evening to prepare the snake for cooking, so we put it alive in a box, which we stored in another friend's basement. (Neither my friend's wife nor my husband was willing to let to that snake overnight!) Unfortunately, the other friend's wife had no idea there was a snake in the box in her basement, and opened the lid when she went down to do her laundry the following morning. Imagine her astonishment (and horror) when she was greeted by a squirming mass of, not just one large angry snake, but also 52 baby snakes as well! The poor woman slammed the lid down on the box and went screaming down the street, barefoot and still in housecoat and curlers, to a neighbor's house.

When my friend and I came to collect our snake, we discarded the idea of eating it – after all, you can't eat a MOTHER. Instead, we gave the big snake to a small zoo that the United States Army used to show newly arrived soldiers what they might find in the jungle, and tried to find homes for the babies.

Each of the baby snakes was about 18 inches long. (Many snakes lay eggs, but boas give live birth.) We found homes for most of the babies, but my friend kept three of them and I was able to convince my husband to let me keep one. I named him Alfred.

I kept Alfred for three years. In that time he grew very rapidly because I fed him much more than he would have found to eat on his own in the jungle. He outgrew first one cage, then another. Eventually, at nearly eight feet long, he lived in a cage in my back yard until someone opened the cage and let him go. I never found out whether he had been set free or if he had been stolen to become someone else's pet.

I learned a lot about snakes from Alfred. But I also learned something first from his mother. I hadn't known that boas have a musk gland that can put out a really powerful scent. After my friend and I had handled her, our hands had a very strong, unpleasant odor for DAYS. No amount of washing seemed to take it away until it just wore off naturally. I have no idea what that musk is used for, but if I had been an animal looking for an easy snake meal, that smell certainly would have turned me off!

The first thing I had to learn with Alfred was what and how to feed him. Having had no experience at all with snakes before, I talked to a biologist friend who told me that it was important that Alfred's first meal be alive, but small enough to swallow easily and not so lively that it would bite him. “If it bites him before he's had a chance to eat, it may frighten him so that he will never eat,” he told me. He recommended baby mice that were too young to have teeth, a meal that would most likely have been his first meal in the forest. The lab where the man worked was able to supply me with all the mice Alfred could eat, and he learned to love his once-a-week mealtimes.

I also learned that snakes have a pretty good memory. Alfred's first cage was a box with plastic window screen for the sides and part of the lid. One night he found a small tear in the screen on the lid and got out. I found the cage empty in the morning, but had no trouble finding Alfred, as he was busy trying to get into the mouse cage nearby. After repairing the hole, I put Alfred back in his cage – and he immediately stretched himself up the wall looking for that hole!

Much later, after Alfred had outgrown that cage and another one besides, I had to be gone from home for several weeks. Although I had learned from books that snakes, boas included, can live for more than a month without eating, I did not want Alfred to go hungry. So I asked my daughter to see that he got his usual once-a-week meal of six full-grown mice. My usual method of feeding him was to give him one mouse at a time, making sure that he ate it before putting another in the cage. (I had been told that if a captive snake does not eat the mouse in his
cage, the mouse may bite him and cause – at the very least – a skin infection. But my tender-hearted daughter could not bring herself to watch the snake kill and eat a mouse, so she just put all six in the cage with him.

Poor Alfred! He got so excited at having so many choices he couldn't decide which mouse to eat first. (Imagine yourself in a candy store and being told you could eat anything you wanted, but had to do it quickly!) As the mice wandered around the cage (no one had ever told them that snakes could be dangerous to their health), Alfred grabbed one in his mouth, but threw a coil around a different one. The mouse he had in his mouth squirmed around and bit its attacker on the nose. Alfred was so shocked that he dropped both mice and rushed over to soak his nose in his water dish, then curled up in a corner with his head tucked under a coil, hoping all those nasty critters would go away. He stayed that way until my daughter took all the mice away.

She offered him a single mouse later on that day, but he went back into his corner and wouldn't touch it. He reacted the same way the next day, and for all the days I was gone from home. In fact it was a full THREE MONTHS before I could get him to eat again! I put a mouse in his cage every week during that time, but he refused to eat until hunger finally overcame his fear and he again began to eat quite normally again.”
Monkeys

There are four monkey species on BCI that are regularly seen by researchers: howlers, tamarins, spider monkeys, and capuchins. There may also be night monkeys on BCI, but since two semi-tame night monkeys were released around 1981 (they hung around the buildings for about a year and were regularly seen by many people who assumed they were “wild”) they are not often seen, if at all.

If you saw the TBS broadcast called “Panama: Paradise Found?” then you saw Dr. Katharine Milton interviewed about monkeys on BCI. She is personally well-acquainted with many of the howler monkeys on BCI, and I was happy to be in the forest with her when she was teaching five of her university students from California how to observe carefully and to follow specific troops of howlers as they went about their daily activities in the forest canopy. Katie assigned different students to follow different troops and keep track of how the troops interact when they meet in the forest. As I arrived on the scene, so did Katie's favorite troop, the one that she had focused on as a graduate student preparing her doctoral dissertation. She pointed out specific individuals that she recognized – who were descendants of the individuals she first studied – and gave a brief commentary on their apparent health and general condition. Some looked very ill and thin, while others were energetic and healthy. As you read the Howler Monkey profile below, you will learn that these monkeys have a rough time with parasites called bot flies. You will also notice that howler monkeys digest leaves by bacterial fermentation. And through Katie's profile you will find out why howler monkeys howl!

There are very few predators of healthy adult howler monkeys on BCI. When they are old or ill, they can be killed by ocelots and even tayras. But the bigger predators that normally eat howlers (like harpy eagles and jaguars) are rather uncommon on BCI. The cause of death of howlers on BCI is more often a result of parasites such as botflies and screw-worms, rather than predators. No amount of howling will protect them from these insects! I’ve noticed that howlers seem to howl when predators are present to warn other howlers, rather than to scare the predator.

A most descriptive account of howler monkeys’ calls comes from a young friend who was hearing the sound for the first time:

“Awhile before my alarm clock sounded, while it was still pitch dark outside, I was [awakened] by the most haunting and back-of-the-neck-hair raising sound I had ever heard, off in the distance. It began as quiet as a whisper, so that I could barely make out any sound at all. And then whatever it was, got ever so slowly louder, louder, and slowly louder still. For the life of me I frantically tried to imagine the sort of creature that would make such a throaty, mournful and downright spine-chilling sound. I could not imagine anything and I started to get scared despite logic telling me not to worry!”

Another young fellow on the same trip into the rainforest had the same reaction:

“Today I was awakened by what I thought was the most frightening sounds I have ever heard in my life. I had no idea what it was. It woke me about 4am. I didn’t find out until breakfast that they were howler monkeys. One thing about the rainforest – it has a built-in alarm clock – animal sounds everywhere.”

Tamarins are tiny, squirrel-sized monkeys that travel in small family groups and seem to talk a lot. Those on BCI are red-naped tamarins or Geoffrey's tamarin. You should be able to find them in Grzimek's Encyclopedia of Animals, for example. Look them up: they are really cute!

Seeing a troop of tamarins in the forest can really make my day! I was walking on a trail early one morning, when I heard some beautiful, complex birdsong. Lots of chirps and whistles and cheerful canary-like warbling. Scanning the high branches, I soon found the sources of the sounds. I don't usually act this way when I'm observing animals, but this time, I started whistling and waving my arms. Three tiny monkeys, tamarins, all turned their human-like faces toward me.
They had lovely, long silky white fur framing their faces and hanging down their necks, chests and arms. As small as squirrels, they weighed only about one pound each. Their tiny black faces showed many expressions, perhaps many emotions, as they examined me. One tamarin opened his mouth wide, as if he were about to scream, but instead lovely birdsong came out. They grasped small branches with their little hands and bobbed up and down to see me better. Their long black tails hung straight down, not prehensile but very handy for balancing. One tamarin leaped from branch to branch descending quickly to get a better look at me.

Tamarins on BCI have not been hunted for many years and have little fear of humans. Instead, they are curious. They delight me because they seem as interested in me as I am in them. They appear to be gawking at me and perhaps “talking” to each other. (I hope it's about me, and that they're saying nice things.) Sometimes they stay a long time to watch me. They definitely win the cuteness award! They make my day very special whenever I see them.

Some days I know I am seeing different groups of tamarins – families of two, three, sometimes up to seven or eight individuals of different ages. It makes me wonder how many tamarins are on BCI. They're not easy to count.

About 20 years ago, it seemed to be getting difficult to find tamarins on BCI. Some biologists said that the forest was changing in ways that made it unsuitable for tamarins. They predicted that tamarins would become extinct on BCI. But I'm happy to say that tamarins are now seen fairly frequently, and do not seem to be decreasing in numbers.

PRIMATES
General Information
by Katharine Milton, Ph.D.

New World Monkeys

In contrast to Africa and Asia, there are no apes in the forests of Central and South America. There are, however, an amazing number of monkeys, perhaps as many as 59 different species, several discovered only within the past few years. The monkeys in the New World are believed to have originated from an ancestral stock which arrived in South America from Africa during the Oligocene epoch, some 37 million years ago. At that time, the continents of South America and Africa were closer together than they are today and the ancestral primates giving rise to New World monkeys are believed to have island-hopped and drifted in clumps of vegetation across the Atlantic Ocean from Africa to South America. Here they were then able to diversify such that they came to fill a number of different ecological niches. All New World monkeys are arboreal and spend their lives in the forest canopy, though some species will come to the ground to forage for fallen fruits.

New World monkeys are known as platyrrhines or flat-nosed monkeys because of their relatively broad nasal septum in comparison to Old World monkeys and the vertical orientation of their nostrils. New World monkeys fall naturally into two taxonomic divisions – the Callitrichidae and the Cebidae. Callitrichids are the small monkeys known commonly as marmosets and tamarins. In fact, the smallest monkey in the world is a New World monkey, the tiny pygmy marmoset, Cebuella pygmaea, which weighs only 107 to 140 grams, about the same weight as a North American chipmunk, and can fit comfortably into a teacup. Marmosets and tamarins are noted for their colorful pelage and elaborate hair tufts including ear tufts, thick fluffy side whiskers and elaborate curled moustaches. Callitrichids typically give birth to twins whereas all other anthropoids (monkeys, apes and humans) tend to give birth to only a single infant at a time. In callitrichids, the cost of carrying and feeding two rapidly growing infants apparently is too high a burden for the mother alone. Thus in tamarin and marmoset groups, we find that other members of the social unit, frequently the males, help by carrying the infants most of the time, passing them to the mother for nursing only when the young are hungry. Many callitrichids, particularly the marmosets, feed on tree sap or gums that they gouge out of the trunk or branches of trees in droplets, using special tusk-like teeth to pierce the bark. Marmosets and tamarins also eat plant nectars and fruits as well as some insects and, at times, small vertebrates such as lizards and frogs.

The other family of New World monkeys, the Cebidae, is composed of a very diverse group of monkeys including capuchin (or organ grinder) monkeys, howler, spider, woolly and woolly spider monkeys, bald-headed
uakari monkeys, squirrel monkeys, night monkeys and callicebus monkeys. Many, but not all members of this family have a prehensile (grasping) tail in which the last few inches of the undersurface of the tail is completely devoid of hair and covered with a touch-sensitive pad just like your fingertips. The prehensile tail serves as a type of fifth hand, aiding its owners in crossing between the slender branches of trees as well as greatly enlarging their feeding sphere. There is no set rule in this family in terms of social structure and we find everything from huge mixed groups of males, females and their offspring (squirrel monkeys), to smaller one-male groups (red howlers) to monogamous couples (callicebus monkey). Cebids tend to take much of their diet from plants, eating quantities of fruit, flowers and in some species, new leaves; many of the smaller species also include animal matter in the diet, particularly insects.

Spider Monkeys (*Ateles geoffroyi*)

Spider monkeys are the acrobats of New World primates. Unlike other New World monkeys, they do not travel about on all fours (quadrupedal) but rather are brachiators, swinging the body down and around the grasping hand and using the prehensile tail as a fifth hand to aid in their rapid locomotion. Like howler monkeys, spider monkeys have a very wide geographical distribution, being found from southern Mexico through most tropical regions of Central and South America. They are totally arboreal – but this does not mean that they, like other New World primates, cannot move about on the ground. Typically they are found swinging and feeding in the tallest and largest forest trees. There is some debate as to how many spider monkey species there are – some authorities want to place all spider monkeys in a single species, whereas others recognize five species. When adult, spider monkeys, like howler monkeys, weigh from eight to nine kilograms.

The Barro Colorado Island spider monkey species is *Ateles geoffroyi*, the black-handed spider monkey. This species is covered with brilliant reddish hair, but the immediate facial area tends to be naked and the area around the eyes lightly pigmented, often with many tiny or large freckles or black dots. It is possible for human observers to recognize individual spider monkeys by their distinctive facial markings. Spider monkey males and females are about equal in size, in contrast to howlers, in which males are about 20% larger than females. When Barro Colorado Island was established as a nature preserve in 1924, there were no spider monkeys on the island, as they had been exterminated from the area by hunters. In the late 1950’s a number of young spider monkeys were purchased in the market in Panama City and released onto the island, provisioned with fruits to help them survive to adulthood. Five monkeys did survive – one male and four females; and they were the founders of the present-day Barro Colorado spider monkey population, which now numbers some 24 animals and is in its third generation. The Barro Colorado Island spider monkeys have the same behavior, social structure and diet as any other spider monkeys even though they were raised without older “role models” to guide them.

Spider monkeys have an unusual social structure. They live in relatively closed social units called “communities,” which are composed of some 18-30 members but, unlike howler monkeys, spider monkeys do not travel through the forest and feed as a cohesive social unit. Rather they have what is known as a “fission-fusion” social structure in which typically only a few spider monkeys are moving about the forest together at any one time. The entire group may come together late in the day, and, on BCI, are often all seen playing, grooming, or fighting around the laboratory buildings in the early evening; but most of the day they are seen in small sub-groups of only a few individuals or even alone. Spider monkeys are dietary specialists in that the great majority of their food is ripe fruits. Because ripe fruits tend to be distributed on relatively few trees in the forest at any one time and because each tree may have only limited amounts of ripe fruit, spider monkeys apparently are forced to break up into subgroups each day to feed – each subgroup moving to a certain number of fruiting trees within the home range area of the total community each day. In this way, competition for ripe fruits should be kept low and all members of the community should get enough to eat. As fruiting trees tend to be fairly sparsely distributed throughout the forest, spider monkeys have a large home range. On BCI, it is estimated that male spider monkeys range over an area of 300 or more hectares in search of food while females range over a somewhat smaller area, estimated at 200 or more hectares. Like howlers, spider monkeys eat a wide array of different plant species, consuming foods from over 125 different plant species per year.

There is intense bonding between males of a spider monkey troop and if you see a group of spider monkeys in the forest, you may discover that all of them are males. As a general rule, males travel farther than females each day to feed and also carry out long, drawn-out episodes of social grooming – a behavior which many believe serves to lower tensions between individuals and helps them remain on good terms with one another. Individual spider
monkeys often give a loud call when they encounter trees heavily laden with fruits; this call alerts other members of their community as to the location of this dietary resource and many individuals may temporarily congregate in the area to take advantage of this nutritious windfall.

Like human infants, young spider monkeys have a very long period of maternal dependence. On BCI, spider monkey infants, in contrast to the brilliant red adults, are black when born and tend to have large naked pink areas around the eyes. Their “baby face” clearly distinguishes them from adults who tend to be very tolerant of younger individuals. Infants remain tiny and fairly helpless until they are almost a year old. They are carried by the mother until more than two years of age and continue to associate and travel with the mother until they are at least 3.5 years old. Spider monkeys have relatively large brains for their body size and it would appear that as they mature, they need time to learn the types and locations of a large number of different fruit species in the forest as well as other behaviors critical for survival. The long period of maternal dependence should permit each young monkey to mature sufficiently to master all of the information that seems to be required to specialize successfully as an independent adult on a diet composed almost exclusively of ripe fruits.

Mantled Howler Monkeys (Alouatta palliata)

Howler monkeys are among the largest of the New World primates, weighing 6 to 9 kilograms when adult. They have one of the widest geographical distributions of any New World primates, being found all the way from southern Mexico to northern Argentina. Six species of howler monkey are recognized – one only in Central America, one in Central and South America and four only in South America. The howler species found on Barro Colorado Island is Alouatta palliata, the mantled howler monkey, so-called because of the long reddish ruff of hair along the flanks of adults. This species is found throughout Central America, extending south into Colombia. All howler species appear to occupy the same dietary niche. They are vegetarian, eating new leaves, fruits and flowers for much of the year. But when fruit is in short supply, which on Barro Colorado Island generally occurs at the end of the rainy season and during the transition into the dry season – late October, November, December – howlers are able to live for weeks or months at a time on diets composed entirely or almost entirely of leaves. Howler monkeys have large sections in their gastrointestinal tract where the cellulose and hemicellulose of leaves is broken down by bacterial colonies. This process, known as fermentation, produces energy-rich fatty acids which are used by howler monkeys to help fuel their daily activities.

Visitors to Barro Colorado Island will inevitably hear howler monkey calls, particularly in the early morning and late afternoon but also at other times of day. In fact, the most outstanding characteristic of howler monkeys is their howl – a long, drawn-out sonorous call produced by drawing air into an enlarged hyoid bone in the throat. This vocalization, produced primarily by males, is regarded as the loudest call of any Neotropical animal and can be heard for a distance of two kilometers or more under appropriate conditions. All howler monkey troops typically give this call early in the morning in a type of “dawn chorus” which serves to let other howler monkey troops in their general area know their precise location. Howler troops dislike one another intensely and tend to fight if they come into contact. By howling, troops are able to space themselves efficiently throughout the forest canopy and avoid energetically costly and dangerous fights with other groups. Howler monkeys also tend to howl in the late afternoon to announce their sleeping site as well as prior to heavy rainstorms.

On Barro Colorado Island there are an estimated 60 howler monkey troops, averaging 19 monkeys per troop or around 1100-1200 monkeys in total. Most troops are composed of some 3-4 adult males, 7-10 adult females, 2-3 juveniles, and 3 to 5 infants. Female howlers give birth to a new infant every 18 to 24 months. In A. palliata, these babies are pale cream in color and are carried on the belly of the mother until they are a few weeks old. Then their fur begins to darken and they move to the mother’s back. A new howler monkey baby is intensely attractive to other troop members, particularly adult females, and a new mother is constantly harassed and pressured by other members of the troop who want to sniff, look at and touch the new infant. The single infant is carried by the mother until it is around six months old. After the infant completes its first year, it is largely independent of the mother and moves about with the troop on its own.

On BCI, howler monkeys eat an average of 7.7 plant species per day – 5.1 leaf species, 1.7 fruit species and 0.8 flower species; over the course of an annual cycle, foods are taken from more than 125 plant species, largely canopy trees. All howler monkeys show a strong preference for foods from the plant family Moraceae, a family which includes the genus Ficus (or fig). On BCI, you will often find howlers in huge, tall wild fig trees as they eat both the tender new leaves and fruits of all of the fig species on the island. Because howlers often eat a lot of leaves, which
are very low in sugars, they are energy conservers and on BCI troops spend an average of 66% of their daylight hours quietly resting and snoozing. Howler home ranges overlap with one another, each troop using about 32 hectares of the forest over the course of a year.

Howler troops on BCI are persistently infested with larvae of a parasitic fly, Alouattamyia baeri, the howler monkey bot fly – a host-specific species which apparently can live only on howler monkeys. These larvae tend to be localized in the throat region of howlers and can generally be seen with the naked eye. Having only a few larvae does not appear to harm the howler host to any notable degree, but if a monkey is reinfested repeatedly or is in poor physical condition, the cost of feeding multiple larvae may prove too high for the monkey to sustain and it may become ill or die. Howler monkeys die in highest numbers during the mid- to late rainy season on Barro Colorado Island (August through November), the time of year when nutritionally rich plant foods are in very short supply and howler monkeys appear least able to support the cost of bot fly larvae.

Red-naped Tamarin, *Saguinus geoffroyi*

Tamarin species occur throughout the Neotropics in both Central and South America. They are often found in secondary forest or areas of forest in which there are many vine clusters and tangles. On Barro Colorado Island, most of the forest is mature, ranging from around 85 to more than 500 years old. Thus BCI is not an ideal habitat for tamarins which tend to be far more common in the surrounding mainland areas where most growth is secondary. In spite of this fact, it is estimated that 40 or more tamarins live in the BCI forest, organized in small groups of 4 to 7 members. Tamarin groups consist of one or more adult females and males with their immature offspring.

Tamarins can be found in various areas of BCI, but they occur in highest density in the Zetek-Armour area, particularly between Zetek-0 and Zetek-10. Not only are tamarins uncommon on BCI, they are also very small monkeys, weighing only about 500 grams as adults and they tend to travel high in the canopy. Thus the best way to find them is to listen carefully for their bird-like chirps and calls, which they will give loudly as soon as they see a human being. The tamarin species on BCI is a beautiful little monkey with a very striking coat composed of a pure white chest, deep red-brown on the back of the neck and tortoise mottling down the back. Tamarins often travel single file through the forest, leaping quietly from limb to limb. They are very active little monkeys and most of their day is spent travelling through the canopy in search of food. Their diet is made up of ripe fruits and animal matter, primarily insects such as katydids and soft-bodied jungle cockroaches. They are remarkably agile and rapid, skills useful in catching fast-moving forest insects.

Generally only one female in a tamarin group, the dominant or alpha female, has infants. Reproduction in other adult females in the group is somehow suppressed. Tamarins give birth to twins, which the mother passes to the father or other troop members soon after they are born. These “helpers” carry the babies through the forest, passing them to the mother when it is time to nurse. Apparently, it would be too much of an energetic burden for a tamarin mother both to carry and nurse two rapidly growing infants. Thus others help with the task of carrying the infants as the group travels and feeds. By the age of three months, tamarin infants are largely independent of the mother and are able to travel and feed on their own.

Because they are small monkeys, tamarins are vulnerable to many predators that do not pose a threat to the considerably larger howler and spider monkeys. Large snakes can easily consume an animal the size of a tamarin, as can many forest hawks as well as small jungle cats such as margays. The shrill, piercing calls of tamarins serve as alarm signals, alerting group members to possible dangers. Tamarins tend to retire earlier than the other monkey species on BCI, moving into leaf clusters, vine tangles, or other dense cover at around 5pm and remaining quiet there until daybreak. This may be an adaptation that helps them avoid the many predators that tend to become active around twilight, such as owls, snakes and small cats.

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Here's another monkey species, often called White-Faced Monkeys or Capuchins. Dr. Betsy Mitchell wrote her doctoral dissertation on field work that she did with white-faced monkeys on BCI. She has worked with these monkeys for many years, but now that she has two children of her own, she has become especially interested in how the mother monkeys care for their babies.

**White-Throated Capuchin**

*(Cebus capucinus)*  
by Jacalyn Giacalone, Ph.D. and Betsy J. Mitchell, Ph.D.

These agile and fast-moving monkeys are often detected because of debris falling from the treetops as the monkeys rip apart fruit clusters and bark to forage for insects and sweet ripe fruit morsels. They forage at all levels of the forest, feeding on a great variety of foods, mainly ripe fruits and invertebrates, but also an occasional lizard, frog, snake, bird's egg, baby squirrel or bird, or even a nestling coati. They have been observed stalking and lunging at adult squirrels and tamarins. Capuchins can be seen in the late afternoon around the residence buildings, feeding on the nectar of balsa flowers. Dr. Betsy Mitchell observed capuchins feeding on 116 species of plants during a two-year study. When combined with a study by the Hladiks, also on BCI, the number of food species totals 169. Capuchins use another 8 species of plants to rub into their fur, perhaps to condition their skin or to repel parasites.

Visitors to BCI are often surprised to see these monkeys walk upright on two legs on the forest floor. They easily use all levels of the forest. Capuchins are very vocal, giving out barks, whistles, and screams as they move, calling to each other to maintain contact. Deer and agoutis take advantage of the falling food under trees where a large group of capuchins is feeding. Visitors can usually find a troop to observe and will often see species that associate with capuchins. Pairs of double-toothed kites, which are small, very elegant predatory birds, move through the forest with the monkeys in order to capture lizards and insects as they flee from the capuchins. Capuchins express their dislike for being observed by humans by shaking vines and branches and pushing loose twigs and leaves out of the treetops. Their distinctive, recognizable faces and individual personalities make capuchins particularly interesting to observe. They have the largest brains, relative to body size, of all the New World monkeys, and are known for their intelligence.

The species of capuchin on BCI, the white-throated capuchin (*Cebus capucinus*) has black upper parts with whitish neck, shoulders and upper arms. The head is yellowish with a black cap; the face is pinkish. The long black tail is used for grasping, but not as extensively as in spider monkeys. As they walk along branches, they usually carry the tail coiled underneath at the tip. Adults weigh 2-4 kg, with males heavier than females. The species ranges from Honduras to northern Ecuador. In Panama they are called *cariblanca* (white-face).

Capuchins are an extremely social species that lives in groups averaging about fifteen, and ranging from 2 to 24. Usually two adult males, four to eight adult females, one or two subadult males, five to nine juveniles, and up to five infants may be present in a troop on BCI. There were 18 groups recorded on BCI in 1966, when Oppenheimer was studying their biology; in 1987, Mitchell recorded 16 groups plus a possibility of two others. She estimated 278-313 capuchins on BCI, while Oppenheimer estimated 270 from his 1966 data. This suggests that the population has increased slightly but is fairly stable over the long-term.

Young capuchins usually stay with their group for the first four years of life, sometimes emigrating as they approach maturity. Emigration of older adults to another group, however, seems to be an unusual occurrence. Young are born most often from February to May. The gestation period is 5 months, and a female usually has only one young in two years. Mothers may nurse a baby for two years, during which time they usually do not become pregnant again. Young start feeding independently at about 4 months of age. Subadults and juveniles share in carrying infants after 3 months of age. The first two years of a capuchin's life are the most dangerous, and mortality is highest at this time. If a capuchin lives to adulthood, it has an excellent chance of living a long life.

A group uses 77-110 hectares of forest in its daily wanderings, moving 1.5 to 3.5 km each day. During the season of fruit scarcity on BCI, capuchins feed on a great diversity of small fruits that are usually thought of as bird fruits. They may also feed on a greater proportion of insects at this time. Mitchell's work on foraging behavior showed that capuchins use different patterns of foraging in different seasons. The season when young are ready to start feeding on their own is the time when many small, easy-to-handle fruits are ripening. These are also fruits that
are found in short trees that are easy for a young monkey to enter. Large trees are barriers to the young, who must wait to be carried into tall trees by an experienced adult. The movements of groups with young that are learning how to forage are more restricted than in groups with tiny portable infants or weaned youngsters. The group restricts both its horizontal and its vertical movements to accommodate the limited climbing skills of the young. The timing of births permits the weaning stage to coincide with the season of small fruits. This timing is thought to be an adaptation to enhance survival of the most vulnerable individuals. Similarly, the peak of births in the BCI population coincides with the availability of large patches of food that allow mothers to feed well and rest frequently. In any season, individuals adjust their behavior to different distributions of food resources in order to also maintain the integrity of the social group.

The home ranges of different groups are broadly overlapping, so groups often meet. When groups meet, they chase each other and shriek. Adult males are dominant over adult females, and adult males defend the group from other monkey groups and from predators. The predators of capuchins on BCI are probably boa constrictors, ocelots, and tayras. Capuchins on BCI have been observed to mob and call loudly when they detect tayras, hawks, and boas.

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Birds

Jane’s Field Notes:
Thursday, January 29, 1998

Before 7am on January 28, I awoke to the strange sound of heavy rain pounding on the metal roof above me. So much for sleeping a bit later on a day when I didn't need to be up in the forest by 6:30 in the morning...

This was the first rain in several weeks, and was quickly over in less than fifteen minutes. Once awakened, I walked out onto my balcony from which I can see Lake Gatun and the Canal beyond the trees. The rain had filled the deep cup-like flowers of the Balsa trees; and before [my] half-opened eyes began the most magnificent parade of birds I've ever seen. They came to drink water from the flower cups, water made all the more precious [because it’s the beginning of dry season]. Like humans lined up for cold sodas at a sunny summer ball game, they took their turns, some nudging and squawking, others waiting, chatting and calling. Some, like the Blue Dacnis and the honeycreepers, were small enough to perch on the rim of the flower and tilt their heads in for a drink; others, such as the Orange-chinned Parakeets, were heavy enough to tip over the flower, spilling its contents on the large leaves below where the hummingbirds hovered. I dashed back inside for binoculars, a pen, and paper.

As I viewed each different type of bird, I attempted to quickly scribble a note about size, color, bill, feet, eyes, anything that would help me identify the species in a field guide later. “A Guide to the Birds of Panama” by Ridgely, published by Princeton Press, 1976 is the resource I used once I got to the lab. Having carefully checked the guide book and conferred with other people here, I'm fairly confident that I can correctly identify for you the birds I saw. Perhaps your library has a guide book that gives sketches and short but detailed write-ups about the bird's description, habitat, and distribution.

Here is the list:
- Hummingbirds – several different types
- Orange-chinned Parakeets
- Woodpecker, most likely a northern migrant Yellow-bellied Sapsucker
- Yellow-rumped Cacique – 10 or 11 inches head to tail, velvet black and brilliant yellow with blue eyes and a pale greenish white bill. Stunning! Not only did this one drink, but also caught his breakfast, an unsuspecting insect flying in for it's own drink. Snapped it out of the air as it was about to land on the flower.
- Blue Dacnis
- Honeycreepers
- Mealy Amazon Parrots

I watched for over an hour. Some I couldn't see quite clearly enough to identify, but by now you probably have the picture. Of course I missed breakfast, but it was worth it to see these exotic creatures of the rainforest.

It rained twice more today: once at noon and again about 4:30, each time for only 10 or 15 minutes, but very hard, what we'd call a downpour. Clouds moved away rapidly, carrying whatever rain they still held to another part of the jungle. When it begins to rain, the Howler Monkeys begin to howl. They don't seem to like the rain. I wonder why?

Here are the other birds I've seen in the past few days.
- Rufus Motmot
- Tawny-throated Leaftosser (Yes, they do toss the dry leaves about on the ground.)
- Crimson-backed Tanagers

And now, for some BIG birds:
Osprey (They don't breed in Panama, just visit.)
Snail Kite
Chestnut-headed Oropendola
King Vulture – circling above the canopy, very large bird.

More than ever before, I appreciate the task tackled by ornithologists, the birdwatchers, both professional and amateur, who meticulously study, research, and catalogue the birds, along with the scientific illustrators and photographers who provide us with the visuals. Those are important jobs we rarely think about until we need the results of their work to enlighten us.
Bats

One of the classes we corresponded with via e-mail while we were working on the island asked, “What's the most numerous mammal on the island?” Some people say it's the three-toed sloths, which are abundant but very hard to see. But my vote goes to agoutis, which seem to be all over the place, especially in the last few years. My friend Barry Koffler in New York differed with that answer, however. He wrote, “Agoutis? You must be Bats! I'd very Shrewdly have guessed it was some small Murid.”

Now, Barry likes to make plays on words, but he gave us a good hint. Although our mammal census does not include bats – which are perfectly good mammals, but too much for us to handle, especially when Dr. Charles Handley has been catching and marking bats on BCI for decades – there are at least 61 species of bats that visit or live on this island! That's more species than all the rest of the mammal groups put together!

Several colonies of bats live in the ceilings and under the eaves of some of the buildings on BCI. Since bats are such strange creatures, I asked our resident BCI bat expert, Dr. Elisabeth Kalko, to write about them. She is a professor from Germany who spends part of the year at her university and part in Panama.

**BATS**

by Elisabeth K. V. Kalko, Ph.D.

Much has been learned in recent years about the usefulness of bats and the important roles they play in maintaining the health of ecosystems. Understanding the amazing diversity of bats will change the common belief that all bats are ugly and blood-thirsty. On the contrary, bats are highly beneficial animals. Fruit-eating and nectar-drinking bats play indispensable roles in maintaining forest diversity and in facilitating forest regeneration through seed dispersal and pollination. Insect-eating bats remove large quantities of insects from the environment, including many that damage plants or are regarded as pests to humans.

Bats are mammals and thus, female bats possess mammary glands, which produce milk. When baby bats are born, they are taken care of and fed milk by their mothers for a few weeks until they can fly and forage on their own. As is typical of most other mammals, the body of a bat, except for its wings, is covered by hair. Due to the way bats look at first glance, in some languages they are called flying mice. However, bats are not related to mice or rodents at all, but belong to a large group (order) of mammals called CHIROPTERA. The order Chiroptera consists of two subgroups (suborders): Microchiroptera and Megachiroptera. Microchiroptera have a global distribution and include about 825 species worldwide. In all of Panamá, we find about 120 species of Microchiroptera. All microchiroptera have a well-developed sonar system (echolocation) that allows them to orient in the dark and to a varying degree to find food. They emit high-frequency sounds, most of them too high for humans to hear, that bounce off objects and allow bats to build up an acoustic image of their surroundings. Megachiroptera do not occur in the New World. They are limited in their distribution to the tropics and subtropics of the Old World (i.e., Africa, Asia, Australia). They consist of a single family containing about 175 species. Megachiroptera have fox-like faces with a long snout and large eyes. Not surprisingly, they are also known by the vernacular name “flying fox.” With one exception, flying foxes do not use sonar. They rely mostly on their keen senses of vision and smell to find their way, mostly in twilight or above the canopy at night and to locate food.

**Bat wings.** Chiroptera means “having wings,” and characterizes the unique way bats fly. Bats literally “fly with their hands.” Imagine a hand with very long fingers; then picture a thin, elastic skin (membrane), that stretches between the elongated fingers and the arm, reaches down to the leg and attaches to the side of the bat's body. This membrane forms the wing of a bat. However, not all five fingers of the bat's hand are part of the actual wing. The first finger, the thumb, is very small and ends in a little claw that the bats use for crawling and to help manipulate food. In many bats a membrane stretches between the legs to include part or all of the tail. This tail membrane is used as a kind of pouch by insect-eating bats to trap prey in flight. Although the tail and wing membranes of bats are very thin and would seem to be easily injured, they are actually highly elastic and tougher than a rubber glove. Sometimes, however, a bat accidentally rips a hole in a membrane or punctures it. Since the membranes have excellent healing capacities, those wounds usually pose no threat to the bat.
**Bat eyes.** Bats are not blind. All bats have eyes, and a number of species, particularly Flying Foxes, have very large eyes and excellent eyesight which helps them find their way and their food in twilight and above the canopy at night. In contrast, bats which rely almost exclusively on sonar for finding their way in the dark and for foraging, have mostly tiny eyes and rather poor eyesight. This may have led to the widespread myth that bats are blind.

**Roosting.** Most bats live in groups; and group size varies dramatically among species. Some form huge aggregations. Several thousand or even several million bats may share a roost. Many bats, however, live in smaller groups, ranging from a pair to a few hundred. Roosts of bats can be found in many situations. Under natural conditions, bats roost in caves, under fallen logs, in tree- and earth-holes, in hollowed-out, arboreal termite nests, between flying buttresses of large trees, in rocky crevices, and in the vegetation. Roosts of bats include also man-made structures such as attics, roofs, and eaves of houses as well as places under bridges, in tunnels, and in culverts.

A very interesting roosting behavior occurs in some Neotropical fruit-eating bats (e.g., small Artibeus, Uroderma bilobatum). They select a leaf of a particular plant, such as those of palms and wild bananas and modify it the way that the leaf forms a small tent-like shelter. This tent is accessible from below and is inhabited for a period of time by a small group of those “tent-making” bats. The tents serve as an excellent shelter against rain and predators. Bats hanging in those tents are very difficult to spot unless one stands right underneath a modified leaf looking straight up. However, although these bats do not appear to be disturbed when one just looks at them, they leave the tent immediately at the slightest vibration of the leaves.

Another fascinating roosting behavior has evolved in the Neotropical Disc-Winged Bats (Thyroptera sp: murcielago de ventosas). These bats have a suction cup on each foot and on each thumb. Anatomy and function of the suction cups resemble those found for instance in an octopus. The disc-winged bats select leaves of wild bananas which are not yet unfurled. They crawl inside the tube-like leaf and use their suction cups to hold on to the leaf’s slippery surface. These are the only bats which roost “head up.” All other bats roost in the characteristic “head down” position.

Most places where bats roost appear dirty and foul-smelling because of the bat guano that piles up beneath them. By the way, the guano is an excellent fertilizer for garden plants! The bats themselves are very clean animals. They groom themselves many times during the night and after each meal. They use their hind feet as a comb and their tongue for grooming, carefully cleaning the fur, the delicate wings, and the tail membrane.

**Group composition.** Not only does the number of bats per group vary, but also composition of groups of bats spans a wide range. Many bats form maternity colonies at certain times of the year which are composed almost exclusively of females. The females raise their young in these colonies which give protection to the individual bats. Males of most species are solitary or stay in small groups for most of the year. Other species form harems in which a male and several females live together. Harem males may defend their roosts from other males.

**Reproduction.** In the temperate zone bats reproduce only once per year. Usually, they mate in autumn before hibernation starts. Over the winter, females store the males’ sperm, a feature unique among mammals. Fertilization of the egg usually occurs in early spring. Young are born at the end of spring and the beginning of summer. Tropical bats often reproduce twice a year, following seasonal patterns in food availability. Long-term studies have shown that females of the Common Fruit Bat (Artibeus jamaicensis) synchronize births of young within groups.

Bats give birth usually to one young. There are only very few exceptions where bats regularly give birth to two or more young. At first, the young bats cannot fly because their wings are not fully developed. For two to six weeks, the female takes care of the baby, keeping it warm, grooming it, and feeding it milk. During that time, a strong bond exists between mother and young. Mothers recognize their own young even when they have to identify them within huge aggregations of hundreds or even thousands of other baby bats. The mother is guided by scent and vocal communication to its own young. After the young has grown up and learned to fly, it begins to forage on its own, and the mother weans it.

**Bat activity and diet.** Bats are active at night and rest during the day. At dusk or shortly after nightfall, bats leave their roosts and head straight to their feeding areas to begin foraging. Many bats spend the whole night outside of their day roost and do not return until shortly before dawn. Usually bats have a number of other places, called night roosts, near their foraging area, for shelter and rest during the night. Neotropical fruit- eating bats and bats that
take large insects or small vertebrates from the vegetation or the ground use their night roosts also as “dining” roosts. Fruit-eating bats carry fruit from the fruiting tree to their temporary dining roost and process it there. Hence, seeds and other remains of the fruits accumulate beneath the roost and along the route between the fruit tree and dining roost. Since seeds distributed away from the parent tree have a much better chance to survive and to develop into seedlings and later into trees, bats are very beneficial for forest regeneration. Bats that eat large insects routinely carry them to a dining roost. While processing their prey, these bats discard and drop wings, legs, and other inedible parts of the insect. Examining the prey remains beneath a dining roost gives a very good idea of kind and amount of food the bats eat. Overall, the variety of diets of bats ranges from fruit, nectar, pollen, and leaves to a great variety of insects, spiders, crustaceans, small vertebrates (including fish, birds, lizards, rodents, and other bats), and blood of birds and large mammals.

**Bat predators.** Numerous anecdotal observations have revealed a wide range of predators for bats. Raptors and owls approach bats and often catch them in flight. Opossums and snakes may wait close to roost sites or attack fruit-eating bats when they approach trees loaded with ripe fruits. Presumably to lessen the risk of being caught by predators such as owls, some bats are known to drastically reduce their activity level during bright nights around a full moon (lunarphobia).

**Echolocation.** All microchiropteran bats use a kind of sonar system called echolocation to find their way in the dark and to find and capture their food. While searching for prey, bats emit high-pitched sound in a regular pattern. Most of the sounds are so high in frequency that they are not audible to humans. The echolocation signals strike all objects around the bats and echoes travel back. The bats process the echoes and extract information about distance, shape, size, texture, and movement of potential prey and surroundings. The bats use this information to avoid obstacles like branches, trees, and walls, and to find food. The resolution of the echolocation signals is so accurate that bats can detect and avoid obstacles as thin and as fine as a human hair!

Perhaps the most impressive “perfection” in echolocation and foraging performance is found in bats that capture insects in the air. As soon as bats have detected potential insect prey with echolocation, they orient toward it and begin their pursuit. When very close to the insect, the bat reaches out with a wing to capture the insect. Then it shovels it into its tail membrane, which forms a pouch. After a successful capture, the bat bends its head into the tail pouch, retrieves the insect, and eats it in flight. Some bats catch and eat the insect directly out of the wing or tail pouch alone.

Why, then, are there stories of bats flying into women’s hair and holding on to it and sometimes touching people with their wings? Are these bats not using their sonar system to avoid obstacles or are they deliberately attacking people? Both answers are incorrect. People are most likely to come into contact with a flying bat either in a room or other confined space or when they walk into the flyway of bats, such as narrow trails in the forest. In the first case, bats in confined spaces are simply confused and trying to escape. In their confusion, and if they are exhausted from being chased by people, bats may seek refuge on a convenient prominence, which might be a person’s head. This is NOT a deliberate attack by the bat! The easiest way to get rid of a bat in the room is to leave the bat alone, turn off the lights, close the door, and open a window. Bats will soon escape through the open window. In the second case, bats flying along well-known and traditional flyways in the forest may not pay much attention to their surroundings since they know the way “by heart.” Thus, a person walking in the trail might just be an unexpected obstacle in the flight path of the bat. By trying to get around the obstacle at the last instant, bats may accidentally touch a person with their wings. In neither case does this behavior of the bats represent an attack on people.
Rats

SPINY RATS
(*Proechimys semispinosus*)
by Gregory H. Adler, Ph.D.

Spiny rats (genus *Proechimys*) occur in virtually every type of lowland forest in tropical Central and South America. These rodents are not spiny like porcupines or hedgehogs, but instead have much smaller spines on their backs that are hidden by soft guard hairs. The spines are evident only when the fur is brushed toward the head. The function of these spines is not known, but they may aid in repelling water in very rainy tropical forests.

The Central American spiny rat (*Proechimys semispinosus*), the only species found on Barro Colorado Island, is distributed from southeastern Honduras to the Pacific slope of Colombia. This large rat (up to 600 g) is generally a rich reddish-brown above and immaculate white under the belly. Juveniles are a darker brown and have only a few poorly developed spines. Spiny rats eat mostly fruits and seeds but may also eat fungi and insects. Because they are abundant and widely distributed, they are important seed dispersers and predators of a wide variety of forest plants and hence may affect forest regeneration. They also serve as important prey for a diverse array of predators, including ocelots, margays, jaguarundis, owls, boa constrictors, fer-de-lances, and bushmasters.

Spiny rats are often the most abundant rodent within their large geographic range. They are found in both young and old forests, but they are generally most abundant in forests of intermediate age with many fruit trees such as palms and figs. In many forests, spiny rats appear to be the most abundant along small streams. Spiny rats are mostly nocturnal and spend the day in underground dens. They emerge from their burrows just after dark to forage on the forest floor. Although they are largely nocturnal, they may sometimes be seen sitting at the entrance to their burrows during the day. They are also readily seen at night if one searches the forest floor with a spotlight. On Barro Colorado Island, Shannon Stream, or along the many forest trails, are good places to search for spiny rats.

An interesting feature of spiny rats is the ease with which their tails break off. If grasped by the tail, the tail will easily break off between the fourth and fifth vertebrae. The rat will then flee to its burrow unharmed, except for the loss of its tail. This characteristic may be an anti-predator adaptation, but it will work only once since the tail will not grow back. In central Panama, about 15-20% of all adult spiny rats are lacking tails.

Recent Research: For the past five years, I have been using 12 small islands in the Panama Canal near BCI as experimental systems to study populations of spiny rats. I had numerous questions about how spiny rat populations vary with food supply and how their reproductive efforts and social behaviors might change as islands become more crowded or less. Specifically, I have tested the following hypotheses:

Hypothesis 1. Spiny rats, which eat primarily fruits and seeds, are not food-limited during the season of greatest food abundance. This was tested by provisioning four island populations with native fruits for six months from May through October 1992, when natural fruit crops are at their greatest abundance. Rats were trapped and marked by toe-clipping and recaptured to determine their population density (number of rats per unit area).

Hypothesis 2. Both sexes of adult spiny rats regulate population densities by their aggressive interactions with young and socially subordinate adult individuals. This was tested by:

a) experimentally decreasing densities of adult males on four islands in June 1993 and June 1994,

b) concurrently decreasing densities of adult females on four other islands,

c) experimentally increasing densities of adult males on four islands in June 1994, and

d) concurrently increasing densities of adult females on four other islands.
Hypothesis 3. Adult female spiny rats regulate population densities by adjusting their reproductive effort in relation to changes in density. This was tested by the same experimental procedures outlined in hypothesis 2.

Analysis of the data thus far indicates that population densities generally were not limited by food availability during the season of resource abundance. Adding food to an island did not necessarily result in an increase in rat population density. Hypothesis 1 appears to be correct. Although reproductive output of females was greater in all four experimental populations when compared with four control populations, this greater reproductive effort resulted in higher densities in only one population.

However, seasonal availability of food resources varied among islands, and one population showed much higher densities relative to those expected based on the abundance of naturally available fruit. Thus, this population was not provisioned solely during the period of greatest resource abundance. Survival rates of young and adults did not vary between control or experimental populations. Results of the density manipulations suggested an important role for adult males in regulating population density, presumably as a consequence of aggressive interactions with young and subordinate individuals and consequent effects on recruitment. When the density of adult males was reduced, more young matured into adulthood and became permanent residents in the area where they were born. Results also suggested that adult females did not play a similar role in regulating densities by aggression. Therefore, Hypothesis 2 is correct for males only. However, adult females apparently increased their reproductive output when population densities were reduced, which indicated that females also played an important role in regulating population density, presumably as a consequence of such reproductive adjustments, confirming Hypotheses 3. Thus it appears that when populations dip low, females tend to increase their reproductive effort (if food is also sufficient for reproduction), but if the population swings high, then aggression by the males prevents young rats from settling down and increasing local densities. Future work will help to fine-tune these conclusions and to relate them to the broader understandings of the dynamic interactions between forest fruit production and animal population fluctuations.

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Cats

Several species of cats are native to Panama: pumas (also called panthers), jaguars, ocelots, jaguarundis, and margays. There seem to be only ocelots and maybe jaguarundis living all the time on BCI. Ocelots are seen frequently. The jaguarundis are hard to see, so it's difficult to say for sure. The last puma sighting had been in the 1960's, until just recently, when someone reported having seen one. However, I expect that one could swim over some day and decide to stay, although the island might be too small to support the larger cats for very long.

Although there is little evidence that pumas swim, we know that other people have seen jaguars swimming, in lakes and rivers and in this lake in particular. They seem to like to swim. Their footprints were found on the shores of this island and also on the shore of the nearest point on the mainland and also on a very small island in between. They weren't here before, but then they were here. And then they were gone. So, we are inferring – based on very strong evidence – that they swam back and forth (sometimes a mom and kitten that left two sets of prints).

Ocelots on BCI have been another one of those mystery species: seldom seen, very beautiful, and thought to be very rare. Ocelots are an endangered species of cat with black stripes, and spots in elongated rows and swirls filled in with brown on a background of cream. They weigh about 20-30 pounds (sometimes more), and are generally about two or three times the size of a house cat. They can be active at any hour of the day or night, but favor the time from dusk to midnight. They are known for spending many long hours slowly patrolling trails in search of prey. While some other species on BCI have become rather accustomed to being observed by humans, none of the cat species has become so trusting. Ocelots never seem to tolerate human curiosity, although they have been known sometimes to examine humans with some interest.

In the 1930's, Robert Enders trapped and observed ocelots on BCI, and collected scats to learn about their diet. In the late 1970's to early 1980's, Bill Glanz did extensive mammal census work on BCI. Bill had a chance to walk the BCI shores in a year of little rain, and found enough tracks of different sizes of ocelot that he thought there could be as many as 12 individuals on the island. Then for 20 years after Bill's study, the ocelots seemed to be out of reach of understanding. Seldom seen by anyone, it was hard to say how many lived on BCI, what they ate, and where they roamed. In those years, Greg and I saw occasional tracks and scats (feces) on many trails, but had only four census records of ocelots when we actually saw an ocelot while collecting census data. There were only three or four sightings per year by all the BCI visitors combined.

Now, 20 years later, we seem to have a wealth of ocelot information. This is partly due to the success of our work with the automatic cameras that Greg and I purchased from the CamTrak South company and carefully placed in likely locations on BCI. It may also be due to an increase in ocelot numbers. We have no way of being certain of an increase, but although we started placing cameras on BCI in 1994, we had little success until the 1999 season.

That first camera, from the TrailMaster company, utilized an infrared beam and sensor, like that on a supermarket door. When the beam was blocked by an object, the sensor triggered the camera to take a picture. We placed the camera under a fruiting Dipteryx tree where many agoutis, a favorite prey of ocelots, can be found feeding. Our very first roll of film had 35 photos of a palm frond that waved back and forth in a breeze and kept taking its own picture! However, the 36th photo was an ocelot. We thought, “Oh, this must be easy: we can get lots of ocelot photos!” But after that first success, we used up a lot of film on agoutis and coatis and squirrels before we saw another ocelot.

From 1994 to 1998, we were able to get occasional ocelot photos with the small number of cameras we acquired. We had more success with cameras placed on trails, but we also got lots of photos of humans. Then in 1999 we were able to purchase six “CamTrakkers” with reasonably good waterproofing, that we could place on BCI and leave all year long, with someone to change the film and ship the exposed rolls to us. With those cameras we started seeing rolls of film with not just one, but sometimes five or six ocelot photos. And we could distinguish individuals by their distinctive and complex patterns of spots and swirls and stripes. This made things much more interesting. We began assigning identification numbers and names to individuals and assembling a “mug book” (http://pumafullmoon.tripod.com/) of cats for easy comparison and identification. We began to realize that each trail that had a camera on it was taking photos of up to six different ocelots. And very few of the ocelots were found
on different parts of the island. We have to be cautious in our conclusions because both sides of an ocelot do not necessarily look the same, but we have been able to match many right and left sides. We are now arranging some camera placements so that we get photos of both sides of each animal.

In all, we think we have photos of 19 adult ocelots. We got our first kitten photo in January of 2001. We “saw” the mother the previous October and she was very heavy in the middle, probably pregnant, so we figure the kitten was only 2½ months old. Ocelots usually have their kittens at this time of the year (during dry season) in this part of the world. They usually have only one or two kittens, and only once every two years. But, with as many females as we saw in the photos, we would expect that more are raising young right now. Somewhere out there must be more youngsters!

When Christian Ziegler, who was taking photographs for a special pictorial volume about BCI, set up his camera in a place we recommended, he got gorgeous photos of two male ocelots. We were pleased that we could identify them as Goliath-#001 and -#002, and give him a little history about these particular ocelots. The ocelot named Goliath-#001, is an exception to the conclusion that BCI ocelots have not been crossing over between trail systems on different parts of the island. But then, Goliath is an exceptional ocelot in many ways. He is large and long-legged and lean. His head is big and wide, with heavy jaw muscles. Ricardo Moreno's plaster casts of tracks showed that Goliath has a crooked toe, and his paws are as big as those of a small puma. Ricardo named Goliath aptly. He is a busy ocelot, always on the move; too busy to groom carefully, he has ticks and red, bloody rashes on his elbow and knee areas, probably mange. And in some of his photos he has torn skin around fresh wounds. He is not a pretty ocelot, but he clearly gets around the island, showing up in photos from cameras on Wheeler, Drayton, Miller, and Snyder-Molino. Other males use the same trails as Goliath, but they seem to always be separated from him by a couple of hours (the photos have time and date stamps), and are usually traveling in the same direction, as if they are all in a long parade arranged to avoid confrontations. This pattern of ocelot traffic has been described by Louise Emmons in Peru, and she has also noted that the “supermales” often have mange. Life is tough at the top of the ocelot social heap.

We also got a sequence of photos that show predation in action! The cameras record the date and time in the corner of the photos. (We say they are “time-stamped.”) The first photo that evening at 8:13pm shows a small opossum peering from under a vine, its eyeshines brightly reflecting the camera flash. The next frame, taken at 8:17pm shows an ocelot in the exact same spot, bending down. Its big jaws are around some dark object and its pink paw is curled under the object, grasping it to its mouth. We were pretty sure this was a record of predation, that the ocelot had caught the opossum. But just to be certain, I went out to the scene of the alleged violence and got down on my knees to check for evidence. Comparing the photo with the actual area in front of the camera, I found the precise location, and soon saw fresh clumps of Didelphis opossum fur, which looks like no other BCI mammal's fur. That makes me feel quite certain that our conclusion was correct.

Ocelots are very hard to see in the wild, so we don't know how many are on BCI. I can guess, but I don't know for certain. It's even harder to see predation happening. It helps to have this kind of photo evidence, which shows that ocelots are doing well on BCI. It also helps to know for sure that ocelots on the island eat opossums, even though we suspected that was the case, and that they probably eat lots of other prey, like agoutis, spiny rats, and tinamous. When we find the remains of dead animals, it’s hard to say for certain whether they had been killed by an ocelot. Very often the vultures and carrion-fly larvae can eat the soft parts of a dead animal in just one or two days, leaving only a skeleton. Greg once found a freshly dead peccary with no obvious wounds or other damage on a Friday. When I went out to look at it on Saturday, there was a nearly clean skeleton – and two vultures. We do find skeletons, but they don't tell us much because so many scavengers have chewed on them! We can usually tell what species it was by looking carefully at the skull and at remains of fur, but not what had killed it.

We wondered about the possibility that the bright flash of the trip camera might have sealed this possum’s fate by bringing its presence to the attention of the ocelot or temporarily disorienting the possum so that it was easier to catch. That seems possible, but he was also in a place where he was already in great danger, on the ground, not near a tree to climb, and busy with fruit to eat. We also wondered if the ocelots might hang out waiting for the cameras to show up a tasty careless small mammal. But we conclude from these photos that the ocelots seem to come around the fruiting trees to check periodically for prey, and that they also cruise the trails.

We'd like to be able to say more about what ocelots are eating on BCI, and whether they share some prey with the pumas. Ricardo has been collecting scats of both ocelot and puma and can say what percentages of the diet are
composed of various prey items, such as opossums, spiny rats, birds, lizards, and agoutis. Other evidence of predation is hard to come by. We have one photo that shows an ocelot carrying a spiny rat. Another sequence of two shots shows an opossum looking at the camera, and then 3 minutes later an ocelot with its jaws around an animal that seems to be the same opossum. And that's all that the photos show of predation. Likewise, Louise Emmons' work in Peru turned up only four observations of predation while intensively tracking nine ocelots wearing radio collars for several months. Ocelots spend most of their time hunting, unlike African lions, and have to work hard to get their prey. Ocelots on BCI and elsewhere patrol their territories, leaving scats and spraying urine as scent marks, while on the lookout for prey. Ricardo took advantage of this scent-marking behavior by spraying a musky perfume near our cameras, in order to increase visits by cats. We have a photo of one ocelot backed up toward the camera, spraying.

Although they are very elusive, our cameras have also caught pictures of pumas (also called mountain lions or cougars). These are the tawny cats without spots. They are smaller here than in the US, and they have thinner, silkier coats of fur. They weigh in the range of 70 to 120 pounds, probably not often reaching the 260-pound size of pumas in the north. There used to be several pumas on BCI in the early years, that were recorded in an old camera study. It was estimated that 16 individuals lived on BCI in the 1920's, but were hunted by poachers until the last was seen in the 1960's. Then there were 30 years when there seemed to be no sign of pumas. In the early 1980's and mid-1990's there were some tracks and brief sightings that seem to have been visiting pumas. Our camera results indicate that perhaps the first puma to take up residence on BCI since the 1960's swam over to BCI before March of 1999, and that by March of 2000 there were two or three pumas living on BCI. Greg and I found carcasses of peccaries in January 2000 that appeared to be puma kills. Ricardo Moreno started finding puma tracks on BCI before that time. Ricardo has been checking the forest near the trails and collecting puma scats to analyze their diet on BCI. They like to eat peccaries, deer, agoutis, pacas, and other mammals.

In our trip-camera photos in 1999 and early 2000, one puma looks like a nearly-grown-up youngster, full-sized but with some of the faint spotting of the young. There is another that is a female (perhaps the mother) who is bigger and heavier. Both are light beige in color. They were photographed on the same trail, on the same night, and not separated by much time. A photo in November, 1999 shows what appears to be a red-brown puma with black markings on its face and tail, so this could be number three. Ricardo said he thought the third puma must be crossing over from Buena Vista peninsula to Fairchild Trail on BCI. Greg and I decided to move a camera from BCI so that Ricardo could set it up along the Buena Vista trail – where he had found signs of pumas and ocelots – hoping to pick up the traffic of cats moving to and from BCI.

There were only three sightings of pumas on BCI in all of 2000, made by lucky people who were alert and in the right place at the right time – all in daylight. In one case, a puma was chasing an agouti, and did not immediately notice the people. Tracks of pumas have been found all over the island, so we assume they are living there and not just occasionally swimming from the mainland.

There have been some visiting jaguars on BCI, big spotted cats up to 340 pounds or more, but the only two sightings were years ago, one by Greg in 1983, and one in 1994 by Jim Dalling. There were tracks found occasionally for a few years, but we have no photos. We think the jaguars just visit, swimming over from the mainland for a meal of deer and peccaries. Some people think that jaguars and pumas will not live in the same place, and that jaguars drive out the smaller pumas. But since Greg and I have photos from Belize that show pumas and jaguars and ocelots all walking the same trails, we are not convinced that this is correct. However, the very large home range of jaguars makes it unlikely that one will want to stay permanently on BCI.
Coatimundi

WHITE-NOSED COATI
(Nasua narica)
by Matthew E. Gompper, Ph.D.

Visitors to Barro Colorado Island usually find that white-nosed coatis (Nasua narica) are the most obvious component of the mammal community. They are readily seen because female coatis and young are gregarious and noisy by nature, and active during the day. Coatis are relatively numerous on the island, so chances of encountering some coatis on a short walk are quite good. BCI coatis have been the subjects of three long-term ecological studies as well as several shorter studies since the late 1950’s. As a result of these contacts with scientists, many coatis are habituated to observers and often do not flee from humans.

White-nosed coatis range from the very southwestern United States (Arizona, New Mexico and Texas) southward throughout Mexico and Central America (including all of Panama), and into north-western Colombia (west of the Gulf of Uraba). Throughout their range, coatis occupy a diversity of wooded habitats from temperate oak and pine forests to lowland rain forests and cloud forests, and occasionally into deserts and savannas.

Two species are now recognized: Nasua narica, the subject of this account, and Nasua nasua, which is found throughout South America. In the past, over 30 populations have been incorrectly designated as separate species based on variable characteristics such as coat color differences. Confusion over the status of males, which live alone, led early researchers to designate additional separate species names (Nasua solitaris and Nasua sociabilis) for solitary adult males and for gregarious band members of Brazilian coatis. Many of the common names still used in North and South America perpetuate the confusion. Common names for white-nosed coatis include coati and gato solo (Panama), pizote and pizote solo (Costa Rica, Honduras), chic and sis (Mayan), quash (Belize), tejon and tejon solo (Mexico), and in the United States: chulo, chulo bears, coati and coatimundi. The common name coati is of Tupian Indian origin, referring to the coatis’ habit of sleeping with the nose tucked on the belly. Although coati monde from the Brazilian vernacular properly refers to solitary males, it is often used to denote all coatis. Through usage the spelling has become coatimundi. It’s easy to see why scientists designate scientific names to species and are careful to define and use them precisely.

White-nosed coatis are readily identified by their long, slender, non-grasping tail, which is equal in length to the head and body, and by their long and flexible snout that protrudes beyond the end of the lower jaw. The claws are long and the feet are flat with naked soles. On Barro Colorado Island, adult males weigh approximately 5 kg and are approximately 114 cm from the tip of the nose to the tip of the tail. Adult females are smaller, weighing approximately 3.7 kg and measuring about 103 cm in length. Coatis vary in coloration throughout their range, even within populations. Breeding experiments have shown that even within a litter, siblings may vary in color. On Barro Colorado Island the usual color is dark brown, nearly black, often overlaid with some silver. The neck and shoulders are whitish, as are the muzzle, chin, and throat. Thin whitish streaks extend from the muzzle between and over the eyes. The ears are often white-tipped. The tail is ringed (more distinct in young than in adults) and generally held vertically while the animal is feeding.

Fossil coatis are rare, and the fossil record and evolutionary history of this species is poorly understood. A few incomplete fossils exist from the United States and from South America (Brazil and Bolivia), and none from Central America. Most of the range of the species is or was tropical forest, which is not conducive to fossil formation. What little can be deduced from existing fossils suggests that the species may have diverged from a raccoon lineage approximately 4.5-9.5 million years ago. Laboratory studies that compare the DNA and proteins of coatis and other small carnivores confirm that the species is genetically most closely related to raccoons and ringtails. People often recognize this relationship because of the similar mask-like facial markings and ringed tails of these species.

Perhaps the most outstanding physical feature of a coati is its long, pointed snout. The area around the nose is rich in sensory receptors, which result in an extremely heightened sense of smell. Numerous muscles allow great flexibility of the tip of the snout, which is used to poke into crevices and to seek out prey. Coatis curl their snouts in an amazing way above the water surface when drinking.
Coatis easily climb small trees and vines, and it can be very entertaining to watch a group of coatis feeding in treetops. They have more difficulty climbing the smooth trunks of large trees, and normally descend or ascend by moving out to the end of a limb and transferring to nearby branches of the same tree. Coatis can rotate their hind feet to descend from trees head first. The tail is not prehensile (that is, it cannot grasp), but does serve as a balancing tool during activity in trees. Coatis spend about 90% of their daytime hours foraging, and at least 90% of that foraging time is spent on the ground, even though they climb well. The forefeet contain long, powerful, blunt, and slightly curved claws, making coatis excellent diggers and shredders. While coatis can stand on their hind legs for short periods of time, they do not normally walk on just two feet. Running speed may reach 27 km/h, and one author noted that coatis can run for three hours when hunted by dogs. Coatis are also strong swimmers, and on several occasions individuals have been observed swimming in the Panama Canal.

On Barro Colorado Island, all coatis breed at the same time within a two- to four-week period in late January and early February. This period may shift slightly from year to year. Actual mating may occur in the trees or on the ground. BCI females may first breed at 22 months of age, although a few females may not breed until 46 months. All females may breed, or as few as 20% may breed, depending on ecological conditions such as food availability. Males may mate at 34 months of age, but due to intense competition between males, an individual may not successfully breed until his fourth or fifth year, if ever. More than one male may breed with the females of a given band during a single breeding season. In addition, the consort male for a given band may vary year-to-year. After the mating season, males return to their solitary lifestyle, and pregnant females eventually separate from the bands to nest and give birth alone in a tree or den in April or early May. Gestation is approximately 70–77 days.

Young coatis weigh about 180 grams at birth, with body lengths of 255-275 millimeters. They open their eyes after 4-11 days, and begin to walk and hold their tail erect at around 11 days. Teeth begin to erupt at about 15 days. By 40 days, when females and their newborn young rejoin the band, juveniles weigh approximately 500 grams. Females on BCI give birth to one to six young and rejoin the band with an average of 3.5 surviving juveniles. When first brought from the nest, juveniles are small, incompletely developed, and have difficulty keeping up with the band. In turn, the band appears to restrict its movements at this time. During the first week after joining the band, females sometimes leave their young unattended in a temporary nest while they forage. Mothers nurse their young for up to three months after band reunion, with most nursing occurring during the band’s daily rest period. Adult females have been observed nursing, grooming, and baby-sitting the offspring of other females. Young males become solitary at the 24th or 25th month of age, when the testes of males descend into the scrotum. Coatis are relatively long-lived: in captivity, individuals are known to live more than 17 years. On BCI, the oldest known individuals are at least nine years old.

Despite belonging to the carnivore family, coatis are quite omnivorous, eating mostly invertebrates and fruit, as well as vertebrates and carrion when available. Major events in coati life history on BCI are closely timed to food availability. For example, birth occurs during the period of greatest fruit ripening. During the wet season in Panama, 89% of foraging time is spent searching for animal foods such as insects and spiders, while in the dry season this proportion drops to 54%; the remaining time is spent under fruiting trees. Food is found by smell rather than sight – by sniffing in the litter – and then is dug up or extracted from under bark, leaves, or clumps of debris. Coatis handle invertebrate prey, even toxic species such as tarantulas, by rolling them between their paws, quickly killing organisms that can bite or sting, and removing the various hairs, bristles, and spines that may make the prey distasteful or difficult to eat. Vertebrate prey such as lizards are pinned with the forepaws, and quickly bitten killing organisms that can bite or sting, and removing the various hairs, bristles, and spines that may make the prey distasteful or difficult to eat. Vertebrate prey such as lizards are pinned with the forepaws, and quickly bitten through the skull. Fruit is eaten both in trees and on the ground, and long climbs are commonly made to reach the outermost limbs of large trees. On Barro Colorado Island, Scheelea zonensis, Dipteryx panamensis, Spondias mombin, Ficus insipida, Quararibea asterolepis, and Tetragastris panamensis are important fruiting species. Some trees of these species produce so much fruit that a band may camp under a tree for several days, with occasional side trips to forage for animals to supplement their diet of sweets with protein.

Being omnivores on BCI is not easy because many species compete for the same foods. Visitors to BCI in the dry season often observe coatis feeding at the same trees with agoutis and squirrels, where the fruit is too abundant to protect and the competitors are too numerous to chase away. In Arizona, by contrast, a successful coati band was observed to usurp a deer carcass from a coyote. More typically, however, competition does not involve confrontation, threats, or fighting. In Panama, interactions with armadillos, agoutis, howler monkeys, squirrel monkeys, tapirs, peccaries, and squirrels are generally non-violent. Night monkeys, fruit-eating bats, and kinkajous
compete with coatis for fruit in trees, but since [those animals] are nocturnal, they rarely encounter the coatis, who are sleeping while the others feed. White-faced monkeys are a different story: they are direct competitors, and will even kill juvenile coatis. Coatis feeding in trees descend to the ground when white-faced monkeys arrive, who may actively chase them from a tree. Harassment by monkeys also occurs on the ground, and even in trees that are not fruiting. However, coatis often sneak back under trees where white-faced monkeys are busy feeding, eating the ripe fruit that the monkeys drop.

Large cats such as pumas and jaguars, large hawks and eagles, snakes, and some monkeys prey on coatis. Much of the predation occurs on juveniles. One study on Barro Colorado Island found that 90% of the disappearances of juveniles occurs within three months of birth. Adult male coatis occasionally kill juvenile coatis. The cause and significance of this behavior remains unclear. Although an adult coati can defend itself very well, predation on adults does occur: one of the author’s adult male study animals was killed by a crocodile near the lab clearing, presumably while drinking or foraging near the shore of Gatun Lake. The $300 radio-collar the coati was wearing at the time of its disappearance continued to transmit radio signals for some time thereafter, sending information that indicated it was transmitting from the lake, making sounds that seemed both sad and ominous.

The population density of coatis on Barro Colorado Island is currently [1998] about 50-55 individuals/km², which is higher than most other Neotropical sites that have been studied. However, large fluctuations may occur year-to-year due to disease or food availability; and periodic crashes in the BCI coati population have been recorded. The gregarious nature of coatis may facilitate the transmission of diseases and parasites and contribute to rapid population reductions. Home range sizes are somewhat smaller on Barro Colorado Island than in other studied tropical regions. Bands have home ranges of approximately 0.34km², and may overlap with some, although not all, neighboring bands. Solitary adult males have similarly-sized home ranges, which overlap with the ranges of many other males.

Coatis are highly gregarious, with several adult females and their immature offspring forming bands of up to 30 individuals, and occasionally more. On Barro Colorado Island, bands average 15 individuals, although this number may vary considerably within years due to mortality and the birth of juveniles. Bands are made up primarily of closely related individuals, although many bands also contain a few unrelated members. New bands may form by fission or fusion of existing bands. Migration of individuals between bands also occurs. Evolutionary explanations for the gregariousness of coati bands include: reduction of feeding niche overlap between males and females, anti-predator behavior, the protection of juveniles from predation by adult males, and a strategy that allows smaller females to access food that is aggressively guarded by large solitary males. Some males do associate with bands, perhaps to gain from the social grooming that removes ectoparasites, or for protection from potential predators and from other adult males. Fighting between adult males is common, especially during the breeding season, and 30% of males display bite wounds or broken canines.

Coatis have a wide range of social behavior, including cooperative grooming, nursing, vigilance, and aggressive anti-predator behavior. Bands are usually slightly agonistic to other bands when they meet. However, peaceful interactions also occur, and are occasionally characterized by inter-group grooming sessions. Adult males that approach bands are generally aggressively chased away by one or several band members, including juveniles and subadults. Females often groom one another in an excited manner following such chases. During the breeding season males are submissive to females and immatures, and occasionally groom them. Bands often break into subgroups for several hours or occasionally one to two days.

Coatis do not voluntarily share food, nor do they store it. However, juveniles are tolerated by foraging adults, and juveniles can often be seen sniffing the muzzles of feeding adults. This behavior helps juveniles learn characteristics of food, as well as foraging techniques. While foraging, bands typically assume an elliptical outline, with subadults and adults forming the periphery, and juveniles aggregated in the center. Animals on the periphery protect juveniles through specialized vigilance behavior, cooperative attacks on potential predators, and assuming protective positions during flight from alarming stimuli. However, when pregnant females leave the group during the nesting season, bands assume a rank formation, a spatial organization efficient for foraging but not for defense. Vigilance levels of individuals are highest in small bands and lowest in large bands. When frightened, white-nosed coatis flee on the ground rather than into trees, and if startled in large trees, will often leap to the ground to escape. This can be quite startling to the observer, as coatis rain to the ground from as high as 5-10 meters.
Coatis are most active during daylight hours, and in undisturbed tropical forest habitats, sleep at night in the forest canopy. Juveniles are usually in the center of the band during rest and sleep periods, with adults on the perimeter. Rest periods of up to two hours are also taken during the daylight hours, more frequently during the dry season in Panama, when fruit is abundant. In populated areas of tropical America where they are hunted for food by humans, coatis (as well as other diurnal species) have become more nocturnal.

During heavy rains, coatis become nervous, with the band grouping tightly together and young remaining close to their mothers. Invariably, the band runs for cover, such as tree buttresses, palm fronds, or dense brush piles and treetops. After the rain ceases, coatis return to normal activities. During light rains, coati bands show little reaction, although they may travel at an increased pace, with juveniles often giving chitter vocalizations.

Coatis are highly vocal, with a rich repertoire of specific vocalizations for aggression, appeasement, alarm, and sexual contact between individuals. Certain vocalizations are only given by specific age or sex classes, with band members generally much more vocal than solitary adult males. Spectrographic and aural analyses indicate that the vocalizations of individual animals may be distinctive. Visual signals are also used, and include nose-up, head-down, and tail-switching displays. Scent marking occurs, and involves a perineal drag, usually on trees, logs, and vines. Although males scent mark year round, females perform this behavior most frequently just prior to the mating season.

Two very interesting behaviors have been observed among coatis that are indicative of the complexity and flexibility of coati behavior. First, BCI coatis have been observed to eat ticks from the coats of tapirs. This behavior is beneficial to the tapir who has parasites removed and to the coati who gets a protein-rich morsel to eat. Called a mutualistic behavior, it may have arisen when coatis and tapirs fed in close proximity at a feeding station in the laboratory clearing, and is likely culturally transmitted. It is presumed that coatis and tapirs do not normally mingle in the forest, but this is not known for certain. Second, and also likely learned, is the behavior of self-grooming and grooming of others with the resin of caraa, Trattinnickia aspera. This behavior is also likely acquired and maintained through cultural transmission, and may serve some pharmaceutical purpose. Similarly, white-faced monkeys and spider monkeys often rub fragrant leaves into their fur.

Coatis are important prey for subsistence hunters, and white-nosed coati population densities decline steeply with increased human hunting pressure. Indiscriminate predator control campaigns, such as poisoned baits, may also sharply impact coati populations. Although coatis are now legally protected in New Mexico (United States) and in Honduras, under the Convention on International Trade in Endangered Species, throughout most of its range, conservation and management issues have either not been addressed or are not effectively enforced.

Coatis are commonly captured and sold as pets; however, coatis do not make good pets. While cute and playful as juveniles, adult coatis are extremely powerful and temperamental. With their strong sharp claws and canines, coatis are difficult to handle and can easily harm humans. Furthermore, like raccoons, they have good manipulative skills and are capable of opening cabinets and getting into food containers or other belongings, so they are very destructive inside a house, and difficult to keep in a cage. Coatis carry a number of parasites and diseases that are transmissible to other pets and to humans. They are in turn susceptible to many common diseases that pets are often vaccinated against. Coatis are well-adapted to their natural habitat, and that’s where they should stay.

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Agoutis

*Agoutis*

(*Dasyprocta punctata*)

by Jacalyn Giacalone, Ph.D.

The species of mammal that is most likely to be seen by visitors to BCI is the agouti or *ñeque*. A visitor does not need to walk in the forest to see agoutis because many live in the laboratory clearing and are easily approached. Along forest trails they are readily seen feeding on *Pseudobombax* flowers (“shaving brushes”) and gnawing noisily on nuts. Agoutis are usually diurnal, but many stay up after sunset in the lighted areas around the buildings. On the mainland in Balboa they are commonly active at night on the town streets. In areas where they are hunted, they tend to wait until dusk before appearing.

Agoutis weigh about 3 kg, are reddish or yellowish brown in color, with dainty deer-like legs and big rumps. They have long hairs on their rumps and very tiny tails. When alarmed or involved in territorial conflicts, they can raise the hairs on the rump until they stand out straight. Agoutis grunt and bark softly, thumping their hind feet rhythmically when challenging territorial opponents. A male may thump on a hollow log. They often jump while running from a predator and make loud barking noises. Agoutis live on the forest floor, and usually occupy burrows on hillsides or in hollow logs and brush piles.

Dr. William Glanz recorded 36 species of fruits that he observed agoutis eating. They feed on fallen fruits and flowers and are especially fond of the large, hard-shelled seeds of *Dipteryx*, *Astrocaryum*, and sometimes *Scheelea*. They have difficulty gnawing the *Scheelea* nuts but often pick up fruits that are partially opened by squirrels. These hard seeds are also hoarded by burial in scattered locations within their territories, and the supply helps tide them over in periods of fruit shortages. This habit of seed burial is important for the dispersal of seeds of many plants.

One pair of adult agoutis on BCI will occupy an area of about two hectares. Agoutis are territorial and monogamous, defending their territories very vigorously from other agoutis in times of fruit shortage. A female agouti may have up to three litters in a year and may live 2.5 years on the average. Males live somewhat shorter lives. Agoutis may give birth at any time of the year, but most young are born between March and July. The one or two young are placed in their own burrows, and are called out for nursing when the mother visits. Young live in these burrows for eight to nine weeks. If food is plentiful, mothers may nurse the young for another two months; but if food is scarce, they are left to forage on their own. The details of their life cycle were revealed by the studies of Dr. Nicholas Smythe on BCI. He was one of the first researchers to clearly show the effects of severe seasonal fruit shortages on the populations and adaptations of mammals on BCI.

The greatest mortality is among the young agoutis, usually because they fail to establish territories, and therefore do not obtain sufficient food. They may weaken from poor nutrition and then are more easily preyed on than healthy animals. They are eaten by cats, snakes, birds of prey, and tayras. Humans hunt agoutis for meat and often reduce their numbers severely in areas where hunting occurs.

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Pacas

*Agouti paca*

by Jacalyn Giacalone, Ph.D.

Pacas are reddish brown with three or four rows of white spots that may form stripes along the sides of their bodies. They have very short tails and large heads with big cheeks. They weigh about 9kg and look like a larger, heavier version of the basic agouti body plan. They look rather pig-like in the season of abundant fruit supply because they store up body fat and then live off this fat, supplemented with a diet of leaves, in the season of fruit shortage (November to March).

Pacas do not climb and therefore live on the forest floor, where they are dependent on arboreal mammals to knock fruit from trees. However, they have a number of special adaptations that suit them to their lifestyle and so they have flourished in a large geographic area. They are found in a variety of forests from southern Mexico to southern Brazil. Their meat is prized by hunters throughout their range. In Panama they are called *conejo pintada*, and are endangered in some localities because of over-hunting.

Pacas eat fruits, and, unlike agoutis, they do not rely on large, hard seeds, but prefer soft, sweet pulpy fruits. They also browse on leaves and seedlings, depending on these less digestible foods in time of fruit shortage. They have a specialized digestive tract with an elongated large intestine that is adapted for leaf digestion through bacterial fermentation. They produce special feces that they eat and re-digest to derive greatest benefit from the nutrients (much as rabbits do).

They generally live in pairs but forage alone and den in separate burrows. Burrows usually have several entrances, some of which are camouflaged with leaves. One pair of adults occupies an area of about three hectares.

It is usually necessary to go out in the forest at night with bright lights in order to see pacas. They are nocturnal, usually appearing about the time when agoutis go to sleep. They have bright eyeshines that are widely spaced and bright orange to yellow in color. They are usually very quiet, but will walk noisily on dry leaves. They also have very deep voices that they use in social gatherings, where they may make grunting noises or stunningly loud barks. Very complex cavities in the cheek bones of their skulls are thought to act as resonating structures for these vocalizations. We have heard them congregate under Smith House when a jack fruit tree (no longer there) was dropping ripe fruits. The pacas made noises like a party of people laughing with deep throaty laughs.

Pacas require water for breeding, according to Dr. Nicholas Smythe, who raised and developed a domesticated non-territorial version of paca, and studied their life history on BCI and nearby Gigante Peninsula. Young pacas are most likely to die in the season of fruit shortage from November to March. Perhaps they are more easily taken by predators because pacas must spend longer hours foraging for food and may be in poorer condition in this season. Adult pacas live about 3.5 years on the average on BCI, but can live more than 7 years in captivity.

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Peccaries

When students asked what it is like to walk in the rainforest at night, I reported on a night walk that Greg and I had taken a few evenings earlier. We had seen a variety of mammals – spiny rats, pocket mice, armadillo, 2-toed sloth, brocket deer, and peccaries. The peccaries had been sleeping in a group of six all piled together beside the trail. We woke them up when we approached, and used a high-intensity lamp to view them. They looked so sleepy and confused! We tried not to disturb them too much, but still wanted to get a good look at them. Soon they all stood up and started to walk away from us, scattering into the forest. They were not alarmed, just looking for another place to sleep, where pesky bright lights would not bother them. Peccaries on BCI are a bit mysterious, and no one has studied them here, although they have been studied elsewhere. I asked an ecologist friend to prepare a species profile for us:

Peccary
(Collared Peccary: *Tayassu tajacu*)
by Barry R. Koffler

Collared peccaries are adaptable to a wide variety of habitats, from deserts to tropical rain forests. This species has the second largest latitudinal range of all the ungulates (hoofed mammals) in the New World. Collared peccaries are found from Arizona to northern Argentina, and only the white-tailed deer has a larger range. With their well-developed pig-like snout they are reminiscent of long-legged, tiny-tailed, bristly wild boars, and indeed are close relatives of the pigs and hippopotamuses. The average collared peccary weighs about 36 pounds. Its coat is black, with a white collar running from the shoulder down to the front of the chest. It also has a very dark mane composed of long hairs which can be made to stand upright.

Peccaries are herd animals their entire lives. On BCI they usually travel in groups of two to ten. When moving from place to place they go single file, but fan out when they get to feeding areas. Peccaries tend to feed early and seek shelter during the heat of the day, sometimes under logs or in burrows created by other animals. On BCI they often sleep lying on the forest soil in a sheltered location, or an entire group may squeeze into a large hollow in a big tree. Each group is made up of individuals who use scents from skin glands to mark each other for easy recognition. They rub against each other and all pile together when they are relaxing.

Peccaries eat fruits, seeds, berries, nuts, vines, snakes, and insects. They locate underground bulbs and tubers by smell and root them up with their sturdy snouts. On BCI the flesh of various palm fruits and the seeds of *Dipteryx* make up an important part of the peccaries’ diet. They have strong jaws, which act like a vise and are used to squeeze hard seeds until they pop loudly. They eat the edible interiors and spit out the shells. They cannot chew sideways like deer because their large canine teeth interlock; therefore they chop up vegetation and swallow it largely unchewed. Most non-carnivores have small canines but in peccaries these teeth are very large and sharp. The canines continue to grow into the fourth year. They are used for defense and in social displays between individuals, especially when groups compete for food at a fruiting tree.

One of the warning sounds used by collared peccaries is a “clack” produced by clashing the canines together. They also make a sound like a dog barking, a “woof” that warns other peccaries of danger. Peccaries that have been frightened usually give off a strong “sweaty” odor that lingers long after they have left the area.

On BCI most young are born early in the year after a gestation of about 145 days. Peccaries can have litters ranging from one to four young, but two is most common and more females are born than males. The young have dark gray backs, are tan below, and have the collar at birth. Weaning occurs at around two months of age. Collared peccaries can live to 15 years but most wild peccaries die by the age of 4. They are a favorite prey of jaguars, and also of humans. They are quickly hunted out in forests that are not protected from over-hunting.
Hidden Tapirs

How many animals can hide on an island small enough to walk across in two hours?

Apparently lots! The dense forest that covers BCI and the many deep streambeds and complicated coves at the edge of the island all serve well to hide animals. There are usually at least 20 researchers and perhaps another 15 field assistants, as well as several game wardens and two men who maintain the trails to keep them clear of vegetation, and about 40 ecotourists weekly with their guides. All of these people roam the trails of BCI every week of the year. Yet, only two or three may be been spotted on BCI throughout an entire year. Tapirs weigh about 500 to 600 pounds or more and look rather like hippos with short elephant trunks. That sounds like an animal hard to miss, but there are some years when no one sees a tapir at all.

So, Greg and I were very excited when we found fresh footprints of tapirs several times during our stay on BCI in January, 2000. We were lucky it rained so often that dry season, making lots of soft mud that preserved the tracks of many mammals. Tapir tracks are very distinctive, being several inches across, and showing the imprint of three hooves on each foot. Tapirs are relatives of horses, but have five small hooves on each foot (but some of the hooves don't touch the ground).

Tapirs like to sleep on the ground or in shallow water during the day, staying clear of the trails where people walk, and consequently are rarely seen or photographed. The last sighting before the ones in 2000 had been in 1998 during the long dry spell that left wide beaches around the island as the lake level dropped. Hubie Herz, a German biologist who studies leafcutter ants, decided to walk completely around the island, on these beaches. Since he knew it would take him several days, he carried a hammock to sleep next to the shore. One night he was awakened in his hammock by the sound of rustling leaves, and in the moonlight saw a big tapir feeding on vegetation nearby at the edge of the forest. It was the only tapir he ever saw. Greg and I don't have time to chase after tapirs because we have the entire trail census to take care of, as well as fruitfall data to collect, usually all in less than four weeks. However, another researcher who studies tapir genetics, came to BCI specifically to find tapirs this past year. He hired a good native guide who knows BCI and they spent a week doing nothing but look for tapirs – and he never saw one.

Greg and I knew tapir tracks very well from when they used to come around the kitchen building on BCI. When animals used to be fed at the kitchen door, several tapirs came to feed every day. We used to see Alice, a female who was released on BCI many years ago, every evening. For about 15 years she would bring each of her newborn spotted babies to visit the kitchen. She would nuzzle us with her long, flexible snout, begging for food, or thump against the kitchen door. Alice liked to have her hide scratched, as she was always covered in thousands of ticks, which must have caused lots of itching. We tried to pick the ticks off her, and she would roll over like a big 500-pound dog. But about 1986, a decision was made that animals should not be fed kitchen scraps. Soon the tapirs disappeared into the forest, feeding on their natural diet of leaves and fruit rather than white bread. By 1990, people seldom saw any tapirs at all.

How does a 500-pound animal shaped like a hippo hide on a small island? Tapirs sleep on the forest floor, where they look like big gray rocks, during the day. I know because I have walked up on sleeping Alice and her young many times, surprising both of us. They also like to nap in shallow water in ponds or at the edge of the island. They move around to feed at dusk and during the night. Tapirs tend to stay away from trails, and to live on parts of the island where people don't spend much time. Very often we have heard other biologists declare that tapirs must be extinct on BCI because no one had seen any in several years. Actually, Greg did see a tapir or two every few years, and sometimes other people did too. With so many scientists coming and going on the island, and no uniform way to record and publicize mammal sightings, records of tapirs were hard to keep track of.

So, when we found those tapir footprints on Miller Trail and then again one week later in a streambed near Pearson Trail, we were very glad to have good evidence that tapirs are not extinct on BCI. The tracks on Miller were from at least three individual tapirs, two adults of different sizes and one very young baby. The streambed had tracks of at least one adult and a baby. These could have been the same animals that were on Miller, but at least we knew that tapirs were still raising young on BCI.
When a small piece of forest like BCI (only 15 square km) becomes isolated from the rest of the forest it used to be attached to, many species of animals become extinct on that new island. Whether the small piece of forest is isolated by water or by an area where forest has been cut down, the end result is pretty much the same. Fifteen square kilometers just isn't big enough to sustain the same number of species as when the forest was connected to more of the same habitat. That's why conservation efforts must protect large expanses of forest and not just small fragments like BCI.

We think there might be 12 or more tapirs on BCI, but that isn't enough animals to sustain a population for very long. Tapirs swim very well, so we hope that there are tapirs on the mainland that will replenish the BCI population if the resident tapirs do not survive. The food supply on BCI is plentiful in some years but very scarce in others. Animals need to be able to roam easily to other locations where they can find food. Therefore, it's very important, not just for tapirs, that a large area of the surrounding mainland be protected from hunting and logging. Extinctions of many species of birds and mammals have already happened on BCI. We hope this won't happen anymore, not on our island and not anywhere else.
Brocket Deer

*Mazama americana*

by Jacalyn Giacalone, Ph.D. and Gregory E. Willis

One of the most elegant mammal species on BCI is the Red Brocket Deer, which has slender legs, a long gray neck, big dark eyes, mobile pink ears, and a rich red-brown body. They can be distinguished from white-tailed deer (*Odocoileus virginianus*), which used to occur on BCI, because brockets are only about two-thirds the size of a white-tail, have a proportionately large rump that rises in a curved back (white-tails have flat spines), and their tails form small, round powder puffs (also white) rather than the long flag of a white-tail. Brockets also do not have the white markings around the nose and eyes that white-tails do. In both species the males have antlers that are shed each year. Brocket antlers are simple, straight spikes only a few inches long, but white-tails in Panama also often have straight spikes, not the large racks of their northern counterparts.

Brockets are well-adapted to rainforest life. They have straight antlers and small bodies (24-48 kg) for sliding under and through tangled vines; they have a habit of freezing when startled and then slipping away into dense vegetation; and they are solitary in their foraging. The white-tails on BCI were never very numerous and seemed to confine their activities to the forest edges and the very open parts of the plateau, where they could run rapidly to avoid predators. Their scats, tracks, and actual sightings dwindled in frequency in the early 1990’s, and we think there are no more white-tails on BCI. Of course, some could swim from the mainland again, but the forest is now even less suitable for white-tails than ever before: they usually favor second growth and edges.

Brockets can be seen on BCI in the late afternoon around the edges of the lab clearing, and at almost any time on any trail. It helps to walk quietly and slowly, and look for brockets under flowering or fruiting trees. Early morning is the best time, or at dusk. The early and middle afternoon are not good times to try to see them, but they can be active 24 hours a day on BCI. They often walk along the trails or lie down beside the trails, chewing cud or sleeping. At night they can be spotted with a headlamp. Their eyeshines are bright yellow and may be low to the ground if they are resting. Their tracks look like very tiny white-tail tracks, and can be confused with those of peccaries.

Brocket adaptations also include a complex stomach that provides chambers for the fermentation of coarse vegetation by symbiotic bacteria. This is the same sort of process that enables cows to eat grass. Both species must regurgitate their food and chew it again as “cud” in order to fully process the food for its maximal nutritional value. They must spend much of their day resting while they chew the cud. This ability to digest thoroughly and to use bacteria for the process makes it possible for brockets to thrive on a diet of leaves, flowers, buds, fruit, and fungi that would not support most other species. We have followed brockets on BCI who became accustomed to our presence and we were able to record 17 different species of leaves, flowers, fruits, shoots, and seedlings that they fed on during several sessions from January to March. This was only a small part of their diet, since much of what they consumed could not be identified.

Young are born at any time of the year. They are tiny fawns with white spots usually in rows along their sides. Mothers leave their young hidden in undergrowth where they are very well camouflaged while the mother forages. Researchers walking off the trails sometimes find fawns accidentally by nearly stepping on one. A startled fawn will run very rapidly a short distance and then drop down again into the leaf litter, tucking its head to curl up, and hopefully, to disappear into the background. Fawns should be left alone so that they do not become exhausted trying to escape. The mother will eventually return to feed her fawn.

Brockets are often seen in pairs, as a male and female usually inhabit the same territory. Boundaries are marked by bucks rubbing their antlers on slender vertical woody stems and by scraping the soil and urinating. They produce a loud sneezing snort when alarmed and stamp their front feet.
A brocket is called “corzo” in Panama, while a white-tail is called “venado cola blanca.” Both are highly sought-after for their meat. In many places they have been over-exploited by uncontrolled hunting and are severely reduced in numbers.

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T-Species (Tough to See)

Greg really enjoys finding T-species! These are the species we see only infrequently on census. They are often very well camouflaged, or they may be nocturnal, or they are rare on BCI. This group seems to be dominated by species that have names beginning with the letter “T”: tapirs, tamarins, tamanduas, tayras, two-toed sloths, three-toed sloths, tapicaras (silky anteaters), tree rats, and tigres (jaguars). There actually are others whose names don’t begin with a T – but we like alliteration.

Tayras (Eira barbara) are among my favorite T-species, although an entire season may pass without my seeing one. That doesn’t mean there aren’t any, just that I didn’t see any.

To see a tayra for the first time is to know some puzzlement: is this a cat, a dog, a weasel, a small coati? Tayras trot through the forest with a flat-footed dog-like gait, but they are large weasels about the size of a house cat. They are generally unafraid of humans or any other animal, and can often be viewed at close quarters. On BCI and in other localities, a tayra may approach and sniff a human before growling and continuing on its way.

Tayras have regular routes along which they trot rapidly through the forest, sometimes stopping to climb trees to feed on sweet fruits of species such as Dipteryx, Mamey, and some lianas. Usually solitary, they can be seen in groups when a mother leads her young on an educational excursion, or when an estrous female is accompanied by one or more males. Females on BCI have been seen escorted by as many as three males. Young may be born at any time of the year, after about 67 days gestation. From one to three young are born in tree cavities or in burrows at the bases of trees. They are not ready to accompany the mother on foraging trips until about two months of age, and may stay with her until they are adult in size, at six months of age. Young tayras on BCI have been seen chasing and playing in vine tangles high in large trees, and outside dens.

The species has a large geographic range, and can be found in a variety of wet and dry forest habitats from sea level to cloud forest, from Mexico to northern Argentina. It is the most common mid-sized predator in that range. Tayras on BCI are a little different from other tayra populations in Central America. While tayras are known for the field marks that make them identifiable, a dark brown body with a yellowish or whitish head, the BCI tayras are usually all black, sometimes with a white or yellow spot on the chest. Black is the usual coloration of young tayras everywhere, but the BCI adults retain this coloration, a conclusion based on many field observations that have been verified by several photographs from camera-traps (J. Giacalone & G. Willis).

Adults weigh from three to seven kilograms (7-15 pounds), with males generally larger and more muscular than females. The head and body length is 56-70cm (22-27 inches), with the tail adding another 36-46cm (14-18 inches). The tail usually has longer hairs on the underside, giving it a plume-like appearance. The body is long, with an arched back, and the tail generally hangs downwards, also in an arch shape. The ears are short and do not protrude above the top of the head. The snout is long and dog-like, with large canines and stiff, long whiskers.

Tayras scent-mark with a strong but sweet-smelling urine, rather like a mild skunk odor, that can be detected along the trails of BCI. They have large home ranges that overlap, and are not defended as territories. They roam far each day, seeking fruits and small prey, usually foraging in the daytime. They move about noisily and with great confidence, apparently unafraid of very much. There are no reports (on BCI or in the literature) of predators hunting tayras. They have been known to attack prey larger than themselves, such as an adult brocket deer (Belize, from interview with witnesses) and a disabled howler monkey (Robin Foster, pers. comm.), but they generally prey on small rodents, opossums, and birds. They also depend heavily on fruits, insects, honey, and carrion. Tayras are frequent visitors to Dipteryx trees during the dry season fruiting, when their prey are gathered for feeding. The appearance of a tayra usually leads to the silent disappearance of agoutis and squirrels that would normally feed in full view of a human.

Tayras have been observed on BCI climbing Dipteryx trees for their sweet ripe fruit. They often climb trees with a vertical gallop, arching the back like an inch-worm. Particular tayras who live near Snyder-Molino trail have habitual routes that they follow to visit the large number of Dipteryx in that part of the island. Camera-traps on BCI
have recorded tayras under Dipteryx, but only rarely on human trails. They seem to prefer to follow game trails or stay parallel to human trails.

There has been a resident population of tayras on BCI for as long as there have been biologists on the island. It is not known how many tayras live on BCI, but the population seems to be self-sustaining. Tayras are known to avoid swimming when they can, so new immigration from the mainland may not happen at all. The retention of the tayra juvenile coloration (all black) in BCI adults is perhaps an indication that the local gene pool has been isolated sufficiently long, with enough inbreeding to result in differentiation from the mainland gene pool.

Tayras appear on the annual mammal census only once or twice per 100 km, and only once in 15 to 20 rolls of film from camera-traps. However, they have been observed more frequently outside the census period because they are most active in mid-day after the 7am to 11am census data-collection times. In addition, the placement of cameras on human trails to maximize ocelot data means less tayra data. Based on the frequency of observations and camera photos, it seems likely that the BCI tayra population is more than a dozen adults, but perhaps not much more. Tayras are some of the more mysterious residents of BCI, and one needs a good “search image” to spot one.

Even when I am not in the forest, but perhaps driving to my office at the university, my eyes automatically scan the road and the tree tops that line the highway. My brain is searching for sloths, even though I am not necessarily thinking of sloths, and even though there’s no chance of seeing one in New Jersey! It’s what I normally do in Panama, and once it becomes a habit and routine, it just goes on without my having to concentrate. This is probably not the best way to drive, but it does keep me alert. And I do find other signs of wildlife in the process: squirrel nests, red-tailed hawks, and other birds of prey, for example. Whether I want to find sloths in Panama or native New Jersey creatures, it is a dark rounded silhouette on a branch that catches my eye momentarily until I can decide if it’s just a crow or a plastic bag, or something more interesting. This idea or concept of what I hope to find is what is called a search image. Birds that feed on insects that are hidden on tree bark have a search image, and can find insects faster if they gain experience in what the insects look like when they are hidden. Think of what happens when you can’t find a school book – if you remember the size and color of the book, you have a much better chance of finding it than if you have no idea what it looks like.

Another species that requires a good search image is the silky anteater, which is called a tapicara in Panama. They sleep most of the day, curled in a tight ball. Someone once said that they look like golden tennis balls when they are asleep, and this makes a great search image. Still, they are hard to see. The best tapicara-finder I know is Bonifacio de Leon, a Panamanian field worker on BCI. Although he had recently retired, he was asked to come back in January, 2001 to find a tapicara for a photographer. Bonifacio made sure I knew he was coming so that I could see the animal too. Some of the researchers on BCI made some private bets as to whether Bonifacio could actually find a tapicara if he arrived on BCI on the 8:00 morning boat and had to depart on the 3:30 afternoon boat. That seemed like not much time to find an animal that almost no one ever sees, especially for a man “getting on in years.” They hadn’t seen Bonifacio in action like I had. I had no doubts whatsoever. I have seen him pull off his shoes and socks to climb a tree to pull down a sloth. When the day came, Boni carried a ladder into the forest, and, sure enough, he came out of the forest in time for lunch, carrying a small sack. He came to me at the dining table, beaming a great smile and eyes flashing.

I peeked inside the sack and saw a sleeping tapicara with a baby. Their paws had bright pink pads and two curved, hook-like claws. Their snouts were long and pink, and their eyes were squeezed shut. The mother had golden-colored fur that was soft and shiny like silk. I touched her gently. The baby was silvery gray, and clung to her back crosswise, with a long tail wrapped around the mother’s body. Their tails are prehensile so they can cling firmly to branches when they sleep or move about. Tapicaras feed at night on ants and termites that live inside sticks. They use their claws to slit the sticks, and then they flick their long sticky tongue into the tunnels in the sticks to pull out their prey. Victor, a student on BCI who was studying bees that live in sticks, showed me some bee colonies that had been raided by an unknown predator that slit the sticks open. I suggested that it might be tapicaras that eat these bees too, and perhaps some day we will know. There’s a lot we still don’t know about all these T-species.

How does Bonifacio find them? I have asked him, and I have watched him, and it’s still a mystery. He tells me that he looks for areas of the forest with lots of lianas that hang from trees. The lianas need to be about the width of pencils or small fingers. He looks upward, scanning the lianas up to where they come in contact with branches or
form tangles of vines. He searches by looking at the vines from different angles, circling the trees one by one. He says it is better on a sunny day, when the tapicaras’ fur gleams in the light. Apparently, tapicaras may move upwards in the early morning to catch the rays and warm up after a chilly night, and then downwards later to be inconspicuous in the shadows. He will keep up this search for a couple of hours or more. I have tried doing this for 15 or 20 minutes and find that I get distracted by other things I discover and can’t stay focused on just tapicara. So, I need to work on my tapicara-technique – sharpen my search image.
Morphos: Pieces of Sky

Flying at low altitude in a small airplane over forested areas of Belize in February of 2000, I saw what appeared to be flakes of sky moving among the treetops. Brilliant sky-blue specks and chunks glinted back the sunlight, and moved slowly across the spaces between trees. These are the famous Morpho butterflies of tropical America, favored by collectors for their impossibly rich, iridescent blue wings and large size.

In Panama, when we see Morphos from inside the forest they seem almost magical. Not only are they eye-catching and breath-taking in beauty, but they are also tantalizing. They fly strongly, alternately flapping with big wings and gliding lazily, but maneuvering quickly when alarmed. They are difficult to catch in flight even with a good net. And when they set down to rest, they seem to disappear suddenly. They fold their wings together so that the blue upper surfaces come together, and only the brown undersides are visible. The under-wings are camouflaged with lines in patterns that resemble tree bark and dead leaves. This is called “cryptic” coloration, which means “hidden.” Nestled within this pattern is also a set of spots that resemble eyes of an owl or a predatory mammal. So if the camouflage fails to hide the Morpho, then the eye patterns might startle an observer.

The most common observers of butterflies in the forest are birds such as motmots and flycatchers, who love to eat butterflies. Motmots sit on the same perches all day long and wait for food to fly by. When they catch a butterfly, they usually beat it against a branch to knock off the wings. The wings of butterflies, as you may know, are covered with tiny scales or flakes that look like a shingled roof when viewed under a magnifying glass. The birds probably don't like to get all those flakes in their throats – I know they make me sneeze if I get too close to the loose scales of a moth or butterfly. These birds that prey on butterflies must be wary of owls and cats that might prey on them! So a butterfly with big eye spots on its wings can sometimes escape a bird by fooling it – for just a moment – fooling it into thinking that maybe it made a big mistake! And in a moment of the bird's hesitation, the butterfly might escape.

There are many Morphos on BCI. I see them close up when I sit under a Dipteryx tree. Sitting and watching is something I do when the Dipteryx trees are dropping their ripe fruits. This species of tree fruits early in the Dry Season, in late December into February. January is when few fruits of any sort are available in the forest on BCI, and many mammal species have had a tough time finding food. We often see squirrels climbing up 100 to 150 feet into the tops of the huge Dipteryx trees to test the readiness of the fruits. Squirrels sniff several fruits and then pick one to chew through the tough nut. They eat the endosperm inside the big seed. (We have to use binoculars and lean 'way back until our necks ache to see all this!) Squirrels knock fruits off the tree top branches, allowing agoutis (who cannot climb) and coatis to feed on what falls. Coatis eat only the sweet and sticky outside of the fruit, the part the squirrels and agoutis do not like. Later in the season, when more fruits are ripe, the howler monkeys, white-faced monkeys, spider monkeys, and birds such as toucans and guans join in the feeding. They don't all get along, so some species have to wait for others to go away before they may feed. It can be very noisy and exciting to watch these feeding activities! The fruits are dropped in large numbers when a troop of 12-20 monkeys is feeding. The fruits are heavy, so they crash to the ground. (Some forest researchers wear safety helmets – hardhats – so that they will not be injured by the falling fruits.)

When there are lots of ripe Dipteryx on the ground, we see many Morphos. They settle on the fruits to extend their long, thin, coiled proboscis (snout) which they use as straws to drink the juices of the fruit, especially when it is starting to ferment. Every so often, they spread their wings and show a glimpse of blue. I love sitting and watching them, trying to get a good photo of the blue upper wings, but rarely have I succeeded.

As you can see, we are very interested in a variety of forest organisms. Although our first interest is in mammals, we are curious about other creatures as well. It is good to have a focus of study, so that we can learn a lot about some species in particular, but it's also good to be aware of and interested in a whole range of topics. This keeps life exciting. It also allows us to make connections between what we learn about mammals with what we see happening with other species in the forest. After all, the mammals are in an ecosystem, and all members of an ecosystem are dependent on each other in many ways.
Stefan Schnitzer is a researcher at the University of Pittsburgh who is studying trees and lianas on BCI. He visits BCI periodically for several weeks at a time, often when Greg and I are there. I know his work is fascinating and that Stefan has some unique ways of writing about his work, so I asked him some questions for all of you – about his work, about lianas – and here are his answers:

“What do you do as a scientist?”

Before I answer that, let me ask you a few questions. Did you ever wonder how tropical forests grow? How do they stay as forests and not turn into grasslands or fields? Do trees live forever? What happens when a tree gets old and falls over? What grows in that fallen tree’s spot? Well, as a scientist, my job is to answer questions like these. My main interests are in learning how tropical forests grow and why there are so many species of trees and lianas in tropical forests.

“So how do tropical forests grow?”

Most of the time, after a tree falls, little trees that are growing in the shadows of the big trees will grow up and take over the spot of the fallen tree. But what I have found is that sometimes the little trees can’t grow because they are strangled by lianas!

“What are lianas?”

Lianas are vines that are woody, like trees. But unlike trees, lianas can’t stand up on their own. They have to climb up trees to get to the sunlight. Lianas are really neat plants and they are all over tropical forests, twisting and twining around the trees. But sometimes lianas twist around the trees so much that they strangle the trees! When lianas strangle the little trees that are trying to grow up under the fallen trees, parts of the forest can actually stop growing. Instead of new trees, the forest can become a big tangle of vines!

“How long do lianas live?”

How long do lianas live??? How many grains of sand are there on the beach? How many drops of water are there in the ocean? How many angels can dance on the head of a pin? When we know the answer to these questions, we may know the answer to How Long Do Lianas Live. Actually, this is a great question! All we know is that lianas live a long, long time, probably many times longer than trees. How do they do this? Well, my theory is that lianas are superorganisms that slowly move through time and space. When a large liana, which can be over a kilometer in length and many hundreds of years old, falls from the canopy with a treefall, it will often stay alive and send out new branches that climb back up to the canopy. These new branches develop their own roots and each branch effectively becomes a new individual. These new individuals, although the cells are young, are really a part of the old liana that originally fell from the canopy. Therefore, some lianas, even though they may look young, may be thousands, or tens of thousands of years old! But until I get around to testing this theory, we don't really know how long lianas live. Another unanswered mystery of the rainforest!

“Why is it important to know how tropical forests grow?”

Scientists want to understand how tropical forests grow because we want to know how the natural world works. Understanding the natural world is important for a number of reasons. First, knowing how plants and animals have evolved and coexist give us an idea of how the natural world works and our place, as humans, in that world. Second, human beings are having a huge impact on the world, and we are destroying tropical forests faster than ever before. If we ever hope to re-grow tropical forests we will need to know how they grow naturally.

“How did you become a scientist?”
I wasn’t always a biologist. After I graduated from college I took a job writing computer programs with a computer company. But I realized that I didn’t want to work in an office; I was more interested in learning about biology and the natural world. So I went back to school to study biology. In addition to learning about biology, I found that school is a lot more fun when you are interested in what you are learning.

“Do you have any advice for kids who want to become scientists?”

Yes! I think that the best scientists are ones that are curious and imaginative. If you are interested in learning how things work and you have curiosity and imagination then you have the potential to become a scientist.
Invasion

When people on BCI talk about invasions, they usually mean something like, “Oh, my room was invaded by army ants yesterday. I had to go someplace else for several hours while the ants ate all the cockroaches and carried away the larvae of some ant colonies in the walls.” This used to happen regularly in the old buildings, which were made of wood and had many small crevices for critters to live in. Most of those buildings were torn down and replaced by concrete and aluminum structures that don't offer so many homes for insects. We see army ants regularly in the forest, carrying away grasshoppers and other ants, and spiders, while the antbirds follow and pick up whatever flees from the army ants.

Invasions might also mean that one's clothing has been invaded by hundreds of tiny baby ticks that hatched from a “nest” on a leaf. The ticks brushed off onto your field clothing when you walked by. (We call this a “tick-bomb.”) The ticks start walking around on your clothing, looking for skin so they can get their first blood meal, drop off and grow, and go on to another host. We use masking tape to quickly pick them off the clothing before we become their dinner.

Another invasion has been by africanized honeybees. They have replaced the more docile honey-bees that used to live in the forest, and have been very successful at colonizing the island – and most of Central America for that matter. There was some concern for a while that they would replace many species of small native forest bees in Panama, but the latest word from an expert is that this is not happening. So far, nobody has been attacked by them on BCI, although they have earned a reputation as “killer-bees” in other places.

However, for a long time, “invasion” on BCI referred to another kind of army action – the 1989 invasion of Panama by the US.

When we left New Jersey in December, 1989, we didn't expect to be in the middle of an invasion. When we arrived in Panama, we rode in a taxi from the airport, and the driver pointed out many American tanks and other armored vehicles parked on front lawns of the military bases. This was unusual, but then the US army frequently showed lots of military equipment and had often practiced maneuvers in Panama. We also knew that the US had problems with the dictator of Panama, Manuel Noriega. He seemed to be helping the drug traffic move illegal drugs from Colombia to the US. He also seemed to be making large profits that went into his Swiss bank accounts while most Panamanians stayed very poor. So there was talk of helping the Panamanians overthrow the dictatorship of Noriega. But we didn't think it was going to happen. We stayed in a hotel in the city, and then took a boat to BCI the next day. The sun was shining; the breezes were balmy; the lake looked lovely; and the forest was inviting. Who could think of political clashes and military distress at a time like that?

That night, very late, there were helicopters flying overhead. No aircraft are supposed to fly over BCI at all, so that was odd. But there were LOTS of helicopters, and they were flying low! This, we knew, was not a good sign. And then we heard the sounds of distant bombs and gunshots. However, the US military do practice frequently, as I have said before, and this has included bombs in the past, on a practice range.

When we got up in the morning, the sun was just coming up, the birds were singing, and except for the clamor of howler monkeys, it was pretty quiet out there. No one else was in the dining hall when Greg went to get some cereal. So Greg and I went out on census.

While we were out on the trail, we again heard distant bombs and sporadic gunfire. We traveled on separate routes, but had planned to meet on a certain trail. It was nearly lunchtime by the time we met, and we hadn't seen another person on the trails. We headed back to the dining hall and found everyone on the island gathered there. They had been listening to a 2-way radio conversation with the scientists from another Smithsonian field station in Panama. Those scientists and their family members had been taken hostage by Panamanian militia who supported Noriega. They were about to be taken on foot through forest to a place where the small band of soldiers could join up with a larger group. The scientists were later that day released and picked up by a US helicopter. But the news scared us quite a lot. The US had actually invaded Panama, bombing particular military locations, and taking over others. That was December 19, 1989.
We were evacuated from the island. Greg and I went to stay with friends in Gamboa, while the other BCI people stayed nearby in Smithsonian apartments. Our friends shared their food with us, even when they didn't know if any more could be purchased. The army had closed the roads, so no shipments came to Gamboa for many days. The US troops regularly patrolled the housing areas to protect the civilians from snipers of Noriega sympathizers who were using ammunition from a storage area in Gamboa.

After Christmas had gone by and we were getting restless to go back to BCI, we were finally given permission to return. But the boats had been commandeered by the US military, and it took the Smithsonian staff awhile to get them back.

We were certainly happy to be back on BCI, where there were no snipers and no ammunition dump! Greg and I were given 2-way radios to carry in the forest; and we were required to report in every hour during our mammal census. Eventually, after three weeks, we finished the census, but then couldn't go home because the commercial flights out of Panama had all been canceled. Sometime around the end of January, we got new flight reservations and went through many security checks before we could fly home. We saw many burned buildings in Panama City, and thousands of newly homeless people living in tents on a baseball field. US troops were in control of the airport, but very nervous because there were still some of Noriega's troops out in the forest past the airport. They made me put away my camera when I tried to take a picture. We flew home, glad to get back (even to New Jersey’s wintry weather), and wanting never to be part of another invasion.
Profiles of Some Scientists

Many students have asked who lives on BCI? Aren't there any “natives?” Well, there are no “regular” people who live there – only scientists, staff who help the scientists, staff who conduct tours for ecotourists, and students who carry out research. Some of the staff are Panamanian, and live part of the time on the island. They have very interesting lives because they are so closely intertwined with the ecosystem of BCI. Oris Acevedo is one of the Smithsonian staff members. Jane McMillan-Brown interviewed her for our Rainforest Connection reports, with questions that might explain what her life is like, how she came to be a scientist, and what she does on BCI.

She told us she is the Scientific Coordinator of BCI. The position is part of the administration of labs, equipment, boats, evacuations in emergencies, and so on. She facilitates people's jobs and research studies and gives logistical support. She also makes sure that no destructive research is being conducted on BCI and that management policies are followed correctly. She is the liaison between the researchers who stay on BCI and other administrators. And she also serves as an official STRI (Smithsonian Tropical Research Institute) guide for visiting dignitaries, such as government representatives, when they come to the island. She has held this position for 5½ years. Before that, she worked on the island as a research assistant, but left to get more education.

Oris lives about 1½ hours from BCI in Diablo, a suburb of Panama City, but stays on BCI two nights of the five-day week. On the other days she commutes back and forth by car to Gamboa, then by boat to BCI. Her work week goes from Tuesday to Saturday.

She feels that BCI is a very special place, being as protected as it is, and being one of the first field stations in the tropics. It is a great responsibility to make sure things go right. “People are looking to see that we are protecting the environment for research,” she says. “The general public can visit to learn what we do and how we do it. I also find it very interesting to meet people from all over the world from many different cultures. I have learned how similar we all are, even though we speak different languages and have different cultures. . . we have many of the same concerns regarding the environment, our health, and education.”

“My parents always told me how important it was to study hard,” she told us, “and they encouraged me to work hard for good grades in all subjects. My father said it was especially important for a woman to get an education and be independent with her own career and not have to depend on others. Although my father only got to third grade before having to leave school to go to work to help pay for food for his nine brothers and sisters after his father died, he always read and learned. He was a maintenance worker for the Panama Canal Commission at the dredging docks in Gamboa for 30 years. He emphasized that he wanted his children to get the education he couldn't get.”

When she was finishing High School, she had an inclination towards biology and considered studying medicine. She applied for and won a scholarship to a university in Germany.

When she received the telegram telling her that that she had won the scholarship, she didn't know how she was going to get the money together to buy a plane ticket. But she found an institution in Panama City that would loan money to students; and with her father and her uncle as co-signers, she borrowed enough money for the ticket.

The arrangements were made hurriedly, as the entry date had already passed by the time she got the notice. When she got off the plane in Germany, she didn’t even know which university she was to go to, but was lucky enough to find a woman in the airport who helped by making calls to find out. The woman wrote a note for her and another woman traveling with her stating that they needed to get to the University and couldn't speak German, so would whoever saw the note please help them. People did help. They finally arrived at the University around 10pm. Luckily, someone was there expecting them.

Then she discovered that she would have to take tests the next day in chemistry and mathematics – and if she failed those tests, she would not be allowed to go to the University. Instead, she would have to go to a trade or vocational school. Fortunately, she passed the tests. But, because she was late arriving, there were no places left in the medical school program. She was offered places in the chemistry or forestry departments, instead. She said she
chose forestry because she thought it was more connected to biology. “I chose Forestry and am glad I did” she says. “For me it has been the right choice. I think Forestry is becoming a very important career of the future.”

She could soon see the need to learn different languages, so she would be able to communicate with people and have a better chance at getting a job she wanted. She already knew Spanish, learned German in Leipzig, then went to the University of California to study English. (She can also speak Portuguese.) Then she attended Syracuse University in New York State to earn a Masters degree in Forest Management and Policy. She got experience doing research for Weyerhaeuser Company in Hot Springs, Arkansas and later in the state of Washington.

Jonathan Gonzalez Santos is also one of the scientists studying the tropical life on BCI. He is a student who has worked as assistant to several of the senior scientists there. A native of Panama, whose first language is Spanish, he is finishing college as a biology major. We asked him how he became interested in science and how he came to work at BCI. He also has interesting stories from the fieldwork he has done on BCI. We asked him to write about some of his experiences:

“Since I was a child I felt curious about how everything works: the plants, communication systems, the human body, machines, the flying of birds and the movements of fishes in water as some examples. I knew that I would be studying and working in the future on something related to science to satisfy my curiosity and my senses.

“I always remember when one of my teachers in primary school told all the students to put bean seeds on wet cotton in an unopened flask, it was so funny to see a tiny plant coming out of the bean and growing so fast that it needed to be transplanted within a short time. It was an event so difficult to understand. How could a whole plant come out from a little bean? Now I am able to understand the story at least in a general way because I decided to follow these kinds of events. When I got into Middle School, things started to clarify a little more; it was the time when I could see through a microscope for the first time. I had the opportunity to see different human blood cells, plant cells – and a simple piece of hair was the most incredible thing I had never seen before. Also it was the time when I studied something that is part of our everyday life. I am talking about gravity – can you imagine the world we know without gravity? We wouldn’t have oceans and rivers and all the things we know, which tend to fall toward the center of the earth.

“Finally I decided to focus on Biological Sciences, I think because life is so complicated and so fascinating at the same time, and more so when I realized that not many signs of life have been found in any of the planets and stars that we can reach and study with the technology that we have, which means that life is unique at least in a pretty big space. After I finished high school I got into the Department of Biology in the University of Panama looking for new opportunities to understand how different organisms can survive and I realized that there are so many ways to exist in this planet. To be in science is not like having any other job, I would say it is a way of life. One of my professors, Dr. Noris Salazar, who is also a staff scientist in the Smithsonian Tropical Research Institute in Panama, recommended me to work for a huge project about Forest Dynamics that consists in knowing all the changes that occur to trees and shrubs in a determined period of time. Every other five years a group of students and scientists with expertise lead by Dr. Richard Condit measure the diameter at breast height of all the trees and shrubs in a 50 hectare area – which means around 250,000 plants. I had never felt so close to nature until I worked for this project. I used to spend the whole day in the woods during rainy or sunny days, in clearings or in the shady understory. But it was not only work; I could have fun watching all kinds of insects, birds, monkeys, deer, anteaters, snakes and many others. The forest is a beautiful place where you can see all those living things attacking, defending, getting rotten, falling down, cracking, singing, building, destroying, walking, running, swimming, floating, hanging, climbing, growing, fading, dying and being born, but in most cases sharing the same space. These were 10 great months of hard work and adventure.

“In this project I was very lucky because I could learn to identify around 300 species of shrubs and trees; and this is the reason I was hired in November of 1995 by Dr. Phyllis Coley and Dr. Thomas Kursar to work on a Bioprospecting project which consists in looking for interesting chemicals from plants of the tropical forest to be used as new medicines against all kinds of human disease. In this project I am in charge of collecting leaves in the woods and identifying all the plants collected. When I get to the lab with the leaf samples I do a kind of leaf shake with alcohol using a machine called an homogenizer. After the entire sample has been processed, it
Jonathan had some close-up experience with Paraponera, ants. He also wrote about this adventure:

“One day, when I was working in the woods of the 50 hectare plot on Barro Colorado Island, I suddenly felt a very sharp pain in my right hand. I was stung by a giant ant of the species called Paraponera, or Bullet Ants. These ants are called giants because they are bigger than all the other ants, are around one and a half inches in length, black in color, and have a very big stinger on the tip of the abdomen. They build their nests on the base of the trunks of trees and normally you can see these nests from several meters away. I had never been stung by a bug so strongly as this Paraponera did. The pain I felt was like 10 times stronger than the pain produced by a bee. The worst thing is that there is nothing you can do to avoid this pain, just wait for a while, three to four hours, if you have been stung by only one of these ants, as happened to me. Ten months after this experience, I was stung by a Paraponera again. Normally these ants go out to look for food in groups, but in both cases the ant that stung me was alone, walking on tree branches, so I could not see it in time. All this happened in 1995, and since then I have not been attacked by these ants and I hope not to feel that horrible pain again for the rest of my life.”

Continuing our interviews with scientists on BCI, Jane also interviewed Diane DeSteven.

Diane DeSteven from the USA, is a Caucasian woman who has been a working scientist for about 18 years. Before 1980, she spent six years in graduate school learning about her chosen specialty, the Ecology of Plants. Before that, she majored in science in college and knew she wanted to learn how to be a research scientist. Here is what Diane had to say about how she chose her area of study, what she did to enable her progress, and what she was researching at the time of the interview.

Jane: “What is your specialty and your current research?”

Diane: “My area of specialty is the Ecology of Plants. I study plant communities to determine which species grow in which places, with what other plants, and why they grow there. And, how do different plants grow in communities in the same place? Knowing the answers may help us to protect their environment or fix places that are damaged. This is often referred to as the concept of conservation and restoration.”

J: “How did you get interested in science?”

D: “As a kid, I was always interested in the outdoors and curious about critters and plants.”

J: “Did anyone or anything in particular influence you?”

D: “Well, I got encouragement from my teachers for being a good student and that pleased my parents who also encouraged me to study. I appreciated knowing that my teachers thought I did good work, and that inspired me to work hard. I read books, lots of books, for example, about dinosaurs, and the Golden Guidebooks series about natural things.

“Around the end of high school, I figured out that my hobby – learning about nature – could also be my work if I got the right training to do it. “In college, I had a professor who really encouraged young women to do graduate work. He provided the opportunity for me to go with a group of students to work and study at a field station.”

J: “Oh, that sounds interesting. What is a field station?”
D: “A field station is a place away from a typical classroom that is set up for you to study what you are interested in, in its natural ecosystem. For instance, BCI where we are, is a field station for biologists to study tropical plants, animals, an aquatic life.”

J: “What exactly interested you first?”

D: “Being outside, seeing creatures and what they did. I actually thought of myself as a naturalist when I was young. At first, I thought I might study animals.”

J: “What about now? What have you been working on recently?”

D: “I switched my main interest to plants as the basis for where animals live, where they get their food, their habitat. I like being ‘out there’ where the plant communities are that I want to examine.”

J: “What did you have to do to become a scientist?”

D: “Study hard. Work hard. Like (enjoy) what I was doing. Stay in school to continue learning. I went to college for a BS (Bachelor of Science) degree. After that, you can work as a scientist's assistant. I wanted to be a research scientist and for that, you have to go to university longer to get a graduate degree. At that point, you have to choose a field of study to specialize in. I found someone at the University doing interesting work and arranged to work with that person to get experience.”

J: “How long have you been coming to BCI and how often do you come and for how long do you stay each time?”

D: “My time coming to BCI spans almost 20 years. I have come once a year for 16 or 17 of those years for about one month each time. Once, I was here for 1½ years. This time, I'll be here for five months.”

J: “Where else do you do research?”

D: “In the southeastern USA in the Carolinas, and in Wisconsin.”

J: “What do you do to earn a living?”

D: “I am a Professor who is also a scientist. I teach at a university. One way people get to do their science as a career is to teach during the school year and then spend the rest of the year doing research. Sometimes, students can work with their professors as an assistant to get experience.”

J: “Do you have any thoughts you'd like to leave with our students?”

D: “Yes. Just that we (scientists) see things out there that we're curious about and maybe want to figure them out. And, we want to teach others how to do it. Science is a process. You have to know about your world in order to keep it healthy and habitable, or fix it!”

J: “Thank you, Diane, for talking to us about your work and your ideas. The students [reading this] are learning what it is like to be a scientist. Some of them may be thinking they'd like to explore their natural world more closely, too.”

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Jane also interviewed Lissy Coley, who was working on BCI during our 1998 session. Lissy is a Caucasian American woman who has been working as a professional scientist since 1981:

Jane: “Hi Lissy, thanks for taking the time out of your busy day to talk about your work and your life. First, please tell us about your specialty area and your current research.”
Lissy: “Tropical Ecology is my specialty. It combines the study of insects with the study of plants. I study how plants defend themselves against getting eaten by insects. This basic research has led to my trying to use the information I’ve obtained to save rainforests and to examine how the chemicals produced by the plants as defense mechanisms might be useful to humans as medicines.”

Jane: “Wow, you have no idea how much that interests me, especially the part about using the plants’ chemicals as medicines. How did you get interested in science?”

Lissy: “From when I was about eight years old until I was twelve, we lived in the country. I liked watching squirrels and bugs, liked being outside, watching stuff. There was no TV watching, so I was outside a lot. My grandfather took me on walks and often made a game out of finding things, living things, and asking questions. He was incredibly influential in getting me interested in nature. I also had teachers who encouraged me and exposed me to questions. They helped me to realize there was a whole field of science and a career potential in learning about it.”

Jane: “What exactly interested you first?”

Lissy: “Animals. Then plants. First I majored in Animal Ecology. I studied the coyotes of the northeastern US. After I graduated from college, I didn’t really know what I wanted to do for a career. I went to work for a company that was building a new power plant and they needed someone to work on an impact study. They needed to know what effect the warm water effluent (discharge) would have on the ecology of the marine life there. After a year or so, I wanted to learn more. I went to grad school and had to choose a specialty. I thought about either the microbiology of sewerage, or tropical rainforest plants. I chose the tropical rainforest. All through grad school, I felt insecure about whether or not I’d chosen the right thing, was it really what I wanted to commit to and whether or not I’d be any good at it.”

Jane: “What interests you now?”

Lissy: “Saving the rainforests is a job that needs doing and we do have the tools to do it. I think there must be a way to preserve the forest for the benefit of the environment and at the same time meet the demands of commercial interests without cutting it down. I see the potential for the forest-as-pharmacy. We’re also looking for genes in wild plants that make defensive proteins that could be moved into crop plants to give them the ability to protect themselves from pests. This would negate or lessen the need for using chemical pesticides.

“When people ask what good [comes from] science, I want to tell them that if we hadn’t started the basic research to understand how the rainforest works, we would not have found the potential applications we know now for medicines and for helping conservation.”

Jane: “What did you have to do to become a scientist?”

Lissy: “In college I got partial scholarships and I worked 20 hours a week in a post office. I studied hard, read a lot. During summers, I tried to get jobs related to science. During the year I worked after I graduated, I realized I wanted to know enough to direct the research instead of follow the directions of other researchers. It was competitive to get into grad school. I really wanted to go. Once I was accepted, I found I would receive funding assistance through fellowship awards.”

Jane: “Would you explain more about that?”

Lissy: “In field science, in most cases, if you get into grad school, you will receive scholarship (financial) assistance to pay tuition and help pay living expenses like room and board. You still have to be willing to work and earn and get experience. During summers, I was a research assistant on other peoples’ projects. Once, I got to go to the Caribbean to study monkeys. Another time, I cleaned houses in order to help pay my own expenses.

“One important thing I needed to do in order to be, and stay, a scientist working in far away tropical rainforests studies was to communicate honestly with my fiancé about what I wanted to do. We needed to find ways to mesh our careers so that neither one of us was compromising unfairly. Fortunately, we have been able to combine our interests and do similar kinds of work with our different areas of expertise. In addition to our University work, we spend 3 months every year together in the rainforest.”
Jane: “How long have you been coming to BCI?”

Lissy: “Twenty-three years. Once a year, for three months each time; first as a student, then as a Professor. I sometimes bring grad students with me to assist with the work.”

Jane: “Where else do you do research?”

Lissy: “Most of it is done right here [on BCI]. I have also worked in Africa and Southeast Asia.”

Jane: “What do you do for a living?”

Lissy: “I’m a Professor at the University of Utah.”

Jane: “Do you have a final comment to leave with our ‘listeners’?”

Lissy: “People tend to view science as memorizing facts. Science is really asking questions and investigating to find new answers. I also want students to know that science is fun, scientists have fun, and we enjoy each other’s company.”

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We also had inquiries from students about what kinds of jobs people might have on BCI or at the Smithsonian that are not strictly research, or not university-based.

**Nelida Gomez** is an Hispanic woman who is currently working as a scientist for the Smithsonian Tropical Research Institute. Right now she spends most of her time at the STRI offices in Panama City. When she came to BCI to attend a lecture, Jane was able to talk with her during the dinner hour.

Nelida explained that she was in a transition period, during which she was expected to publish her research findings and raise money to support her research project in order for it to continue. Her field is Chemical Ecology.

She explained that one way to understand Chemical Ecology would be to think of it as “perfume,” or odors. The communication between plants and animals or between living organisms is done through odors produced by the organisms. Organisms use this technique to identify other organisms and what they do. Humans imitate this practice by using perfume to attract or please others.

Jane asked, “When did you first get interested in science?”

“I remember when I was a child and lived in the country, I was outside a lot. We didn't see much TV. Sometimes when we did watch TV, it was with a group of friends, but not often. What first attracted my attention was noticing the sun and its position relative to the earth at different times of the day and different times of the year. I wondered why it changed. Even in Panama, only about nine degrees north of the equator, it changed and I wondered why.”

Nelida talked about how her teachers gave her recognition for the work she did and praised her a lot and at other times encouraged her to go further and try to improve it. “They impressed me and made me interested in studying, especially in high school,” she added.

She said that her first interest in working for STRI began when they gave her a fellowship to do field work in Panama. She worked in a Mangrove forest, which can be very difficult (they're often swampy and home to many mosquitoes) and she also worked on a coral reef doing chemical analysis after she graduated from the University of Panama with a B.S. in Chemistry.

Her schooling began with elementary school in the countryside in Panama. For high school, she had to attend in Panama City. After graduating from the University of Panama, she attended graduate school in the US and received a Master's degree specializing in the Chemistry of Natural Products. She returned to work in Panama at
STRI for four years, where she worked as scientific coordinator on BCI (assisting scientists in establishing their research) and then went to Germany to earn a Doctorate at university there.

Nelida had some final thoughts to share with us. “Use your eyes, your ears, your nose. Ask yourself what you see, what you find out. Trust yourself, your feelings about what you think is right or what situation or fact is correct. Have confidence in yourself. Confront yourself, your fears, and you will have an easier time of meeting your goals. Be positive. Work hard!”
Research Trends

In February of 1999, Jane had an opportunity to talk for a few minutes with Bob Pearcy, an American scientist from the University of California at Davis, about observations he's made as to how scientific research has changed in the past several decades, particularly in his own area of expertise, Physiological Ecology. Focusing his research in tropical rainforests, he had been going to BCI part of every year for the past 5 years. He had also conducted research in both Hawaii and Australia.

Here are the highlights of their discussion:

Jane: “Bob, could you explain for us just what you do in the area of Physiological Ecology?”

Bob: “Sure. We look at how plants function in their environment. How much photosynthesis do they do? How do they use the carbohydrates produced by photosynthesis to grow? And, how do these factors influence what environments they survive in?”

Jane: “Would you talk about any major changes you've seen occur regarding the conducting of research?”

Bob: “I started doing research in Tropical Forests around 1977, first in Hawaii. One major change I've seen has to do with taking measurements. Back then, the idea was that very sophisticated measuring couldn't be done. I measure photosynthesis. It required that the necessary, heavy equipment be moved into places that were difficult to get things to and it was thought that the climate could interfere with getting accurate readings.

“Now, the equipment has been designed to be able to fit into a backpack. I can take it anywhere. Many of the instruments have computer capability built right in, making it possible to ‘miniaturize’ the instruments. So I can take them right to the field area with no problem.”

Jane: “What about the humidity and its effect on the instrumentation?”

Bob: “Well, computers can actually produce just about enough heat when they're running to dry themselves out and that protects them fairly well from the humidity.”

Jane: “Any other changes?”

Bob: “Yeah, the nature of the research that people work on. At one time, it seemed that the major interest people had was looking at what went on between organisms in a particular species or between one species and another. That's changed in regards to research in the tropical rainforest. Now there is a lot of interest in studying the relationship between the tropical rainforests and the environment. For example, what role do the rainforests play in climates and climatic changes? Right now there is great interest in looking at the El Niño effect. It will affect the tropical forests. How? Which species will survive any changes? How? How will this event affect the tropics as a whole? Previously, when important events like this occurred, we didn't have enough warning to know about it coming and so we weren't able to study it until after the fact, when after-effects had already had an impact. Now we are able to get enough information to predict the El Niño and prepare in advance to study it as it happens, not just after the fact. That's an important change.

He also observed: “Over the years, there's been a continual change in the nature of what people do. For instance, in the past, people would have an Herbarium (a place where carefully dried plant specimens are stored for study), and identify plants and record what they could see. Now there are molecular techniques for looking at species which allow the researcher to access information about the species he or she wouldn't get on their own. It is not possible for any one person to have all the knowledge needed to do the research. There is a dependency on using the findings of others when doing your own work.”

Jane: “As teachers, we have begun talking more about using collaborative group-work and cooperative strategies in our classrooms so that students get a sense of how to work that way. Would you say that collaboration is a key strategy in the area of research?”
Bob: “Yes. It's certainly useful. We can't do research as effectively without paying attention to what others are doing in the same field.”

Jane: “I really appreciate your insight and have enjoyed learning about what you had to say. Thanks for the chat, Bob.”
Changes in the Forest

The first thing we noticed when we arrived in Panama in mid-January of 1998 was that the lake seemed much lower than when we had left it the previous season. More shoreline was exposed. The red clay banks stood higher above the water’s edge. And we could see stumps sticking out of the water where we had never seen stumps before. This condition could have been the result of several things:

El Niño, a temporary ocean current that arrives with little warning, usually around Christmas. (El Niño is Spanish for Christ Child). El Niño affects climate dramatically, causing heavy rains and flooding in some areas and droughts in others. The dry season had begun early this year, on December 9 officially, but many people said it seemed to have begun in November. The 1997 El Niño resulted in events such as the winter storms in Maine and the drought in Australia. El Niño also causes the changes in the rates of evaporation and precipitation, which can effect the water level. And that year was the year of the lowest amount of rainfall in 73 years of records for BCI. I was told that it was seven feet below normal for that time of the year, and the Dry Season still had many weeks to go!

Long-term data on rainfall in Panama indicate a small, gradual, but definite decline in rainfall in over the last 70 years, when a corresponding increase in forest-cutting became widespread. We (humans) could be making some permanent changes in our climate. Panamanian friends have complained of the heat in the last few years – it seems to be getting warmer and dryer there than it was 30 years ago.

Water use by the Canal system also has an impact on the amount of water remaining in Gatun Lake. Much water is lost to the lake system when ships are taken through the locks. Water to fill the locks is taken from the lake, and drains into the ocean as the level in each lock is lowered.

Panama City draws on this water supply, as well – and the city has grown tremendously in the last 20 years.

Leslie Sokolow, our mammalogist in Georgia, found a news item of interest to us, so we are reprinting it below (from CNN):

**Panama Canal conniption**

*El Nino reduces depths, sending ship lines hunting for freight alternatives*

by staff writer Allen Wastler

March 18, 1998: 2:33 p.m. ET

NEW YORK (CNNfn) –

One of the world's major shipping arteries is constricting, a situation which threatens to add strain to an already taxed system for getting goods in and out of North America.

El Niño droughts are reducing the navigable depth of the Panama Canal. Eventually the maximum allowable depth could be reduced from the normal 39.5 feet to 34 feet before next fall's rainy season, unless there is a drastic change in the weather, according to the Panama Canal Commission. The agency already has notified shipping lines that depths will be restricted to 36 feet by mid-April.

That means ships using the canal can't carry as much cargo as they usually do or, depending on their size, can't use the waterway at all. As a result, shipping lines using the canal are scrambling to figure out how much cargo they will have to divert to other routes.

“IT's a major headache,” said Ole Sweedlund, general manager of logistics for Hanjin Shipping Co. “The question becomes how much freight is going to be affected and finding alternatives for it. That's the juggling act....It's already a strong import market, and this is a compounding factor.”
And the problem comes just as a wave of imports, driven by cheaper prices in Asia, is expected to hit the United States.

The Panama Canal Commission expects up to 17 percent of the ship traffic transiting the waterway between March and October to be affected by the restrictions. Normally about 8,800 ships would go through the canal in that period.

“Ship lines, our customers, have been understanding,” said Cynthia Riddle, a spokeswoman for the agency. “They know the weather is beyond our control.”

Shipping lines serving the United States primarily use the canal to carry a portion of the goods traveling between Asia and the U.S. East Coast. The majority of goods travel to and from the West Coast using railroad connections. However less time-sensitive cargoes like waste paper, chemicals, clay and bulk goods typically go through the canal because it costs less.

Those ship lines that move merchandise cargo packed in standard marine containers have two basic choices: channel the cargo through the West Coast via railroad or use the Suez Canal and bring cargo to the East Coast from the other direction.

Both alternatives would add to the cost. The Suez route is longer, depending on the shipment's origin point, and costs more in tolls. The rail option, on the other hand, typically costs several hundred dollars more per shipment. The low-value cargoes moving through the Panama Canal, however, might not merit such a price increase.

In addition, recent problems with the Union Pacific Railroad system have made some shipping executives leery of channeling additional freight to the rail system. Last year the railroad, which just completed a merger with a competing system, suffered major delays and traffic tie-ups, the effects of which are still being felt. While some believe the system will improve, not all are sure, especially if Panama Canal traffic is added to what is already expected to be a strong import traffic year.

“We can handle the traffic if the railroad is going. We have the infrastructure...but I'm not confident UP has a real handle on the situation yet,” said Don Wylie, director of trade and maritime services at the Port of Long Beach, the port handling the lion's share of ocean freight coming into the West Coast.

Shipments of grain, chemicals and other bulk commodities could also be seriously affected. If less commodity per ship can travel the canal, the cost per unit of the commodity will go up. That will affect their competitiveness in overseas markets.

“Where it would be particularly significant is if the draft restrictions become so severe that it isn't economical for the ship to go through the Panama Canal at all,” said Malcolm Jupe, a shipping analyst with Drewry Shipping Consultants in London. “Freight rates, which are currently at a low point, would have to rise to offset such a situation,” he said.

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We on BCI wondered what this lowered lake level would mean to Panama, since the shipping tolls are important economically? Normally, the rains would start very soon, but many months could go by before the lake reached its optimum level.

But when El Niño fades away, it is often replaced by another weather phenomenon called La Niña, which can cause extremes of weather the reverse from that brought by El Niño. La Niña began to show her face in 1999, and continued on into 2000. I'd guess that she was just as influential as her big brother because there was so much rain – much of it still falling in what is supposed to be dry season. This sort of odd season has an effect on when trees bloom and whether or not bees can fly around to pollinate the flowers, which ought to produce fruit as a result. That in turn affects how much fruit is available for birds and mammals to feed their young.

When Greg and I returned to BCI in January of 2000, we found changes.
It seems as if every year is different from all the previous years, even though the forest looks pretty much the same. That year was extremely wet, and when the data are gathered, it may turn out to be the second wettest in the last 60 years. This means the lake was very high and the crocodile and iguana nest sites were all covered with water. We hoped the rain would soon stop – since it was supposed to be Dry Season – and the waters would recede by the time the animals were ready to lay eggs in February.

All that wet also meant that the sloths were the greenest we had ever seen them! Perhaps you know that sloths have thick hairs with grooves running down their length, which provide a small space for microscopic plants (algae) to grow. The sloths also have communities of moths that lay their eggs on the hairs and the larvae (like butterfly caterpillars) eat the algae. So the small moths live their lives amongst the shaggy hairs of the sloths. Kind of a busy skin they have! The algae did very well in the constant heavy rain, and the sloths looked rather bright shiny green across their shoulders. The sloths benefited from this because they are great artists at camouflage, so the more they look like vegetation, the better for them.

We usually try to visit Barro Colorado Island in the dry season, and we usually succeed, even though the beginning of dry season varies from year to year. Dry season in most years begins in late December or early January. In some years it has started as early as November (and we arrived in time for it that year!) and as late as late January. It's rather a game of chance, so we try to get weather information by e-mail from friends down there, before we buy our airline tickets. But we need to buy tickets in advance to get a good airfare, so we need a crystal ball to see into the future! We usually figure that if dry season was early one year, then it could be late the next year.

Why do we try to be there for dry season? For one thing, the breeding seasons of some of the common mammal species begin at that time. They have just been through a season of low fruit availability (late wet season), and some animals die because food is scarce. At the start of the dry season, some tree species with very nutritious fruits begin to ripen their crop, and the mammals can fatten up again. This is a good time to prepare for a new family. It's also a good time to get a count of these mammals, before there's a major increase in babies.

It's also much easier to see many species in dry weather, partly because squirrels and agoutis, for example, will tend to find a dry hiding place to rest when the rain gets heavy. They seem to have more sense than some biologists. We don't wear raingear, because it gets too warm and clammy inside a jacket or poncho: we just get wet. If we get wet enough, and the wind blows, we also get cold! If you wear eyeglasses, as we do, they will tend to fog up and make it difficult to see. A hat tends to increase the fogging. And contacts are not recommended for long-term visits because the fungal diseases of eyes are very numerous and prevalent in the tropics. And if it's raining, the sounds of raindrops on the leaves overhead can make it hard to hear animals – and hearing is an important sense for doing a count of mammals.

So, boots get wet, and they don't have time to dry out completely each night. Mud cakes up on the soles and adds pounds of weight to your feet. When you try to take a step on this layer of caked-on mud, your feet slide. Cameras and binoculars keep getting wet, and pretty soon a fungus grows on the lenses and ruins the equipment. The automatic cameras we place in the forest have to have waterproof housings, but humidity still gets inside, and fogs the lenses. Electronic gear starts acting funny or simply quits working. And fungus grows on people too.

We had some REALLY hard rains at the beginning of our supposedly dry-season stay that year. They were quite like typical rainy season downpours. First the forest starts to darken and I hear howler monkeys in the distance, howling off in the direction of the rain clouds. They often howl in the rain, and I don't know if they are responding to the sound of the rain, or if they are unhappy about getting wet. Again. Then there is a pattering sound on the leaves above as the first drops fall. That's when I pull out a plastic bag for my camcorder and put on a hat. Then there is a loud hissing of lots of raindrops slapping the leaves. I usually look for a small tree that has lots of leaves, to stay a little bit dry. I try to avoid big trees on ridge tops because lightning is so dangerous. If the downpour reaches the stage of a major roaring sound, and it looks like I can't get any more field work done, I head home. At that point there's no dry place to stand anyway, and it's too cool to stand still. So, now the trails look like narrow, muddy creeks with rapidly running, yellow-brown mud. The mud is boot deep, and the water washes over the tops and into my waterproof boots – which now hold lots of water. Making progress on the trail is slow and slippery, because I have to avoid tripping over rocks and also not slide too fast down the slimy inclines. There is no
place to walk on BCI without going up and down many times. And in the rain, it's all covered in mud. The real creeks are no longer easy to step across (but never deep enough for swimming on BCI) and it's hard to see where the stepping stones were. We hope to get back to our room without falling down and getting thoroughly covered in mud.

It rains like that almost every day during the regular rainy season. However, the very fact that usually there is a distinct dry season, with much less rainfall than the wet season, means that experts do not rank BCI forest as true, classic rainforest. REAL rainforests have no sharp seasonal differences. Rather, the forest here is called a moist tropical forest. But most people, other than the true experts, would instantly recognize this as “rainforest” – it's way beyond what most people call just moist!

Also of interest that year was the fact that we had left some automatic cameras on BCI that can sense body heat and take pictures of warm animals. One of the fieldworkers had kindly agreed to change the film periodically and mail it to us. We were extremely surprised back in March of 1999, when one roll of film showed a series of pictures of people working under a tree studying fruitfall, and then, later the same day, a puma (cougar, mountain lion are all the same). Since people had been saying that pumas were extinct on BCI, this was proof that at least one was very much alive. True to the nature of pumas, it had been hard to see. Some fieldworkers from the University of Panama put out smoothed areas of mud so they could find clear animal tracks; and they reported there was at least one puma on the island.

People have often called BCI a “zoo without walls” because it's so easy to see some species which are rather tame, and because they are so abundant. I don't care for that description of the island because it's based on the assumption that there are few predators there to keep the prey on their toes – that there have been no jaguars or pumas. Actually, both species had been there for perhaps many years; and there are abundant large ocelots and tayras, which are excellent predators.

And in 2000, some new superb predators were added to the mix. The Peregrine Foundation, a conservation group that releases captive-raised birds of prey into the wild, released two harpy eagles on BCI. Harpy eagles are extremely large birds with 3-inch long talons; and they like to eat monkeys, sloths, deer, iguanas, coatimundis, and other large prey. They were released wearing harnesses with radiotransmitters, so that the researchers could follow their activities and make sure they were fitting into the community. When we were on the island in January and February of 2000, they were eating very well.

Greg and I were invited to accompany Janeene Touchton, who was working for the Peregrine Fund, which had a project to release young harpy eagles into areas where the species had become extinct. We jumped at this opportunity even though it meant lots more walking off trails in addition to our usual daily census walks and fruitfall monitoring. We might never again have a chance to see harpies in the wild.

The two harpies on BCI had been hatched and raised for two years in the USA, but they would not be adults and able to breed for another two years. The male’s identification number was 007, and so was named James (Bond). The female didn’t yet have an official name, but Greg and I called her Miss Moneypenny, who is a strong and independent female character in James Bond’s life, as was this eagle.

The two eagles had been raised by humans and the male was taken to many classrooms to teach children about the importance of not shooting birds of prey. Since both birds were accustomed to people, they could be recaptured to give them medical care or change their radiotransmitters. Both eagles wore harnesses with little backpacks that contained the radios. Janeene used a special receiver with a big antenna to locate the eagles so that she could observe them. The harpies were living on the west end of the island, away from the area of the laboratory clearing. Greg and I separately did some census walks early in the morning and met Janeene at the high point in the middle of the island. She listened to the “beep-beep-beep” of the signals from the eagles’ radiotransmitters, and used the antenna to determine the direction the signals were coming from. James was closer, so Janeene decided to find him first. We headed out on a trail, found that the signal was coming from our left, and so turned off the trail to find him.

Harpies are considered the most powerful eagles in the world. They are about 36-40 inches in length from beak to tail tip. The females are larger than the males, which tends to be the case in most birds of prey in which the females are territorial. Harpies have big, hooked, sharp bills; broad, rounded wings; large eyes with extraordinary
vision; and legs two inches thick with immense claws tipped with curved 3-inch-long razor-sharp talons. Their legs are bare, long, and yellow, and are used to snatch their prey from tree branches or from the ground. They are very capable of killing monkeys, sloths, coatimundis, and small deer. These young ones on BCI were various shade of dark and light gray, but, as they matured, they would develop black areas on their breast, back, and the tips of crowning feathers on the tops of their heads.

Harpies used to live in the forests of BCI and surrounding areas. Now they are very rare. Even though they are protected by law in Panama, people shoot them. Many farmers fear that harpies will carry off their dogs, pigs, and other livestock, so they shoot them. And other people just think it’s pretty exciting to shoot a really big bird off its perch. Harpies don’t have any enemies except people, and they often fail to be afraid of people, making it easy for them to be shot.

After sliding down into and climbing laboriously out of three steep ravines, we found James sitting on a huge fern-covered horizontal branch, not far from a trail. He was standing on top of some kind of prey, and Janeene told us that he had killed a sloth the day before, and was probably still snacking on the remains. When he saw Janeene, he started screeching. His great beak opened and the pointed red tongue came out and he screamed his eagle scream, over and over. Janeene told us that he always calls to her when she arrives and that she could whistle and call him to her if necessary – a good way to change the transmitter when the batteries run down. He was huge and elegantly feathered, but acting like a big baby calling for his Mom. We left him to see if we could locate the female, who was not near by. For the next hour we could still hear him screaming, even though we were no longer in sight.

We wound up on the wrong side of a cove and had to back-track to come around the other side, again going up and down ravines. I found fresh tracks of a big tapir and a baby in one of the stream beds, and Greg found some ocelot tracks. But still no Miss Moneypenny. Radiotracking equipment helps, but it still isn’t easy to find animals, especially those that can fly. Eventually, I felt worn out and headed back to the lab, leaving Greg and Janeene to continue the search. When they found the female harpy, she was crouched oddly on a branch, peering intently at something. She jumped to another branch and seemed to be sneaking around. Finally, Greg noticed a sloth hidden in a tangle of vines, and the eagle was trying to reach it. This sloth was lucky – it was protected by a basket-like mesh of vines – and the eagle gave up and left it alone.

We hoped then that the harpies would decide they liked BCI and that they would like each other enough to build a nest and raise some young on the island, but, after a time, were a little more ambivalent about their being re-introduced to BCI when we learned that the sloth and monkey populations were rapidly diminishing.
Rare and Locally Extinct Birds of Barro Colorado Island

One of the New Jersey science classes had questions about extinct animals on BCI. Jackie’s friend George Angehr, of Smithsonian Tropical Research Institute, put together a list of rare and recently extinct birds of BCI.

RARE AND LOCALLY EXTINCT BIRDS OF BARRO COLORADO ISLAND
George Angehr, STRI

Barro Colorado's avifauna has changed continuously since it became an island in 1913, with many species becoming extinct and a few others colonizing. The most recent revision of the bird list was published 15 years ago (Willis, Edwin O., and Eisenmann, E. 1979. A Revised List of Birds of Barro Colorado Island, Panama. Smithsonian Contributions to Zoology No. 291). The present list summarizes available information on rare and locally extinct birds of BCI, with the intent of alerting visiting birders to the species that are of particular interest on the island (many of these species are common on the mainland). . . . A total of 384 species have been recorded, of which 221 are or were breeding birds. Between 50 and 60 breeding species are now extinct on the island.

Locally Extinct Species

Crypturellus soui - Little Tinamou
   Last record 1966
Morphnus guianensis - Crested Eagle
   No recent records; probably extinct
Harpia harpyja - Harpy Eagle
   Last BCI record 1950; Bohio Peninsula 1951
Daptrius americanus - Red-throated Caracara
   Fairly common until 1963, when it disappeared from both BCI and the rest of central Panama; one record since, 1993
Crax rubra - Great Curassow
   Last record 1927; attempted reintroduction 1960 failed
Odontophorus gujanensis - Marbled Wood-Quail
   Last record 1953, except for a group of 5 or 6 recorded June-September 1982, possibly vagrants; apparently no records since
Neomorphus geoffroyi - Rufous-vented Ground-Cuckoo
   Last record 1935
Claravis pretiosa - Blue Ground-Dove
   Last pair 1965; any recent records of transients?
Otus choliba - Tropical Screech-Owl
   Last reported on BCI 1950; Mona Grita Island 1977
Nyctibius griseus - Common Potoo
   Not uncommon in 1930s; no recent records
Threnetes ruckeri - Band-tailed Barthroth
   Occasional to 1950s (?) ; no recent records
Anthracothorax nigricollis - Black-throated Mango
   Breeding in 1930s; last definite records of transients 1978, 1979
Amazilia tzacatl - Rufous-tailed Hummingbird
   To about 1971, very common in the clearing; apparently only transients since, last definite record 1979
Chloroceryle amazona - Amazon Kingfisher
   Once fairly common, to early 1970s (?) ; no recent records
Chloroceryle inda - Green-and-rufous Kingfisher
   Present between 1952 and 1970, apparently not since
Momotus momota - Blue-crowned Motmot
Occasional in 1930s, last record 1961
Notharchus macrorhynchus - White-necked Puffbird
   Not uncommon until 1950s; scattered records to 1970s; any since?
Celeus loricatus - Cinnamon Woodpecker
   Occasional in 1930s; last record 1976
Automolus ochrolaemus - Buff-throated Foliage-gleaner
   Last record 1966
Dendrocopeltes certhia - Barred Woodcreeper
   Last record 1969
Cymbilaimus lineatus Fasciated - Antshrike
   Last record 1961, except for one in about 1977
Thamnophilus doliatus - Barred Antshrike
   Occasional to 1950s (?); transients 1966, 1971
Myrmotherula surinamensis - Streaked Antwren
   Not uncommon in 1930s; no records since.
Myrmiciza longipes - White-bellied Antbird
   Not uncommon to 1950s; last record 1971
Phaenostictus mcleananni - Ocellated Antbird
   Last records late 1970s
Formicarius analis - Black-faced Antthrush
   Last record 1951
Hyloptilus perspicillatus - Spectacled Antpitta
   Common until 1965; last definite record 1971
Cnipodectes subbrunneus - Brownish Twistwing (Flycatcher)
   Occasional in 1930s; no records since
Onychorynchus coronatus - Royal Flycatcher
   Uncommon in 1930s, one record since, 1983
Myiobius barbatus - Sulphur-rumped Flycatcher
   Not uncommon in 1930s, no records since
Myiobius atricaudus - Black-tailed Flycatcher
   Fairly common in 1930s, no records since
Myiozetetes granadensis - Gray-capped Flycatcher
   Occasional until 1958
Pachyramphus cinnamomeus - Cinnamon Becard
   Last record 1963
Pachyramphus polychropterus - White-winged Becard
   Infrequent in 1930s; last record 1977
Cyanocharax affinis - Black-chested Jay
   Last record 1971
Thryothorus fasciatoventris - Black-bellied Wren
   Last record 1964
Thryothorus leucotis - Buff-breasted Wren
   Occasional until 1950s
Thryothorus nigricapillus - Bay Wren
   Rare in the 1930s; one apparent transient or possible pair 1982
Troglydotes aedon - House Wren
   Last record 1978
Henicorhina leucosticta - White-breasted Wood-Wren
   Present in 1930s; (reintroduction in 1976 failed)
Microcerculus marginatus - Southern Nightingale-Wren
   Recorded in 1933; one record since, in 1977
Cyphorhinus phaeocephalus - Song Wren
   Last pairs in 1961; (two pairs reintroduced in 1976; breeding occurred, but introduction ultimately failed; last record 1983)
Turdus grayi - Clay-colored Thrush (Robin)
   Last record as breeder 1966; vagrant to clearing 1986
Vireo flavoviridis - Yellow-green Vireo
   Former rare breeder, last record 1974
Basileuterus rufifrons - Chestnut-capped Warbler
   Last record 1961
Euphonia laniirostris - Thick-billed Euphonia
   Not common in 1930s; only records since in 1956, 1977, 1991
Tachyphonus rufus - White-lined Tanager
   Last record 1961
Rhamphocelus flammigerus - Flame-rumped Tanager
   Irregular to 1962; only record since in 1991
Saltator maximus - Buff-throated Saltator
   Last record 1964

Possible Recolonists
The following species were considered to be extinct in Willis and Eisenmann's list but seem to have recolonized the island. Some recolonization by birds of open areas may be due to enlargement of the BCI Lab clearing by construction of new housing in 1990.

Melanerpes rubricapillus - Red-crowned Woodpecker
   Occasional to 1956; apparently not recorded between then and 1991; now again occasional in clearing; breeding?
Myiarchus panamensis - Panama Flycatcher
Thryothorus modestus - Plain Wren
Rhamphocelus dimidiatus - Crimson-backed Tanager
   Breeding to 1966; between then and 1991, only vagrant young males to clearing; several males and females present in clearing mid-1991 to 1992; males singing regularly; breeding?
Arremonops conirostris - Black-striped Sparrow
   Pairs in clearing to 1966; one record 1983; regularly singing around new dining hall 1991; breeding?

Status Uncertain
The following rare, cryptic, or elusive species have not been definitely recorded recently, or else their status as breeders is uncertain. Many are probably still present, but definite confirmation would be desirable.

Agamia agami Agami - Heron
Butorides striatus - Green-backed Heron
   Any recent records of "striated" type (apparently locally breeding form)? A rufous-necked, possibly migrant individual, was seen in August 1991 on Maiz Island.
Accipiter superciliosus - Tiny Hawk
   Recorded 1971, 1978; any since?
Spizaetus ornatus - Ornate Hawk-Eagle
   Last known record 1978?
Geranospiza caerulescens - Crane Hawk
   Last known record 1977?
Micrastur ruficollis - Barred Forest-Falcon
   Present to 1966; only definite records since in 1977, 1979
Falco rufigaralis - Bat Falcon
Eurypygia helias - Sunbittern
   Present in 1920s; apparently absent from the 1930s until 1979, now recorded occasionally in streams above Fuertes Cove, but apparently irregular
Dromococcyx phasianellus - Pheasant Cuckoo

   Rare but regular (?) to 1971; fledgling seen 1978; one recent record (late 1980s)

Crotophaga ani - Smooth-billed Ani

   Not recorded in searches of available habitat in 1991-92

Lophostrix cristata - Crested Owl

   Last definite record 1986

Lophostrix semitorquatus - Short-tailed Nighthawk

Panpyilla cayennensis - Lesser Swallow-tailed Swift

Glaucis hirsuta - Rufous-breasted Hermit

Phaethornis longuemareus - Little Hermit

   No known remaining leks; possibly now only a transient

Chloroceryle americana - Green Kingfisher

Chloroceryle aenea - Pygmy Kingfisher

   Two recent records, October 1992, January 1993, Wheeler Cove

Colonia colonus - Long-tailed Tyrant

   Recorded 1962, 1971, several records 1975-1979; any since? (Willis lists as breeding species, but possibly just transient)

Legatus leucophaius - Piratic Flycatcher

Laniocera rufescens - Speckled Mourner

   Last known record 1978

Rhytipterna holerythra - Rufous Mourner
Q & A

During the five years of RAINFOREST CONNECTION communications between our team and students from many parts of the world, we received a multitude of thoughtful questions concerning the ecology of tropical forests. This chapter includes those that didn’t seem to fit into any of the subjects covered in previous chapters.

“Why is BCI covered in red mud?”

Many rainforest soils are full of clay, which has a reddish color, usually because of a high iron content—think of the color of rust—what is rust? Soils that are in areas where there’s lots of rain and hot weather are often transformed by weathering so that only clay remains and other chemicals are washed out. These soils lack some of the important nutrients that plants require for growth, and so are not good for farming.

“Are fossils found on BCI?”

I know of no fossils on BCI. The climate in tropical areas makes fossil formation uncommon because remains of organisms decay and disappear too rapidly, with little opportunity to form fossil imprints; and the volcanic rock in Central America usually doesn't preserve fossils. More often, tropical fossils are found in caves—and there are none on BCI.

“Why are the trees so fat? We noticed that the trees seem to be very broad at the base. Is this an adaptation for a specific purpose?”

YES! These wide wall-like bases are called buttresses. Look at buttresses on Notre Dame Cathedral. They serve the same function in stabilizing a tall structure in strong winds. Try building different model structures using straws and paper, and test their stability with a fan.

“Are there any plants that have leaves as big as a person?”

Yes, in Brazil, there’s a type of plant that floats on the surface of lakes and has very large leaves.

“What do you think is the most unusual plant on B.C.I.?”

The most unusual plant species on BCI? That's hard to say. I guess Dieffenbachia is interesting. It is grown also as a houseplant and is called “Dumb Cane” because it produces a chemical that seems to paralyze the mouth of anyone who tries to eat it. So the person becomes “dumb” in the sense of being incapable of speech. You can see why this might protect it from animals that try to chew on the plant. Also the fig trees, of which there are many species in many rainforests, have unusual life cycles that involve tiny wasps that live and die inside the fruits and are required for pollination of the flowers. (You can look up details under the scientific name of Ficus or fig wasps.)

“What kinds of medicines come from plants or animals that you see on BCI?”

I actually don’t know that any new medicines were derived from BCI plants. Not yet, but studies are now in progress. Many medications such as birth control substances, a cure for malaria, and some cancer treatments are from tropical plants in other areas.

“In the rainforest, how do trees differ from the types we have here? Are they larger?”

They are about twice as tall and the trunks are often 6 feet or more in diameter. Some pot-bellied trees store water and have buttress roots that support trunks in shallow soil. Rainforest trees often have roots that spread outwards in the thin soil and don't go down deep.

“Are there a lot of colorful trees in the rainforest? What are their characteristics?”
There are yellow flowers and pink flowers and purple ones on certain species that bloom in the dry season. One species is very odd in that the trees bloom only once and die after they form fruits, which contain the seeds for the next generation.

"Are there any plants on BCI that don't tolerate a lot of water?"

Yes, certain epiphytes that live on tree trunks are adapted to drying out in bright sunlight and breezes. These epiphytes include not only orchids and bromeliads, but also ferns and cacti. They like lots of humidity and periodic heavy showers but can't tolerate constant soaking.

"Do you think there are more plants with toxic compounds than plants without toxins on BCI? Is the poison in plants always deadly?"

I think there are more plants with toxins than without, but I don't think anybody knows this for a certainty. We would need to do extensive testing on thousands of plant species to answer that question definitely. When we were on BCI in January of 2000, scientists like Dr. Lissy Coley and her student Jonathan Gonzalez Santo were studying the chemistry of many plants on BCI to find out which ones might offer a set of cures for various types of cancers and other disorders. The toxins in plants are not always deadly. A plant chemical, like any drug, can be poisonous in high doses, but can be beneficial in small doses. Some plant chemicals act like hormones and may prevent caterpillars from pupating into adult butterflies or moths. Some retard growth of insects. Some can be used in small doses to cure diseases in humans and other vertebrates, but will cause death when taken in large doses.

Plants produce many very complex chemicals – they are masters at chemistry! So we need to use what plants produce – but we know very little about these plant toxins. It's important to know why plants produce these toxins – what do they do for the plants – why they go to this trouble to produce these chemicals that are poisons to humans and other mammals and insects (if eaten in large doses). If we can answer these questions by finding out what eats these plants, it can put us on the path to knowing how to use the plant toxins to our benefit.

"What foods are on the trail that you can eat?"

Monkey plum is OK, but not much else.

"Do you have any natural water slides on BCI?"

In the rainy season some of the steep trails are like water slides, but too rocky to be fun!

"We can't believe you don't wear rain gear when it's raining! While we were searching the web we discovered that Panama's temperature is between 72° and 90° F a day, while BCI is between 72° and 86° F, and the cloud forest in the mountains has temperatures in the 50's, even when the sun is shining. Why is it so different in each of those places?"

If we wear rain gear, we sweat so much that we might as well just get wet in the rain. In fact that's much more comfortable. (After all, the howler monkeys just sit in the rain and take it – with some howling, of course!) As for temperature differences within Panama, you need to think about Panama City, with lots of buildings and concrete pavement, and car exhaust fumes and thick smog. That's where the temps get very high. Then think about how much colder the hilly parts of your own home state are, compared to the lower areas in the winter. Well, the highlands of Panama go up to something like 11,000 feet an altitude – which makes a big difference in temperature. These gradual changes in temperature with increasing altitude are called an altitudinal gradient.

"What is the highest temperature in the rainforest?"

On BCI it hardly ever gets above 84° F in the forest, except in big treefall gaps where it can be in the low 90's in the sun.

"Since you can't wear any heavy clothing what do you use to protect yourself from hidden animals, insects, and snakes when you're walking through the forest?"
We protect ourselves from insects and snakes by wearing boots with our pants tucked in the tops. And we try to stay alert: avoid walking under an Azteca ant colony hanging from a tree trunk, or standing in the middle of a column of marching army ants, and don't grab a tree trunk without looking first, and basically watch where we put our feet. And we rarely sit down on the ground – ticks and chiggers will quickly find you. It's better to sit on a fallen tree trunk or rock, but even that may be somebody's territory. If we know we'll be hanging out in the same place to observe animals quietly, then we bring a poncho to put down so we can sit. However, there are people who wear shorts and sneakers in the forest, but they are lucky to be rather more immune to chigger bites than we are. BCI is certainly a friendly forest compared to others in the tropics. We saw only one snake on BCI the entire trip this year [2000], and I was stung only once by a small ant. In Africa, we have seen many more deadly poisonous snakes than in Panama. We found land leeches in Australian tropical forests to be very painful and really disgusting – much worse than chiggers or ticks. Some leeches were small enough to squeeze through the cloth of our socks, and formed little bloody rings around our ankles.

“We learned that on BCI the rainy season is from mid April until mid December. Is that why you make your journey there at this time? Is it easier to do your research at this time?”

Yes, it is easier to do the mammal census in dry season, and also, many species start their breeding season then; and it is the end of the seasonal fruit shortages, so many mammals are hungry and easier to trap than at other times of the year.

“Will you ever miss a year in the rainforest? If so, why?”

Greg and I led an Earthwatch expedition to Costa Rica one year to study Mountain Squirrels. This was instead of going to BCI. Another year we returned to Costa Rica instead of BCI. And one year I didn’t have the money to go anywhere!

“Would you ever like to relocate to BCI on a permanent basis?”

That would be something I'd like, although maybe not all year long. However, nobody lives on BCI permanently: it just isn't permitted by the Smithsonian. Some scientists have been resident researchers for several years, but not permanently. You can't just build a house or buy one on BCI.

“How do you survive with only one TV on the island, in a community type room?”

Many of us on BCI don't usually watch TV when we are here – there are too many other interesting things to do, including catching up on the lives of old friends who are other scientists visiting at the same time we are on BCI. Greg and I know some people who have been visiting here for the last 20 to 30 years. Our visits are often very social events. Imagine if you knew people you liked very much but who lived hundreds of miles away and you got to see them every winter in a lovely tropical place?

“What’s the funniest thing that has ever happened while you have been in the rainforest?”

A male tamandua mistook me for a female tamandua, left his girlfriend alone, ran right up to me, and tried to follow me home!

“How do you protect yourself from the fungus growing on you?”

We protect ourselves from fungus by washing with soap, by drying off after washing, and by putting anti-fungal powder in our boots. We are careful to change our socks every time we come in from the field, and to wash socks and other clothing in strong detergent with hot water (we are lucky there are washing machines and dryers at this field station – this is a great luxury). We have electric boot dryers, which we put into our boots at night to thoroughly dry them before we go out in the morning.

“Have you discovered any new species since you’ve been on the island?”
Greg and I have not discovered any new species, but people who study insects and lizards have found some. These groups of animals are not well-studied, which means there are often species previously unnoticed that a careful observer might be lucky enough to find.

“Do you ever go off the trail?”

We certainly do go off the trail. When we check trees for their fruit crops, we have to go off the trail and walk around under the trees. Also, we have followed deer off the trails to see where they feed and sleep. When we had radiotransmitters on squirrels, I used to follow the squirrels wherever they went: down ravines and up the other side, zigzagging around in areas where palms have fruit, or building nests in several trees. This gets tiring because much of the terrain on BCI is hilly, and to get from one point to another, you usually have to do a lot of up and down in steep ravines, where climbing is slippery and rocks tend to slide. Then it's also difficult to look out for stinging ants and wasps and potentially poisonous snakes.

“Have you ever been lost in the forest?”

Not on BCI; there are lots of trails and markers on them. But I did get lost in a forest in New York – at night and carrying a ladder – because I was looking in tree holes for flying squirrels and not watching where I was going. I found a trail after about an hour.

“How did you get into the work that you do as a researcher?”

I liked being outdoors to study animals – frogs, lizards, salamanders, birds, mammals – in their natural habitats. So I studied animal behavior and ecology and evolution in college, and did my doctoral research on wild flying squirrels on Long Island. Then I went as a tourist with a friend – Pat Detamore’s daughter Bobbie – to Panama and had to go back again and again!

“How did you first find out about BCI?”

My advisor in college had been to Panama and he told wonderful stories about his visits to BCI. So I couldn't wait to go! [But first] I had to find a way to pay my airfare and get permission from the Smithsonian to visit. That came years later.

“When did you first start going to BCI?”

My first visit to BCI was in 1974 when I went with my friend Pat Detamore, who lived in the Canal Zone at that time. I went back almost every year after that, sometimes twice a year.

“How long do you stay in the rainforest to do your work?”

We stay four to six weeks.

“There is so much advanced technology available now – how come you don't use infra-red video cameras that require no light, or other forms of the latest technology?”

The answer is simple: NO MONEY! It's very difficult to get funds to do the kind of work we do. And the latest technology is extremely expensive. We spend our own money for the cameras that we have. Greg and I both have jobs other than what we do on BCI. Greg has no income while we are on BCI; and I use my vacation days to be there. I have no time to write research grant proposals because I am already busy writing proposals on my job for science education. We get a little funding from the Smithsonian to pay Greg's airfare and room & board on BCI – and Montclair State University is doing the same for me. The video cameras cost lots of money; but they would be really great to have! Or just having another few cameras like the ones we already have would help. It's very important for a scientist to be a good writer, to get grant funding for research, but sometimes even that isn't enough.

However, in 2001 we actually did have an infra-red video camcorder for field-testing. The company that makes the still cameras we use, CamTrak South in Georgia, has designed a video camera that will automatically film passing animals in total darkness using infrared. They generously gave us an opportunity to try the camera in its
waterproof container on a trail on BCI. We placed the camera where we had obtained the most interesting still photos. Because the video camera requires no flash and is extremely quiet, it is less disturbing to the animals. We hope to get some information about the normal behaviors of some of the very elusive species that share the trails with the people on BCI.

“Is the rainforest scary at night with all those strange noises?”

Some nights are quiet and that's not scary. Some nights are noisy with kinkajou's calling and that is like finding old friends. Kinkajous are very beautiful and we love to watch them feeding on nectar and fruits in the treetops. Some nights we hear loud and mysterious calls that we can't identify, and that can be scary. We are always looking to see if we can find a puma or a jaguar, but have so far seen only ocelots at night.

“Is it too noisy at night to sleep?”

Sometimes the howling of monkeys in the middle of the night wakes us, but otherwise I usually sleep well with the sounds of insects and frogs singing. The scratching noises of bats and opossums in a roof or attic can be annoying, however. And we also once lived in a house under a fruiting tree that dropped football-sized fruits onto the roof. They would hit the metal roof with a great boom, rattle while sliding down the roof, crash into the undergrowth, and then provide a feast for pacas. Pacas are territorial; and they would fight over the food, making loud noises like people laughing at a big party. That was very hard to sleep through.

“We are studying animals right now and beginning to look at animal adaptations. Can you give some examples of adaptations that you see?”

Check the mammal species profiles – you will notice lots of adaptations, from the hook-shaped claws of sloths and the gnawing incisors of squirrels to the bacterial fermentation used by howler monkeys to digest leaves.

“We have discussed a little bit about animals that develop in isolation and how those animals begin, over time, to differ from a common ancestor, and eventually each other. The large flightless birds are one example. Since animals on BCI have been isolated from others since the canal was built, has there been any evidence of changes among species on the island as compared to those on nearby islands or the mainland? Or, is the process of evolution too slow to really see anything yet? Or, is this not likely to happen for some reason?”

The species on BCI are not totally isolated – many species can and probably do swim or fly across from the mainland, making it difficult for a BCI species to become much different from those on the mainland. The isolation might be sufficient for some species, but we have no evidence yet of new species on BCI. The process often takes much longer than the 90-year time span since the Lake was formed. Severe El Niño effects might provide a change in weather sufficient to select out – kill off – many individuals of a species, leaving only those who have very useful adaptations in difficult seasons. The studies have yet to be done to show these changes in species on BCI. (See the work by Peter and Rosemary Grant in the Galapagos Islands described in the book by Jonathan Weiner, “The Beak of the Finch.”)

“Speaking of adaptations, we heard of some people suggesting that an animal in the US (snakes) that lived in an area where it was in danger of losing its habitat, due to building, be moved to an area where others of the same species may live, or moving the animal to an area with similar climatic conditions.”

Moving snakes can be difficult if they require winter hibernation dens – they have to find appropriate places to spend the winter and usually have traditional dens that have been used for many generations. Also, what people might regard as good habitat for snakes is not necessarily so for that species – we are not the best judges of habitats.

“We have heard that animals in the rainforest are so highly specialized that several different species may be found in only one small section of the forest. Could animals from one rainforest, or part of a rainforest, be moved to another rainforest or even another part of the same rainforest if the climatic conditions were the same? Would this be a good solution to the habitat destruction that we hear about?”
Probably not – as you have indicated, many species have their own well-defined niche as well as a specific habitat. If you move them, then they have to deal with new conditions and new neighbors – very often they don't live at all. Or they might bring new diseases to the new habitat that kill off other species and cause new problems! For example, moving squirrels doesn't work well because they are rather territorial and have to fight with a resident squirrel in the new location in order to settle into that site. And many squirrel species tend to go home if they are moved – or at least die trying to get home.

“In the rainforest, do you think there is a giant ground sloth still living there?”

No, I don't think so. Some people specialize in looking for “extinct” species and a few people do believe there are some species left over from the distant past, still living, that we have overlooked somehow, and that this is one of them. There are plenty of other species, especially insects and plants, that have yet to be discovered, and hopefully, will be discovered before they become extinct.

“The most unusual behavior you have observed is....?”

The most unusual behavior I have ever observed was a bower bird in Australia constructing a small building of sorts – his bower – that is used to attract females. This bower bird had built up a small area about one foot square with upright dried twigs and grasses that he stood in an arrangement to make a room. And then he had decorated by gathering everything blue he could find – plastic straws, bits of candy wrappers, a girl's barrette, some plastic toys, cellophane, blue toothpicks, and so on. All these blue things were stolen from the nearby campsites in the park where the bird lived, since trash was kept in tightly closed bins. I never found out if a lady bower bird appreciated his sense of style and the bravery it took to collect all his treasures.

“Do the animals allow you to touch them as on the Galapagos Islands – feed them?”

Some of the coatis like to beg for food, and would take food from your hand if offered, but you can't touch them because they are still wild, and you could get bitten. The kitchen staff used to feed the leftovers to tapirs and monkeys and coatis and pacas, and then you could touch the tapirs, but none of the others. The tapirs had lots of ticks and must have itched, because they loved to have their hides scratched. They would also roll on their backs so you could pull off ticks, if you wanted to. Some of the coatis ate the ticks off the tapirs. A 500-pound tapir rolling on its back like a big dog is pretty impressive. Otherwise, the animals were pretty wild.

“What rainforest animals are endangered species?”

Many species of rainforest organisms have probably become extinct without our ever having been aware that they existed in the first place. The most obvious endangered species are the bigger animals, or the prettier ones, like tamarins and ocelots and jaguars or parrots of many species. But there are many secretive forms, such as frogs, that have disappeared or are nearly extinct. And we should worry about plants, from little ones to trees, as well as fungi (not really plants) and mosses and their relatives. It’s probably smarter to think in terms of entire habitats and to worry about what happens when a habitat disappears, because then entire ecosystems go too!

“What endangered species do you see at BCI?”

We saw an ocelot one night! Ocelots are pretty common on BCI, but there might be less than 20 of them on the island. They are definitely endangered outside of BCI. We also see various large predatory birds – Greg saw a crested eagle – and small ant-following birds that are endangered. All frogs are now endangered by a mysterious fungus disease that is wiping them out in western Panama and in other countries. The list is very long!

“Are ocelots endangered because they're hunted for their fur?”

Yes, there is evidence that people are still killing thousands of ocelots every year in South America, for their fur. But again, if the forests disappear, then there will be no place for ocelots to live, even if the hunting stops. When Greg and I were in South Africa last year, we stopped in some gift shops in the Johannesburg Airport and were saddened to see great piles of caracal hides for sale. Caracals are ocelot-sized wild cats that have tawny fur.
and long pointed ears with black tufts on the end. They are very elegant, sleek long-legged cats, and we were able to see only one alive out on a savannah, after much searching by local guides. This sort of hunting goes on in many parts of the world.

“Are the animals we just mentioned endangered all over the world or just on BCI?”

The animals that are endangered on BCI are also endangered all over the world. The more people use trees from forests to build, and the more they cut big areas of forest into little areas, the less habitat there is for the native species. Habitat loss, sometimes more than hunting, will cause extinctions of species.)

“Do you have any rainforest animals as pets?”

No, I don’t. I don’t like to encourage the pet trade in rainforest animals. They should stay in their natural habitats.

“What is everyone’s favorite rainforest animal? Why do you like that animal so much?”

I don’t know that there is a favorite — maybe sloths? They look like they’re smiling. Maybe spider monkeys?

“Are some animals cute?”

You betcha! The tamarins, hummingbirds, red-eyed tree frogs, and lots of others are very cute! One of my favorites might be hummingbirds. I found a nest one day, and the female hummer tried to divert my attention as I accidentally passed too close to it. She flew at my face and stared straight at me, hovering in midair, and buzzing her wings loudly. When I looked around, I saw the tiny (5-centimeter or 2-inch diameter) nest, woven of spider webs and lichens on a high shrub.

“Which animal do you think is the most unusual?”

Silky anteaters are the strangest. They are tiny — fit in my hand — anteaters that live on thin lianas and eat mostly termites. Their tongue is long and thin and pink. They have golden silky fur and hooked claws for grasping, and tiny eyes. They sleep all day curled in a ball and move around at night.

“Do silky anteaters have prehensile tails? How about night monkeys?”

Silky anteaters have prehensile tails, but neither night monkeys nor tamarins do.

“What is it like to catch an animal in a trap?”

Read the episode called “Trapped!” Jane wrote about how we do it and why. I would add that it's very exciting to check the traps, never knowing what got caught. You get to see and touch animals that you have only seen from afar with binoculars. And when they are released, you might learn more about where they nest or what they eat, and eventually how long they live. I just don't like to scare the animals, and really hate it when a squirrel starts to whimper in fright. They don't all get frightened; some just sit in the trap and eat the bait even while we are carrying the trap through the forest to the lab! I also don't like it when the more experienced ones try to bite us: the squirrels have really big teeth.

“How does the red-tailed squirrel behave during different times of year?”

In the times of scarce food, they move around a lot searching for food. And females become very protective of their food sources and fight frequently. During December and January there are many courtship chases and the males fight to be near the females. In the time when females have young in their nests, the females are very secretive. When the young come out and follow their moms, there is lots of squawking at predators to warn the families.

“What effects do each of the seasons (Rainy and Dry) have on the behavior of the squirrels?”
The abundant fruit in the early half of the rainy season provides good conditions for raising young squirrels and weaning them to solid food.

“Do birds in tropical forests eat different types of food than birds in deciduous forests? If so, what are the differences?”

I don't think one could say that tropical birds eat different kinds of food from birds that live in temperate areas – they all eat categories of food that are pretty much the same: insects or fruits or nectar or other birds or small mammals or carrion. The specific prey species are different, but the broad categories are similar. You might want to look at specifics within the categories, such as insect-eating birds that feed by picking at tree bark (such as tree-creeper), or catch insects in flight (such as fly-catchers), or follow army ants to get their prey (the ant-birds and their friends). You'll find some interesting specialists in the tropics that don't exist in temperate zones.

“Do fruit bats eat a variety of fruits or are they selective? If so, what fruits are in their diet?”

Fruit bats on BCI eat lots of fig fruits, but there are many species of figs and different species of fruit bats tend to specialize on particular fig species. The bats are important dispersers of fig seeds. With over 65 species of bats living on and visiting BCI, there is quite a lot of variety of lifestyle – bats tend to specialize on particular kinds and sizes of food, which for different species can be insects, fish, frogs, fruits, nectar, and so on.

“What types of seeds do pacas eat?”

I don’t know that they eat many seeds. Even though their teeth are large and they have chisel-shaped incisors like squirrels do, they seem to prefer soft sweet fruits. They used to like to eat the leftover fruits and cooked rice that the kitchen staff threw out to the animals. In the night, when pacas are actively roaming around on the trails of BCI, I have never heard the sounds of a paca gnawing on a hard seed coat. Not the way squirrels, agoutis, and spiny rats gnaw. I have found them eating jack fruit, for example, and fighting over the fruits as they fall out of the tree. I believe they also eat the soft, sweet pulp that surrounds the seeds of Gustavia, mamey, black palm, and royal palm.

“Do tapirs eat algae on rocks in the river? I know they like to be in the water sometimes. When do the babies change from spotted to all gray? Can a mom tapir ever have twins? How long between babies? Do you know what color their eyes are?”

Tapirs love to cool off in water and to wallow in mud. The mud probably protects their skin from mosquito and fly bites. I have not heard of tapirs eating algae off rocks, but that doesn't mean they don't do it. They eat quite a variety of leaves in the forest and along the edges of the lake and streams. They change from spotted to all gray sometime toward the end of their first year – at least that's what I recall from knowing Alice's babies. They ought to be able to have twins, but I have never seen any twin tapirs. The moms appear to have babies about once every year and a half or maybe two years. Alice and her babies had dark brown eyes.

“How come when basilisk lizards run, their feet move out to the sides in a funny direction? What do they do in the dry season when the creeks dry up? And can they move their crest up and down or spread it out?

Lizards generally run the way that basilisks do, with their legs sticking out from their bodies. This is different from the arrangement in mammals and birds, which have their legs tucked under their body. Lizards evolved before mammals and birds, and run the way salamanders do. It isn't very efficient, but it works well for small, lightweight animals. Crocodiles and alligators are considered more advanced than other living reptiles and probably are related to birds and dinosaurs. They pull their legs in under their body when they are going to move fast, and they can really move! Basilisks walk on land and climb in trees like any other lizards, taking to water only if they have to. Their crest moves like a little fan. When they are frightened and feeling shy, it collapses down on the neck and isn't very obvious. When they feel tough and bold or are trying to impress another lizard, they raise the crest.

“Are crocodiles a rare species on BCI? Are there more crocodiles or alligators on BCI? How big can they get?”
Crocodiles are very common there. They are American Crocodiles. There are no alligators, but there are caimans. We often see both crocodiles and caimans, and they all look like logs most of the time. They are in the lake and on the shores, and the caimans are also in ponds on the island. The largest crocodile we have seen on BCI was about 17 feet long.

“What is the most poisonous animal you deal with?”

The most poisonous animals I deal with are coral snakes. All I do with them is gently and carefully move them out of harm's way, such as when they wander into a building or onto a busy trail, where they might get stepped on. I use my foot – covered by a high boot – or a stick or a pail to move them, not by bare hands. Anything more dangerous than a coral snake (like a Fer de Lance), I just leave alone. I don't deal with it at all. I just mind my own business and watch where I walk! I also walk away carefully and swiftly when I find “killer” bees or wasp nests. When attacked – which is almost never on BCI – I run real fast!

“How big can the snakes get in the rainforest?”

I have read that anacondas in Brazil can grow to 29 feet in length. We don’t have any on BCI, but I once saw a snake on BCI – possibly a Spilotes, - that was about 11 feet long. I have not seen any larger than that.

“Do the cats on BCI act differently than in other places they can be found?”

We don't think so, except that there are many individuals in one small area and they seem to manage to avoid each other.

“Do you have a favorite big cat? If so, what is it? Are big cats common in Panama? Why are they so hard to find on BCI?”

Big cats are hard to see on BCI or anywhere, because they are either cautious or they are dead. They are still hunted heavily in most parts of the world. They can walk quietly even on dry crackly leaves. My favorite species is the jaguar. Greg saw one years ago on BCI, someone else saw one a few years ago, and someone else last year [1998]. They don't seem to stay long on BCI, perhaps because they have to leave the island to find a mate; and we never seem to have two at the same time. They have to take a long swim to get to the island, so perhaps not many jaguars are willing to do that. There used to be several pumas on the island, in the 1930's. I don't know why they disappeared, except that their favorite prey, peccaries, went into a decline at that time; and the white-lipped species became extinct on BCI. There are still many big cats in Panama, but many is not good enough when they get killed young and don't get to reproduce enough to maintain their population. There are jaguars and pumas in Panama.

“What types of rodents do pumas eat?”

Pumas probably eat some pacas, agoutis, and spiny rats, but they seem to prefer peccaries and brocket deer. Just before we left BCI at the end of one visit, we found four carcasses of small peccaries that were in different stages of decay, and were all located in a fairly small area. One was inside a standing tree that has a big hollow base, and two had been dragged into a very large hollow log. The last was freshly killed and right outside that same log. We don’t know of any other way those dead peccaries would end up where they did, unless a puma moved them. Pumas like to stash a carcass when they can, if they can’t eat all of it at once. The trouble with storing carcasses on BCI is that there are so many scavengers and decomposers, a carcass is usually reduced to bones in about 24 hours.

“Where do you get your drinking water from?”

Our drinking water is from Lake Gatun. It is treated with chlorine (just enough to kill off most pathogens) and we sure hope this doesn't eventually cause cancer. But then many water supplies in the U.S. are treated in this manner.
“What would happen if the water level dropped too much? We predicted a restriction in the sizes of boats allowed on the canal if the water level dropped to a point that the biggest boats might scrape the bottom. Are we correct? Has this ever happened before? How low does that water have to drop to get to this point?”

There were already restrictions on ship sizes going through the Canal when we left in February, 1998. The Canal Commission keeps a close watch on water levels and ship drafts so that none get stuck. On the rare occasions that a ship has actually gotten stuck, big dredges had to be brought in to dig away at the bottom of the lake so it could be re-floated. That’s a very expensive operation!

“If the rain forest is in trouble, why won’t more governments get involved to help?”

Money and ignorance: Too many governments are short of money and see fast ways to make a big profit by selling to corporations the rights to mine or log in a forested area. Mining and logging in the tropics usually destroy the entire ecosystem and may make the area unfit for humans to live in – but for a short while a few people get rich on the mined minerals or the lumber that can be sold on international markets. This is very short-sighted because then these resources are used up – and how will the government make more money in the future? Many organizations are working on teaching people how to use rainforests to make a profit, to benefit the people who live there, and to sustain the forest for future use by our children. This requires more research to increase our knowledge of “management” techniques of forests that do not harm the ecosystem.

“Also, who owns the rainforest in Panama?”

Good question! Some is privately owned, and some of these owners are conservationists, and take good care of their habitats – some don’t. Some land is government owned, but may not be adequately protected by game wardens and forest rangers. The area of BCI and its surroundings is highly protected by the Panamanian military and the Smithsonian forest rangers. It must be patrolled every day, otherwise various people find ways to cut trees and to shoot peccaries and deer and other wildlife that can be sold for a high price in the restaurant market in Panama City. That’s a big expense, and the Panamanian government may not have the funds for protecting every forested area under government control. Environmental education will help, as will projects that provide people with jobs that don’t endanger ecosystems.
High Points

Once I asked Greg what he thought the highlights of that season’s stay on BCI were. I think he thought I said “high points,” so he spoke very enthusiastically, and came up with what I sometimes thought was an odd list:

1) Just being back on BCI was wonderful, exciting, like coming home, and full of surprises. The fragrances of the forest, the breezes off the lake, the sunlight filtered through the tree leaves, the songs of birds, all of these and more provided many sensory delights. Of course, there were also the more than 220 chigger bites that Greg got the first day, because he thought he didn’t need any insect repellent. He couldn’t sleep that night what with all the itching.

2) Catching the Fer-de-lance. It really was a big adventure for Greg (and for the people watching), and he formed a bond of sorts with the snake. I’m glad I didn’t witness this event, because it upset me when I heard about it, and afterwards I scolded him for handling the snake, when I thought it could have been shoved into a bucket with sticks, without his grabbing its head. I don’t like anyone taking any chances with a snake as dangerous as a fer-de-lance. But when some people said it ought to be killed, we quietly moved the snake to our office and began to plot a safe place to release it. What he finally did was take it to a trail far from the Lab clearing and away from most of the study localities, and released it there.

3) Help to carry Jackie out of the forest on a stretcher board. Greg really did say this was a high point! Apparently he and the other guys who carried me found this rescue mission rather exhilarating. I found it embarrassing and annoying (that I slipped and messed up my ankle) and a little scary, what with being tightly strapped to the board and unable to do anything but keep my arms out of the way. I am grateful to all of them, especially since I don’t think I had the energy to walk the rest of the way. I am glad that on some level this was some sort of “special event.”

4) Finding a Rufous Tree Rat in its nest was also special for Greg, and for me. I was glad he had the video camera and brought me lots of taped views of the animal so that I could be sure of what it was. I would have been very frustrated that I couldn’t walk out there to see it myself because of my injury if I had had to rely only on Greg’s description. He had looked at the drawings in a field guide and found them not very helpful. Many of these tropical mammal species are not available in zoos or in photos for artists to draw. Museum study skins are often the only materials available, and are not very useful for depicting the living animal. Being able to show each other videos of what we have seen separately in the forest has been a real boon this year.

5) The sloth wars. This is what we called the interaction of three adult and one baby sloth that Greg witnessed, as well as the three male sloths flailing at each other while Jane watched.

6) Doing the job. Greg finds it satisfying that he was able to walk the remaining 65 kilometers of trail census that I was unable to help complete because of my sprained ankle. He finished the data collection of the full 100 kilometers, single handed.

7) Meeting a Nobel Laureate in Physics. Dr. Charles Towne from the University of California at Berkeley, and his family, visited BCI in 2001. Several of the BCI researchers were field guides for the visitors, and Greg enjoyed talking with them about the mammal census. Greg found Dr. Towne a very down-to-earth and approachable person with a genuine interest in natural history. One special thing about staying on BCI is that it seems as if the entire world of scientists eventually comes to visit BCI. If you stay there long enough, you will meet almost everyone!

8) Exploring the lives of cats, both ocelots and pumas, through the camera study on BCI. We sent one of our cameras with Ricardo Moreno to the mainland peninsula called Buena Vista, and he set it up near where he found tracks of ocelot. Ricardo was asking where the pumas on BCI might have come from, since they must swim over from the mainland. We thought that Buena Vista might be a good possibility because there were recent puma tracks on Fairchild Trail on BCI, just opposite Buena Vista. The first roll of film from the mainland on Buena Vista had an ocelot photo, but no pumas. Unfortunately, that camera quit working after two years out in the forest. We sent the old cameras back to CamTrak for repair. Two years of exposure to high humidity and some rain when they were opened for a change of film led to clouded lenses (there is a fungus that grows on glass in the tropics and causes
permanent damage) and electronics that don’t work consistently. But we set up our last two working cameras on Fairchild Trail, one camera on each side of the trail so as to get both sides of the cats (so helpful in ocelot identification).

9) Bonifacio bringing in a silky anteater (*tapicara*) for us to photograph. We always enjoy talking with Boni about his experiences, and it’s a pleasure to see his own satisfaction at being able to find those tough-to-see species.

10) Testing an infra-red video camera in the forest. That got us some video clips that show how great the system is and what it can do in dry weather. Now it needs to be set up for surviving drenching rains.

So, that’s Greg’s list.
Rainforest Connection in the Classroom

The Rainforest Connection e-mail reports were intended as classroom aids for science classes in both elementary and middle schools. I was gratified to receive the following letter from a teacher in New Jersey:

“The Rainforest Connection is an integral part of my reading, writing, and science curricula every January and February. From its inception in 1997, each group of students has been enthusiastically involved, following the research and adventures of Jackie and Greg Willis. I am a looping teacher, which means I have the same group of children for two years – fourth and fifth grades. How I use the messages and web site each year varies, depending on the group of students.

“This year [2000] was unique, as there was a lot of public interest in Panama right before RFC began, because of the turnover of the Panama Canal. Although I am currently teaching fourth grade and this is the first time my students have been introduced to RFC, they were aware of that news event and had read a ‘Time for Kids’ article on it right before the holidays. So this group, unlike previous fourth grades, possessed prior knowledge about Panama and its location.

“I introduced the project before ever receiving the first e-mail message from Jackie, January 6th. We started with a predicting lesson, what the children thought they knew of Panama – its location, its climate, its landscape. Then the children spent time in the school's computer lab, surfing the RFC website, before brainstorming as teams, what they'd like to learn about Panama and BCI. They also saw clips from the Scientific America program, ‘Expedition Panama.’ By the end of the first week of January, student teams had selected topics of interest for themselves and their first messages to Jackie reflected those topics.

“Throughout the RFC each team of students has maintained focus on their research topic, while enjoying the general entries sent from Jackie. As a class, we have read and enjoyed each entry, discussing them at length. At the same time, student teams have taken useful information she provided for their research projects. They have also used the RFC web site, other Internet sources, and books to gather information related to their topic.

“They will not, however, be writing a ‘research paper’ with this project. That will come later in the year or even next year, after they've had more practice developing questions, finding information, and taking notes. For this project they will each create a ‘postcard from Panama,’ pretending they are on BCI with Jackie, writing home to a friend or family member about their research topic.

“At the fourth grade level, I believe research should be an evolving, incremental process. Because I have the same group of children for two years and they will be conducting extensive research in fifth grade, process is much more important to me than product. As a teacher, my focus with RFC this year is for my students to develop questions that will guide their research and direct their learning in a manageable way. I also expect them to be able to take notes, finding the answers to their questions. My hope is that next year, when they select a research topic, they will be able to delve deeper, conduct meaningful research, and develop a product, such as a news article, that they will be able to publish and display at the school's writing fair.”

I was happy to hear that this 4th grade class’s writing projects were to be incremental in development, and that “process” would be learned before the “product” was scrutinized. I too don't believe that a paper in 4th grade is a good idea, since children at that age have yet so much to learn about organization and focus. I loved the postcards from Panama idea!

Some students might be surprised to learn that when I write my journal entries, I usually start with some free-writing about my experiences and thoughts. About three-fourths of this is never seen by anyone else. I take what I've written and choose an interesting paragraph or even a few sentences, and then I build a focused journal entry centered around that piece. I don't use outlines, and I don't usually start at what will finally be the beginning. I start with a kernel or crystal, and let it grow out from the part I like best.
I think that teaching writing by starting with an outline is not really very helpful. I believe that's best used much later, for large papers that are difficult to organize and bring into focus. Developing focus is difficult even in one page, but it needs to be learned first in short pieces before an entire paper can be written. Of course, there are also some stories that almost write themselves, but that doesn't happen every time.
Some Letters From Students

Dear Dr. Willis,

I really just want to thank you for helping me with my research and postcard. I wish we could spend a lot more time learning about the interesting facts of Panama. I bet you have so many stories. There are so many other topics to learn about Panama, not just plants, mammals, birds, and weather. We barely even touched on the very fascinating facts about the Canal. I wish you could stay there a year, so we could learn about Panama all year long. This was a great project. I hope we can write and be e-pals with you through your next journey.

--Your rain forest friend, Lindsay D

Dear Dr. Willis,

How are you doing? I hope you know, I was totally sucked into the Rainforest Connection!!! Every time Mrs. Macht would tell the class we were going to your web site, I was like dynamite wanting to blow up with excitement!! I really like the title, “The Rainforest Connection.” It makes readers like me want to explore the site. The pictures you added were just superb! I think the Rainforest Connection was really great idea. It's valuable for small kids and older kids, too. Now, that's what I call great ideas in science!!

--Your amazed pal, Grace H

Dear Dr. Willis,

Thank you for all the entries you sent my team and me. I really liked the one when you described how muddy it was on BCI. It gave me an excellent picture in my mind. If it weren't for you, I would have never been in this unit. I bet you would be an excellent teacher, too.

--Your student, Wayne H

Dear Dr. Willis,

It has been a really great honor working with you on the Rainforest Connection. You gave me a lot of suggestions on what kinds of animals to research. Then you gave me information on sloths. Also, because of the web site you suggested, I gathered even more information on sloths. Thank you so much!!!

--Sincerely, Mark Q

Dear Dr. Willis,

How was your trip to Panama? I heard it was WONDERFUL!!! The Rainforest Connection project was GREAT!!! I learned so much ... there is no more learning space in my head! The web site you sent us to was awesome!! There was so much information, it wouldn't all fit in my folder. The pictures especially were so cool. Every time I saw one I said, "WOW!" Did you see the humongous crocodile or was it just Greg? When Mrs. Macht read that entry to us I imagined myself in Greg's spot. You gave such a clear picture. Once again, I hope you had a great time in Panama and the RFC project was awesome!!!!

--One of your students, Ishaan K

Dear Dr. Willis,

THANK YOU so much for the Rainforest Connection! I appreciate all of it. The postcards we're creating are looking great! If you were here right now, you would just love how they're turning out.

--Adios! Monica V

Dear Dr. Willis,

WOW!!! I really enjoyed the Rainforest Connection. You should be very proud of yourself. I could not have done my project on Harpy Eagles without you. . . Thank you again for helping me on the Rainforest Connection project and for the learning experience. Now I know what a Harpy Eagle really is!

--Your Rainforest Connection partner, Heather N

Dear Dr. Willis,
...I loved the Rainforest Connection. I have learned so much about silky anteaters. Before this project I never knew that they are nocturnal and grow only to be 13 inches long. I also didn't know what were their enemies, or that they prefer to sleep on the ground or in holes of trees...

--Your friend, Sharon S

Dear Dr. Willis,

Thank you for all the great information in the Rainforest Connection. I loved the entry, “A Snake in Hand.” I totally did not know that fer-de-lances were thought to be extinct on BCI. That must have been a real surprise! Thank you again.

--Sincerely, Casey L

Dear Dr. Willis,

...Was Panama awesomely cool? Did your camera get all yucky? I bet it did! ...How different is Panama from Florida? Does Panama have manatees or pelicans? I doubt it...

--Your student, Kristine P

Dear Dr. Willis,

Thanks so much for doing the Rainforest Connection with us. I really had a terrific time communicating with you. From your messages I learned a lot about T-species and the animals our group chose (mine was the fruit bat). I also hope you had a great time in Panama. I still have one question. Do you take census for other kinds of animals, like amphibians? [No] If so, when was the last one you took? I also want to know if you will be going to Panama and doing the Rainforest Connection again next year? I hope so! [I hope so, too.]

--Sincerely, Alyssa P

Dear Dr. Willis,

Hola, from Room 209! ...Thank you very much for sending us information for our research projects. It helped us a lot! The information was so useful for creating our postcards. They turned out fabulous, thanks to you! I bet the whole class will join me in saying, THANKS A BUNCH!!! Adios!

--Sincerely, Ellisa S

Dear Dr. Willis,

I had a great time working with you on the Rainforest Connection. I bet next year will be even better. I sure did learn a lot from this Rainforest Connection. I learned some very interesting facts. Unfortunately I cannot remember them all. The first one was that the amount of rain BCI receives in a year is 264 cm and 238 cm falls during the rainy season alone. Another fact I learned is that in the dry season BCI receives less than 10% of the annual rainfall. The most important fact I learned is that the Rainforest Connection is fun!!! I have to say it again, the Rainforest Connection is so much fun. ...I really hope I can see you soon so I can learn even more.

--See ya, Alex M

Dear Dr. Willis,

Thanks so much for sharing your experiences in Panama with our class. The info was wonderful. We put it to good use, by sharing it with our families on postcards. I wish I could really come along to see Panama for myself. I would love to see the beautiful wilderness. The information and pictures created a mind-bubbling place in my head. A place of wonder! To be in Panama, in the forest of BCI would really help me to understand the loss of rain forests and the creatures in them. Just learning about five species helped me to understand more. To think about hearing of a rain forest cut down ... then later, hearing that the sloths, bats, silky anteaters, ocelots, and night monkeys that were there, are no more ... I would be miserable for days.

Thanks again for the info about BCI. It changed the way I look at rain forests forever!

--Your scientist, Jessie S

From JACKSON ACADEMY:

“Monday proved to be quite an adventure for us. So much discussion was going on in the classroom. Wow! What an experience! [We] knew this connection would be exciting but you would of thought we were there on the BCI with you. Research started right away because the students wanted to find answers to your questions.
Out came the maps, books, videos, and anything else we could get our hands on to learn or review. Students worked in groups and presented their findings or raised questions about their concerns. This is what they learned today:

1. The Panama Canal is a great water tollway, often called the “Big Ditch.” It links the Atlantic and Pacific Ocean.
2. The fame of the Panama Canal is not its size. It is only 50 miles long but it is an engineering triumph over nature.
3. To build the canal, engineers had to remove 95 million cubic yards of earth. It took 10 years to build.
4. The first two years of canal building were devoted largely to clearing brush, draining swamps, and cutting out large areas of grass where mosquitoes swarmed. We found through our research that disease was the greatest obstacle to building the canal.
5. The Panama Canal Locks take ships up the side of a hill and down again. They are built in pairs for two-way traffic or sometimes parallel traffic in the same direction.
6. Gravity helps the locks work. The water flows by the force of gravity from one chamber to another.
7. Enormous quantities of water are needed to keep the Panama Canal locks operating. Lockages required for the canal journey of a single ship release about 52 million gallons of water into the oceans.
8. We also learned that the tops of trees and hills jut above the water now because engineers flooded the valley to create Gatun Lake. There is also a special hyacinth patrol that destroys more than 42 million plants a year to keep the channel clear from coarse stems that may become tangled in ship propellers. (My students were concerned about this.) [It’s a constant problem to keep boat propellers clear of aquatic weeds. A friend of mine who is a biologist works for the Aquatic Vegetation Office of the Panama Canal Commission.]

“As you can see, the students have been busy! The more they learn, the more questions arise. We will continue to think and learn.”

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Students had questions about the history of the Panama Canal and Panama City, so a friend who lived many years in Panama, Mrs. Pat Detamore, assembled some facts for them:

The Panama Canal
The official opening of the Canal was Aug. 15, 1914, with the transit of the SS Ancon. (The SS Cristobal went through 12 days earlier, unofficially.)

The first American workers began to arrive during 1904-05. During the first 8 months about 600 Americans were employed; by the end of 1905, about 2,000. Only 359 Panamanians worked on Canal construction from 1904-1914.

A pre-Panama Canal was in use in Colombia in 1788.

The first commodity to transit was sugar, on barges towed by the tug La Boca on May 18-19, 1914.

The Queen Mary, a British passenger liner, launched in 1936, was the first ship built too big to transit the Canal.

Canal transits totaled 100 in the first week of October 1914. And total tolls in the first six weeks were $369,706. Total transits for 1944 were 5,130. Total transits for 1969 were 14,609. The number of transits has continued to grow every year.

Panama City
Panama Vieja was the first city founded by Europeans on the Pacific Ocean. Its founding ceremony was held August 14, 1519. Official recognition was given by Charles V of Spain on Sept. 15, 1521. The town was called “Nueva Cuidad de Panama.” By 1541 the city held 112 houses and some 4,000 inhabitants.

Henry Morgan captured Panama City in 1671.
Mammal Species Checklist
for BCI

* = probably not on BCI now, although a re-population is possible

MARSUPIALIA (Opossums)
- Caluromys derbianus - woolly opossum
- Marmosa robinsoni - pygmy opossum
- Philander opossum - gray four-eyed opossum
- *Metachirus nudicaudatus - brown four-eyed opossum
- Chironectes panamensis - water opossum
- Didelphis marsupialis - common opossum

EDENTATES (Sloths, Anteaters, Armadillos)
- Tamandua mexicana - vested anteater
- Cyclopes didactylus - silky anteater
- Bradypus variegatus - three-toed sloth
- Choloepus hoffmanni - two-toed sloth
- Dasypus novemcinctus - nine-banded armadillo
- Cabassous centralis - naked-tailed armadillo

CHIROPTERA (Bats)
See Bats profile by Kalko for names of selected species. There are atleast 120 species in all of Panama, and 70 species have been found on BCI. There are probably more species to be found in the future on BCI.

PRIMATES (Monkeys)
- *Aotus trivirgatus - night monkey
- Alouatta palliata - howler monkey
- Cebus capucinus - white-faced monkey
- Saguinus geoffroyi - tamarin
- Atel es geoffroyi - spider monkey

LAGOMORPHA (Rabbits)
- Sylvilagus brasiliensis

RODENTIA (Squirrels, Agoutis, Pacas, Porcupines, Rats, and Capybaras)
- Sciurus granatensis - red-tailed squirrel
- *Sciurus variegatoides - variegated squirrel
- *Microsciurus alfari - pygmy squirrel
- Heteromys desmarestianus - spiny pocket mouse
- *Liomys adspersus - spiny pocket mouse (arid lands)
- *Oryzomys fulvescens - rice rat
- Oryzomys capito - rice rat
- Oryzomys bicolor - rice rat
- Oryzomys concolor - rice rat
- *Rheomys raptor - water mouse
- *Tylomys panamensis - naked-tailed climbing rat
- *Zygodontomys microtinus - grass mouse
- *Sigmodon hispidus - cotton rat
- Proechimys semispinosus - spiny rat
- Diplomys labilis - rufous tree rat
- Hydrochaeris hydrochaeris - capybara
- Coendu rothschildi - Rothschild's porcupine
- Cuniculus paca - paca
- Dasyprocta punctata - agouti

CARNIVORA (Coatimundis, Kinkajous, Tayras, Otters, Cats, and relatives)
- Procyon lotor - raccoon
- *Procyon cancrivorus - crab-eating raccoon
- Nasus narica - white-nosed coati
- Potos flavus - kinkajou
- *Bassaricyon gabbei - olingo
- Lutra longicaudis - southern river otter
- Eira barbara - tayra
- Felis onca - jaguar
- Felis concolor - puma
- *Felis wiedii - margay
- Felis pardalis - ocelot
- *Felis yagouaroundi - jaguarundi
- *Speothos venaticus - bush dog

PERISSODACTYLA (Hoofed mammals, horse relatives: Tapirs)
- Tapirus bairdii - tapir

ARTIODACTYLA (Cloven-hoofed mammals: Deer and Peccaries)
- Mazama americana - brocket deer
- Odocoileus virginianus - white-tailed deer
- Tayassu tajacu - collared peccary
- *Tayassu pecari - white-lipped peccary

CETACEA (Manatees)
- Trichechus manatus - manatee