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BAT CONSERVATION INTERNATIONAL

ISSUE 3 · 2020
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bats

Saving Malaysia's Fruit Bats

Research group led by former BCI student scholar promotes education and coexistence

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BAT CONSERVATION INTERNATIONAL

Are you a bat photographer?

Bat Conservation International is working to collect images of bats from all over the world and we would love to include your photo in our next issue of *Bats Magazine*. You keep the rights and photo credit. We help archive and share your work. Please submit high-resolution images (at least 300 DPI or 2K resolution) along with specific species information and the photographer's name for photo credit.

To submit your photos, please email **submissions@batcon.org**.

PHOTO: MICHAEL DURHAM / MINDEN PICTURES

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Pale spear-nosed bat (*Phyllostomus discolor*)

Photo: Jose Gabriel Martinez Fonseca

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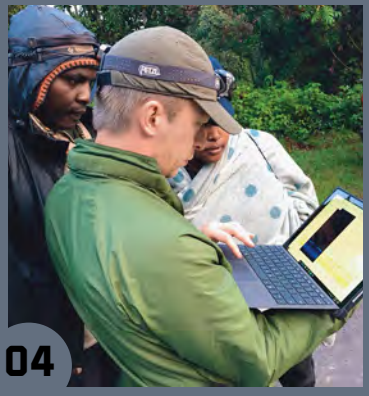

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Photo: Dr. Winifred Frick

ON THE COVER

Protecting Malaysia's bats by providing education to farmers and tourists.

Photo: Sanjitpaal Singh / Jitspics.com

off the bat

A few words of introduction from your friends at BCI

The Future Needs Us All

By Mike Daulton

This Bat Week, we are reminded of the importance of our commitment to bat conservation. We will not back down as long as bats are threatened with permanent, irreversible extinction.

In 2019, Bat Conservation International (BCI), in coordination with Florida Power & Light Company (FPL) and Zoo Miami, opened the first FPL Bat Lab at Zoo Miami. Our goal was simple: to protect the federally endangered Florida bonneted bat—the rarest bat in the United States. Since then, we have made tremendous progress. The 16 custom-built bat houses that we erected throughout urban Miami are now 50% occupied by this bat. We have had the most success on the grounds of Zoo Miami, where our bat houses are 100% occupied. We are deeply proud of this partnership, the progress we are making toward advancing urban wildlife conservation, and the hope we are bringing for the future of this species that is clinging to existence in urban and suburban habitats.

> "Thousands of BCI supporters like you made their voices heard with messages sent directly to the commissioners."

Even with these achievements, our work is not complete. Just recently, a poorly planned and badly sited hotel and water park development, Miami Wilds, has been proposed on the Zoo Miami grounds. In its currently proposed location, this development will eliminate a critical foraging site for the Florida bonneted bat in the Miami-Dade area, pushing it further toward extinction. Tragically, it is proposed directly on the grounds of Zoo Miami where our recovery work for the bat is taking place. It would be awful if the hope we are building for the species would instead be turned into despair.

BCI is making our voice heard, loud and clear, to the developers, the county commission, and others involved in the project. Thousands of BCI supporters like you made their voices heard with messages sent directly to the commissioners. This project directly threatens America's rarest bat with permanent extinction. We will not back down. With your help, I know we can continue to give this bat a fighting chance at survival.

Mike Daulton
BCI Executive Director

Florida bonneted bat

Photo: J. Scott Altenbach

BAT CONSERVATION INTERNATIONAL

Bat Conservation International (BCI) is a 501(c)(3) organization dedicated to protecting bats and their essential habitats around the world. A copy of our current financial statement and registration filed by the organization may be obtained by contacting our office in Austin, below, or by visiting batcon.org.

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Members: We welcome your feedback. Please send letters to the Editor to **pubs@batcon.org**. Changes of address may be sent to **members@batcon.org** or to BCI at our Austin, Texas, address above. Please allow four weeks for the change of address to take effect.

Visit BCI's website at **batcon.org** and the following social media sites:
Facebook.com/batcon
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YouTube.com/BatConservation

BCI 2020 Student Scholar Temidayo Adeyanju collects a bat's measurements in Nigeria.

Photo: Adeyanju Taiye

For more information visit batcon.org/student-scholars

SCHOLARSHIPS

Apply for a BCI Student Research Scholarship

Graduate students can apply for funding through October 31

Conservation-minded bat scholars have until Oct. 31, 2020, to apply for the 2021 BCI Student Research Scholarship. To date, the program has funded 460 student scholars working in 70 countries around the globe. Master's and Ph.D. researchers can apply for financial support for projects examining one of three broad topics:

1. The effects of human-caused environmental change on bats;
2. Understanding and resolving bat/human conflicts;
3. Answering ecological and behavioral questions essential to the conservation of imperiled bat species.

Additional awards are available for Women in Conservation Science and the Verne & Marion Read Bat Conservation Honor, which is awarded to a student who inspires education and community action to protect bats around the world.

Applications are open from Oct. 1–31, 2020.

CONSERVATION

Evidence Champion

BCI recognized for its commitment to use and contribute evidence in its conservation practice

CONSERVATION EVIDENCE, a conservation organization affiliated with the University of Cambridge, has named BCI as an Evidence Champion to recognize BCI's commitment to practicing evidence-based conservation.

The UK-based organization compiles and maintains an online database allowing people to look up conservation actions and learn about whether or not evidence backs certain practices. The Conservation Evidence online database collates and provides summaries of relevant scientific literature that demonstrate what conservation actions are based on evidence for different species groups or management categories. The program also publishes the online journal "Conservation Evidence" and provides annual updated synopses of evidence, including for bat conservation. Individual actions are summarized and scored by the available evidence in the scientific literature. For example, under bat conservation, "creating artificial water sources" is deemed "likely to be beneficial," citing evidence from five studies that tested the efficacy of the approach.

BCI recently signed an agreement with Conservation Evidence to use evidence in our project planning; test and publish results of our conservation interventions; and ask BCI student scholarship recipients to use the conservation evidence database when planning research.

Learn more:
ConservationEvidence.com

"BCI's collaboration with Conservation Evidence is part of our commitment to ensuring that our work contributes to global efforts to improve conservation practices for bats," says BCI Chief Scientist Dr. Winifred Frick, who is on the Scientific Advisory Board for Conservation Evidence's Bat Conservation Synopsis.

BCI Director of Endangered Species Interventions Dr. Jon Flanders performs acoustic analysis in the field. (This photograph was taken before social distancing requirements.)

Photo: Dr. Winifred Frick

BCI staff look forward to connecting with colleagues and exchanging information about their latest work at NASBR each year (BCI pictured here in 2019).

Photo: Dr. Winifred Frick

RESEARCH

North American Society for Bat Research Turns 50

Researchers honor five decades of work with celebratory volume

FIFTY YEARS AGO, a group of bat researchers gathered in Arizona for the Southwestern Symposium on Bat Research. With the name later changed to the North American Symposium on Bat Research (NASBR), researchers from around North America and beyond have gathered to share their research and knowledge, network, and work towards a more inclusive and diverse field. The North American Society for Bat Research hosts the annual meeting each year, which is typically held in October. However, this year's symposium has been postponed until 2021.

"During our first five decades of existence, NASBR has grown from an informal gathering to one of the largest scientific organizations studying bats, and our emphasis on student participation bodes well for continued success into the next half century," says NASBR Board Chair Dr. Burton Lim.

In honor of the meeting's 50th anniversary, researchers are compiling a "Celebratory Volume" entitled, "50 Years of Bat Research: Foundations and New Frontiers." The volume includes review papers from the conference's early years, with an emphasis on how bat science has developed over the past five decades.

Learn more: NASBR.org.

"NASBR played a pivotal role in advancing our knowledge of bats and their biology," says BCI Board Member Dr. Brock Fenton, who has attended NASBR for decades. "The most obvious contribution was providing a venue where bat biologists could exchange information and ideas. The diversity of bats, researchers, and topics is reflected in the book '50 Years of NASBR.' But I think that NASBR's most important contribution is its impact on the research, careers, and ideas of bat biologists. Many of them were students when they first came to and participated in this dynamic forum of bat biologists."

BAT WEEK Virtual Bat Week

Oct. 24–31, 2020

THIS YEAR, Bat Week is an all-virtual international celebration! Bat lovers around the world will come together virtually to celebrate these amazing winged wonders from Oct. 24–31.

Join in the fun and learn about the world's 1,400+ bat species. Become a bat advocate, find a virtual event to enjoy, organize a bat club, or take an urban bat walk. The Bat Week website offers a wide array of options, including a community science component through Project Noah's North American Bat Tracker. Or get a bit artsy by painting a mural, building a bat house, or cooking a meal with ingredients that rely on bats' crucial pollination work. There are many ways to celebrate these amazing mammals.

Photo: Jonathan Alonzo

Join in the virtual fun: BatWeek.org

SPECIES study

There are 1,400+ species of bats in the world. This is one of them.

Fish-eating Myotis

Only the finest seafood will do for the Americas' largest mouse-eared bat

by Christie Wilcox

bat stats

Binomial
Myotis vivesi

Family
Vespertilionidae

Colony size
~10,000

Weight
20-30 grams

Diet
Mostly seafood (~90% marine fish & crustaceans)

Status
Vulnerable

Region
Islands in Gulf of California and off Baja California

Photo: Dr. Marco Tschapka

At first glance, Partida Norte Island in the Gulf of California doesn't look like much of a home for bats. There are no large caves to shelter them from the salty sea spray or the intense sun, and the dry, desolate landscape boasts little in the way of insects or plant life—"maybe a cactus," says Dr. Luis Gerardo Herrera Montalvo, a physiological ecologist with the National Autonomous University of Mexico in Mexico City. But, just out of sight, are tens of thousands of fish-eating myotis (*Myotis vivesi*)—the only bat in the world that dines almost exclusively on seafood.

Despite the vulnerabilities that tend to come from island living, Dr. Herrera's research has discovered these unusual bats are flourishing on the few islands in the world where they exist. He notes we must prevent predators like cats and rats from establishing on the islands where the bats roost, so they can continue to thrive.

Dr. Herrera first began working with these bats a little over two decades ago. He'd just started at the university when a colleague mentioned little was known about the bat species endemic to the islands in the Gulf of California and nearby coasts. Since these bats live only in that area and nowhere else in the world, it makes them vulnerable to a variety of threats. Herrera made his way to Partida Norte Island for the first time shortly after he learned about the bats, and he or his students have gone back every year since.

It's a long and dangerous trip. The weather can be unpredictable, and there's no infrastructure on the island, so everything the team needs has to be carried with them.

During the daytime, the bats roost amongst the seabirds that nest on the island's jagged cliffs, or beneath the rocky rubble that dominates the island. "You can be walking by, and they are under your feet," Dr. Herrera says. To take measurements, obtain genetic samples, or tag the bats, you first have to extract them from the rocky rubble. That means moving a lot of rocks, as they tend to wedge themselves about a meter down.

"Every year, we think this is the last time we go," he says. But every year, he finds some reason to return. "All of a sudden, some new idea comes about, or some colleague shows his or her interest in doing something with this bat, and we just keep going," he says.

A mysterious fisher

Before Dr. Herrera started working with the fish-eating myotis, pretty much all that was known about them was their striking diet. "They're the only species of bat that regularly eats marine creatures," he says.

Over the decades, he and his students—particularly the now-graduated Dr. José Juan Flores—examined the bats' diets in a variety of ways, from sifting through guano to using advanced molecular techniques. All of these methods confirmed that more than 90% of what the bats eat comes from the sea.

"I like to say it's a marine mammal," says Dr. Edward Hurme, a behavioral ecologist with the Max Planck Institute of Animal Behavior in Germany, and one of the many researchers Dr. Herrera has taken to Partida Norte Island. While they aren't what we typically think of as a marine mammal, the bats are unbelievably well-adapted to a seafaring life. They don't need freshwater to drink, for instance—they can subsist on seawater. And they're experts at locating seafood buffets.

Myotis vivesi doesn't require freshwater—it can subsist on seawater.

That's actually what led Dr. Hurme to study them. For his Ph.D., he wanted to use GPS technologies to track bat movements. "With GPS tracking, you need clear skies for the signal to transmit, and a bat that you can easily recapture," he explains. "So, a bat that lives on an island and always comes back to the same spot is ideal."

His research revealed the fish-eating bats are impressive voyagers. "They go on these really long trips out into the open ocean, over these deep, crazy, choppy waters to find prey," he explains. They'll fly out up to 50 kilometers (31 miles) from land in a single evening—not bad for a bat measuring about 14 centimeters (5.5 inches) from nose to tail.

But it's not clear how they choose their flight path. "We still don't know how they find the fish," Dr. Herrera says.

They seem to keep an ear out for other fishing bats, Dr. Hurme notes. "If you play the feeding buzzes of one bat, you get a lot of other bats checking you out—even if you're on land."

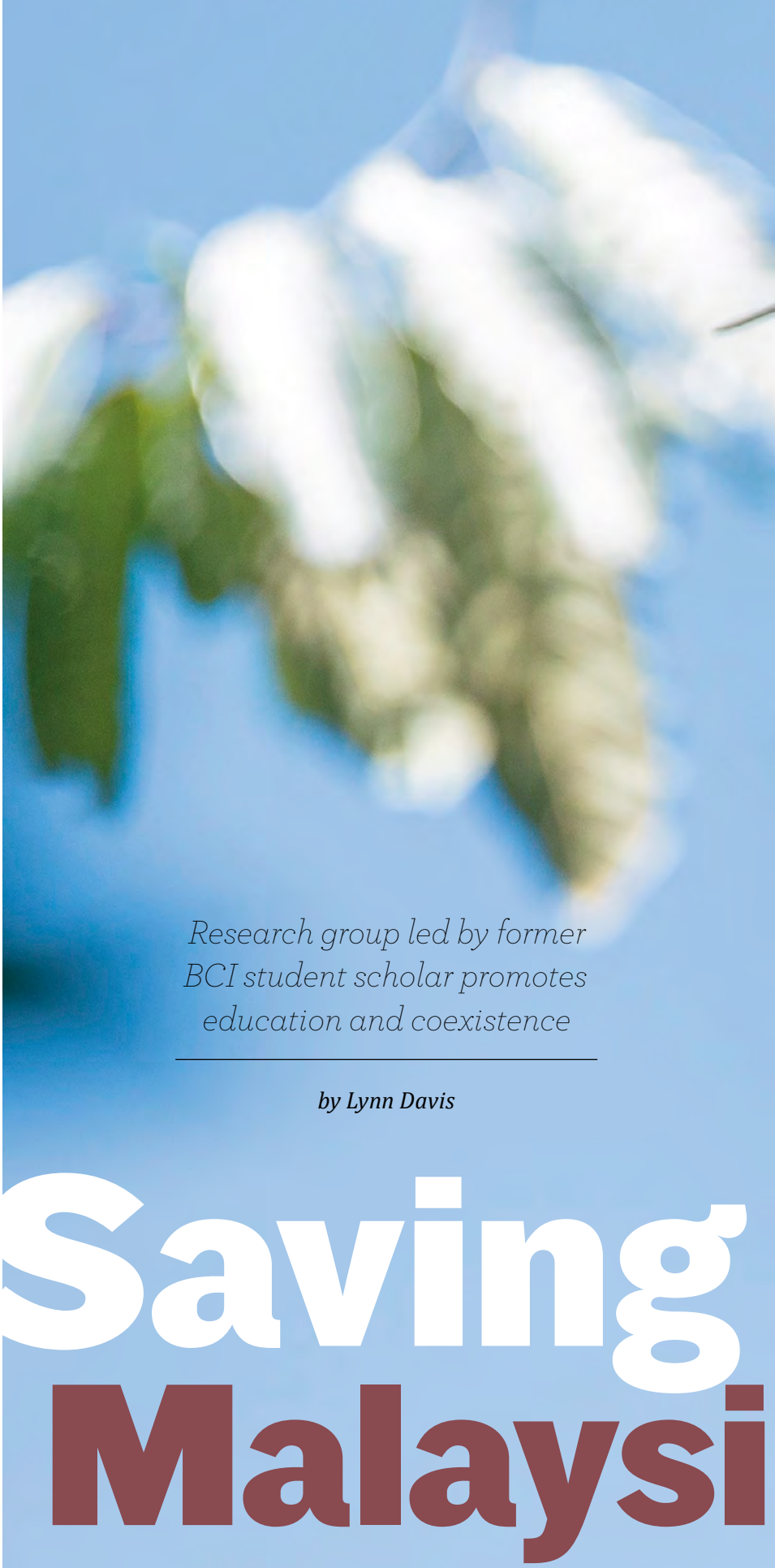
Still, exactly how that first bat spots the meal in the often flat and glassy waters of the Gulf of California remains a mystery.

The bats' penchant for marine fare explains their most distinctive feature: their humongous feet, perfect for plucking morsels from the sea surface. Each foot is nearly 2.5 centimeters (1 inch), about three times the length of similarly sized insect-eating relatives. And the long, curved claws are so sharp that they tend to snag on anything they touch. "They would always get hooked on my watch or stuck in my shirt," Dr. Hurme recalls.

But while their toes are ferocious to fish, Dr. Herrera says the bats themselves are sweethearts. "They are very nice—easygoing," he notes. "You can tell by how many papers we have published on this species that they are very close to both our academic and our human hearts."

Myotis vivesi only lives on the islands and coastlines near Mexico's Gulf of California. Its enormous feet are used for catching fish and other prey.

Photo: Dr. Marco Tschapka



Research group led by former BCI student scholar promotes education and coexistence

by Lynn Davis

Saving Malaysi

Photo: Sanjitpaal Singh / Jitspics.com

As on most workday mornings, Dr. Sheema Abdul Aziz is up early. She suits up in a long-sleeve shirt and cargo pants—clothes that protect her from Malaysia's intense sun, and also guard against swarms of jungle mosquitoes.

She packs her lunch, takes a quick sip of coffee, and checks the weather from her high-rise apartment in Kuala Lumpur in Peninsular Malaysia. Looking out the window, she sees gleaming glass skyscrapers, domes, minarets of Malaysia's dominant Muslim faith, upturned roofs of traditional Chinese structures, and European-styled buildings from the country's colonial period. The city of nearly 8 million people wraps around rivers and stretches to nearby low mountains.

Malaysia—with its urban cities, rural small villages, tropical islands, and dense rainforests—is at the intersection of history and modern-day progress, at the crossroads of saving (or potentially losing) dozens of plant and animal species.

Dr. Sheema (in Malay culture, people use their first names rather than their last names) plays a significant role in Malaysia's overall commitment to conservation, because saving bats helps save ecosystems and other species. She is president and co-founder of Rimba, a well-regarded nonprofit research group that works on multiple Malaysian conservation issues. Her focus is sustaining healthy populations of the large flying fox (*Pteropus vampyrus*) and the island flying fox (*Pteropus hypomelanus*). Both species are frugi-nectarivorous which means they devour fruits and nectar, oftentimes leading to tragic conflict with the country's fruit farmers.

Rimba, the name of Dr. Sheema's nonprofit research group, means "jungle" in the native language of Malay.

Pteropus vampyrus in Peninsular Malaysia

a's Fruit Bats

Photo: Reuben Clements

▲ Dr. Sheema climbing a durian tree during her BCI-funded Ph.D. research in 2015.

The morning she is interviewed, Dr. Sheema loaded her dusty 1990s-era Land Cruiser with long telescopic poles, camera traps, mist netting, and video recorders to drive with her research team to a newly found secret location. There, they documented a small colony of large flying foxes, which roost in "an exciting new location." Dr. Sheema says it is a place "that our team never predicted or could have imagined."

The discovery of the unusual roost has been both exciting and perilous. If the location is disclosed, the colony could face carnage. In Southeast Asia, bats are shot down by fruit farmers who mistakenly believe bats damage their fruit crops. They're also killed for bushmeat and medicinal purposes. They're illegally hunted to be sold to restaurants that serve exotic foods, and they're sometimes slaughtered simply for sport.

Scientists estimate **20%** of the world's species live in Malaysia.

The life-changing 'puffball'

In the early 2000s, Dr. Sheema worked as an archaeologist for the Malaysian government. Her work required considerable travel and taxing fieldwork, which Dr. Sheema thoroughly enjoyed. So, she reasoned, why not use her two-week vacation to try a different kind of fieldwork?

Dr. Sheema applied to Earthwatch Institute, an organization that connects volunteers with scientists. She received a fellowship to work with Dr. Tigga Kingston, an American-based bat researcher who is globally renowned for her work in the threatened rainforests of Southeast Asia and coordinator of the Southeast Asian Bat Conservation Research Unit (SEABCRU).

For two weeks, Dr. Sheema and other volunteers helped Dr. Kingston capture bats and data as they painstakingly moved through the challenging terrain of the Krau Wildlife Reserve. The reserve, which bisects the interior of Peninsular Malaysia, is a pristine and unspoiled lowland tropical rainforest valued for its exceptional diversity of birds and mammals, and is strictly off-limits to anyone without a research permit. For Dr. Sheema, who had hiked only recreationally in the forests around Kuala Lumpur, the dense, swampy, and thorny landscape was nothing like anything she had experienced before. Difficult—yet exhilarating.

When Dr. Kingston's research group brought bats from the forest to the field lab, Dr. Sheema held a bat for the first time. It was a small woolly bat (*Kerivoula intermedia*), a little-known species of vesper bat found only in Malaysia, and one of the smallest mammals on earth. It weighed less than two ounces.

Dr. Sheema says it was a life-changing moment. "There it was, in the palm of my hand, a tiny puffball weighing practically nothing, with its little eyes looking at me," Dr. Sheema recounts. "I can't fully describe the feeling. I was filled with awe and I was intensely aware of the bat's fragility. I realized I needed to do more than save the past. I needed to do something to save the future."

Dr. Sheema turned her passion to bat conservation, moving from her initial fascination with one of the smallest of insectivorous bats to becoming a foremost researcher and prominent advocate for some of the largest fruit-eating bats. She pursued a master's degree and worked with the World Wide Fund for Nature-Malaysia.

In 2010, Dr. Sheema and her husband, Dr. Gopalasamy Reuben Clements (a.k.a. Reuben), co-founded Rimba, which means "jungle" in the native language of Malay. Since then, she has

launched important bat research and conservation initiatives, published prolifically, and traveled extensively. She also completed a doctorate in ecology, funded by Bat Conservation International and other bat-saving organizations.

The lay of the land

Malaysia—divided by the South China Sea into the regions of Peninsular Malaysia and Malaysian Borneo—is the heart of Southeast Asia, bordered by several countries and surrounded by small tropical islands. Multi-ethnic, multicultural, and endlessly diverse, the country has approximately 32 million residents, and scientists estimate it contains 1 in 5 of the world's animal species. It is a picture-perfect paradise and a perfect storm for conflict between humans and nature.

Ten years ago, Malaysia stepped up its commitment to conserve natural resources and began to see a significant uptick in ecotourism. But conservation challenges persist, including deforestation and habitat loss due to logging, agricultural expansion, quarrying, and wildlife poaching and trafficking. Conservation organizations, like Rimba, are working to address these issues.

"There are many local and international organizations in Malaysia that focus on terrestrial mammals: tigers, elephants, rhinos, pangolins, sun bears, and orangutans," Dr. Sheema says. "But no Malaysian-based group was specifically focused on bats. So, we jumped in. Our work conserving fruit bats will help save complete ecosystems, which, in turn, will help conserve the 110 bat species in Peninsular Malaysia, and many of those big iconic species."

In Malaysia, there are dozens of bat species that range from short-nosed dog-faced fruit bats to small flat-headed bamboo bats. Dr. Sheema dedicated herself to conserving Malaysia's two species of flying foxes after prior research on flying foxes mostly focused on viruses, parasites, diseases, and public health, rather than sustaining the mammals. Her work protecting fruit bats will have ecosystem-wide results.

Fascinating facts about Malaysia's fruit-eating bats

- The large flying fox (*P. vampyrus*) is the world's largest bat, with a wingspan that can reach up to 6 feet.
- Large flying foxes and island flying foxes (*P. hypomelanus*) roost in trees but almost never co-roost.
- For decades, the Malaysian government licensed the hunting of bats, resulting in up to 22,000 bat deaths yearly. Seven years ago, hunting restrictions were tightened, but enforcement is difficult in the country's rural outreaches.

> "Most farmers understand bee pollination, but many don't think of bats as pollinators."
> — *Dr. Sheema Abdul Aziz*

Conflict with farmers

Small family-owned fruit farms, village orchards, and corporate fruit plantations border Peninsular Malaysia's dense government-owned

Photo: Reuben Clements

▲ Dr. Sheema and members of her research team meet with a durian farmer in Terengganu. (This photograph was taken before social distancing requirements.)

Photo: Dr. Sheema Abdul Aziz

> "Through simple and basic outreach, we're witnessing community recognition of the bats' value and importance."
> — *Dr. Sheema Abdul Aziz*

Bats and Malaysian culture

Rimba's "Project Pteropus" researchers are beginning to incorporate ethnobiology—the study of how humans interact with nature—within their public outreach and education, tapping into rich, interesting cultural traditions. Malaysians depict bats in positive ways, both in art and creation stories. One indigenous group has a traditional dance that represents the beauty of a flying fox in flight.

"Malaysian ancestors had ways of coexisting with bats," Dr. Sheema says. "We believe a lot can be learned from talking with elders and applying their knowledge."

▲ Dr. Sheema's research team collects bat fecal samples on Tioman Island. (This photograph was taken before social distancing requirements.)

rainforests and tangled mangroves. This might be considered a good place for large flying foxes—except for fatal conflicts with humans.

Many farmers believe bats hurt their crops of bananas, mangos, water apples, rambutan, jackfruit, and durian. Farmers survey the morning remnants of partially eaten fruit and grimace at the durian blooms strewn on the orchard floor—though many of these blooms are naturally shed overnight. Some farmers respond with their shotguns, while others string fishing hooks and monofilament line to catch and kill.

Dr. Sheema's doctoral research was the first to provide evidence that, rather than being destructive, flying foxes are vital pollinators for durian crops. Pungent, smelly, and considered a delicacy, durian is Malaysia's most lucrative fruit crop. She seeks to educate farmers and others about bats' important work.

How do you say "bat" in Malay?
In Malay, the general word for all bats is "kelawar." However, flying foxes are known specifically as "keluang."

"Most farmers understand bee pollination, but many don't think of bats as pollinators," Dr. Sheema says. "They too often see bats as destructive." What they don't realize, she says, is that fruit bats contort themselves to gently and tenderly drink the durian nectar, never damaging the durian blooms.

Dr. Sheema and her team travel to the fruit farms, sometimes dropping in and sometimes by appointment. They pull her Land Cruiser off Malaysia's well-maintained roads and drive along dirt roads through the sloping orchards, bouncing along and grinding the manual transmission.

Some farmers are receptive to learning more about bat pollination and are interested in solutions to save their fruit. Others are more resistant. Her work isn't restricted to mainland farms and forests, though. Sometimes, her work brings her to the country's islands.

Quest for coexistence

On Tioman Island, one of 64 small islands off the west coast of Malaysia, Dr. Sheema and her team meet with dive and snorkeling centers, shops, hotels, restaurants, and the local villagers. The island, best known as the backdrop for the 1958 film "South Pacific," has become an increasingly popular ecotourism and adventure travel destination. Dr. Sheema is on a mission to persuade the locals that flying foxes could add even more tourism appeal.

There, where the brilliant blue sea meets white sand beaches ringed by dense tropical rainforests, roost hundreds of island flying foxes. They are visible in plain sight in the trees, along the walkways of the island's few villages, and on the beaches.

Dr. Sheema points out that the island bats live unusually close to humans, a fact she believes could be attributed to the Islamic way of life, because Muslims do not eat bats. "The bats seem to know that they will not be hunted or eaten. They actually seem to want to hang out near humans."

The feeling, however, is not necessarily mutual. Villagers consider the bats a nuisance because they're stinky and noisy. Children in the villages use slingshots on them and adults try to smoke them out of their roosts, which seldom works.

So, Rimba tested a public outreach campaign. "We started small. We put up a hand-painted information sign near one of the roost sites, near a popular walking area, to provide some info about fruit bats and advise to not come close," she says.

> "Our work conserving fruit bats will help save complete ecosystems, which, in turn, will help conserve the 110 bat species in Peninsular Malaysia, and many of those big iconic species."
> *— Dr. Sheema Abdul Aziz*

They also produced posters and brochures, which they brought around to resorts and other tourism spots. "Those simple measures had significant results. We started hearing from the local people that tourists were asking to see the bats," she says.

Dr. Sheema is encouraged by the people's interest in the bats, and she is optimistic her team's efforts will continue to help people and bats get along—for the good of the entire ecosystem.

"Through simple and basic outreach, we're witnessing community recognition of the bats' value and importance," Dr. Sheema says. "Hopefully, that will build local pride in their resident bats. Yes, the bats are still smelly and noisy, but we hope that coexistence is on the horizon."

Dr. Sheema mist netting fruit bats in a durian orchard.

Photo: Sanjitpaal Singh / Jitspics.com

Out to Dark

Big leaps in bat genomics illuminate the animals' most closely held biological secrets

By Christie Wilcox

In 1990, an international group of geneticists began what was, at the time, an astonishingly challenging endeavor. Their goal: to sequence the human genome, all 3 billion base pairs. It took dozens of researchers from 20 institutions in six countries longer than a decade and cost more than $2.5 billion, but they ultimately succeeded. In the ensuing years, genomes for other animals have followed. Most are still incomplete, but researchers have unveiled six complete bat genomes.

Published in *Nature* in July, the six complete bat genomes are the first to come from the ambitious Bat1K global genome consortium, which aims to sequence the genome of every single bat species. Achieving this lofty goal would allow unprecedented comparisons between species with different abilities or ecological roles, which, in turn, would help researchers unravel the mysteries of bat evolution, including how they took to the skies.

The ultimate goal, though, reaches far beyond illuminating bat biology. "Both humans and bats are mammals, and that means that we also have something in common in terms of our overall physiology," explains Dr. Sharlene Santana, an evolutionary biologist with the University of Washington and the curator of mammals at the Burke Museum of Natural History and Culture in Seattle. "So, understanding how bats' physiology works may eventually help us understand how we, ourselves, might fight disease or live longer."

ness

Photo: Stephen Dalton/Minden Pictures

Unprecedented insights

Before this new batch, genomes from a little more than 125 of the roughly 6,500 species of mammals had been constructed. Only 13 of those were bats, even though the Chiroptera account for about one-fifth of all mammals.

"Bats represent a large amount of the diversity of mammals," Dr. Santana says. "So, just understanding the diversity, not only their external features but also their genomes, that tells us a lot about how they became survivors."

"Genomics is really powerful," says Dr. Hannah Frank, an evolutionary ecologist with Tulane University. Because all living things can trace back to a single common ancestor, comparing genome sequences can help scientists figure out how species split into the ones alive today. It can also tell us how those splits occurred by revealing what genes changed the most or the least—signatures of strong evolutionary selection.

Such comparative analyses will provide researchers novel insights into the origins of quintessential bat traits like echolocation and flight. But even more so, Dr. Frank says, "we hope that, by looking at their immune systems and looking in their genomes, we will perhaps see how they're tolerating or fighting disease, and then maybe apply some of that to ourselves."

Even before the new set, previous bat genomes had deepened our understanding of immunology,

says Dr. Stephanie Pavlovich, a clinical researcher and medical resident at the University of North Carolina School of Medicine. For her Ph.D., she helped construct a draft genome of the Egyptian fruit bat (*Rousettus aegyptiacus*)—a species known to harbor the deadly Marburg virus without showing signs of illness. That genome revealed that the animals have a much larger number of type one interferon genes—proteins essential for the body's initial attack on invading viruses—than we do. The discovery meant researchers could now perform the kind of experiments that tease out what role each of those genes plays in the bat's immune system.

"Understanding how bats' physiology works may eventually help us understand how we, ourselves, might fight disease or live longer." — *Dr. Sharlene Santana*

"Having more genomic information is always helpful in terms of asking the right evolutionary questions," she says.

The new genomes not only expand the number of species we can mine for similar insights, but they also provide richer data on previous species genomes that can be used to deepen our understanding of previous discoveries. "There are always genes that you've missed, spaces that you need to go back and fill in with additional sequencing," Dr. Pavlovich says. She is hopeful the new, more complete Egyptian fruit bat genome, one of the six, can help fill in some of the blanks her team may have missed. And looking forward, she says having these diverse genomes—which represent both of the major lineages of bats, as well as bats with different geographic ranges, traits, and ecological roles—will help improve the process of sequencing genomes for other species.

Size matters

The researchers refer to their genomes as "reference-quality" because they're much more complete than the previous bat genomes—in many cases, by orders of magnitude. But obtaining the six incredibly complete genomes was no simple feat. Though genome sequencing has become a lot cheaper and faster in the 30 years since the Human Genome Project began, putting together a high-quality genome remains a challenge. There are trade-offs to consider when it comes to your method of sequencing, explains Dr. Frank.

Learn more:
BatIK.ucd.ie

When you chop the DNA up into smaller pieces, the sequences are more accurate, but they're harder to piece together—hard enough that genes or even sections of chromosomes can get left out on accident. Longer strings give you a better sense of the overall architecture of the genome, but they're also more prone to error.

The "big breakthrough" for the Bat1K team was using both, says Dr. Liliana Dávalos, an evolutionary biologist with Stony Brook University, BCI science advisory committee member, and one of the researchers involved in constructing the six genomes. By combining multiple technologies, especially newer ones that sequence longer strings of DNA, they ensured the genome was both accurate and complete.

"The only genomes that are better, in terms of completeness, than the bat genomes in the paper, are actually the ones from mouse and human," Dr. Dávalos says. And because they're so accurate, they will allow scientists to do something really new: to learn more about ourselves.

The 6 Sequenced Species

Greater horseshoe bat (*Rhinolophus ferrumequinum*)
Range: Northern Africa, Europe, and Eastern and Central Asia
Family: Rhinolophidae
Echolocation: Yes
Diet: Insectivore, especially moths
Previously sequenced? No

Egyptian fruit bat (*Rousettus aegyptiacus*)
Range: Parts of Africa and the Middle East
Family: Pteropodidae
Echolocation: No (uses tongue clicks)
Diet: Frugivore
Previously sequenced? Yes

Pale spear-nosed bat (*Phyllostomus discolor*)
Range: South America into Central America
Family: Phyllostomidae
Echolocation: Yes
Diet: Omnivore
Previously sequenced? No

Photos by Yushi & Keiko Osawa; Steve Gettle/Minden Pictures; Jose Gabriel Martinez Fonseca

Which Came First: Echolocation or Fruit Bats?

Apart from flight, perhaps the most impressive bat feature is their ability to "see" with sound by using echolocation. But fruit bats in the family Pteropodidae (flying foxes) lack this sonic superpower, and that sets up two possible scenarios for the trait's evolution: either it arose separately in the close cousins of these fruit bats and all other bats, or the ancestor of all bats could echolocate, and these fruit bats lost the ability. "This has been a long-standing question in bat biology," explains Dr. Santana—one that these six genomes may have finally answered.

Comparing physical features and genetic ones has yielded different answers in the past, Dr. Santana explains, but the six highly complete genomes were able to provide clearer insights. Instead of having to zero in on known genes and compare them between species, the BatIK team was able to compare whole genomes and look for areas that differ between the various bats. That allowed them to uncover mutations present only in echolocating bats, including a tiny duplication in part of a hearing-related gene that no one had noticed before.

Since these genetic features were identical in all echolocating bats—including in previously published genomes—they concluded that two independent origins for echolocation was extremely unlikely.

It's one thing to sequence a genome, and a whole other to decipher what that sequence really means. And, to date, all other animal genome sequences have relied heavily on the human and mouse genomes to infer what different genes do, a process called annotating. Because of this, other animal genomes struggle to provide novel insights into how human genes work. But now, because the six bat genomes are "on the level of the human and the mouse genomes," Dr. Dávalos thinks these animals will start teaching us a few things.

> "We hope that, by looking at [bats'] immune systems and looking in their genomes, we will perhaps see how they're tolerating or fighting disease, and then maybe apply some of that to ourselves."
> — *Dr. Hannah Frank*

Bats are sometimes known for their ability to survive and not even seem ill when infected with viruses that are lethal in humans. Now that we have their genomes, we can dive deep into the nitty-gritty of how bats pull that off. Dr. Dávalos envisions a not-too-distant future where experimental work in bats and in cultured bat cells reveals essential information about how our immune system works—or why it doesn't always work.

Such studies could pinpoint genes that bats have that we don't, or ones that bats turn on at different times or in different amounts, for instance—all of which might provide clues to boosting our own anti-virus systems. "It's a very exciting time," she says.

Greater mouse-eared bat (*Myotis myotis*)
Range: Europe into Asia
Family: Vespertilionidae
Echolocation: Yes
Diet: Insectivore
Previously sequenced? No

Kuhl's pipistrelle (*Pipistrellus kuhlii*)
Range: Europe, Northern Africa, and parts of Asia
Family: Vespertilionidae
Echolocation: Yes
Diet: Insectivore
Previously sequenced? No

Velvety free-tailed bat (*Molossus molossus*)
Range: South America into Central America
Family: Molossidae
Echolocation: Yes
Diet: Insectivore
Previously sequenced? No

Photos by Jeroen van der Kooij; Sherri and Brock Fenton

RESEARCH

Ears in the Field

Ultrasonic recorders help researchers detect bats remotely

by Melody Schreiber

ON THEIR FIRST NIGHT IN RWANDA, the BCI field research team got lucky in an unexpected way. They had set up nets in Nyungwe National Park, one of the oldest rainforests on the African continent, to try to catch the critically endangered Hill's horseshoe bat (*Rhinolophus hilli*), which has not been seen since 1981. But instead of catching that rare bat, they caught another—the Damara woolly bat (*Kerivoula argentata*)—which had never been caught in Rwanda before.

BCI Chief Scientist Dr. Winifred Frick teaching BCI partners in Fiji how to capture bat calls using a bat detector to monitor for the endangered Fijian free-tailed bat. (This photograph was taken before social distancing requirements.)

Photo: Dr. Winifred Frick

They were able to record the newly confirmed bat's echolocation call, which means they can now detect it by sound without needing to catch it again. They used an ultrasonic recorder from Wildlife Acoustics, a Massachusetts-based company specializing in bat and bird acoustic equipment, to record the call.

Recording and tracking bats with acoustic equipment can be a less intrusive and less resource-intensive way to monitor bats, particularly from a distance. The equipment can be pointed at the sky to record and identify bats, but it can also be stationed in remote locations for long periods of time. The recorders run on batteries and can be programmed to run from sunset to sunrise.

In Rwanda, for instance, park rangers trekked for about a day and a half to position recorders at the entrance to a remote cave. The recordings showed the bats in the cave were not the Hill's horseshoe bat, freeing up the researchers to spend their valuable time focusing elsewhere.

Acoustic monitoring projects are being used to detect the Jamaican flower bat (*Phyllonycteris aphylla*) and the Jamaican greater funnel-eared bat (*Natalus jamaicensis*), the Fijian free-tailed bat (*Chaerephon bregullae*), and the Florida bonneted bat (*Eumops floridanus*), the rarest bat in the United States. The Florida project uses 16 recorders to form an acoustic monitoring grid to track the federally endangered bat through changing seasons, food sources, and roosts.

Sherwood Snyder, director of product management at Wildlife Acoustics, says it would be "excruciatingly expensive" and time-consuming for bat biologists to do that level of work every day across multiple locations. "It would take an army of bat biologists to match that," Snyder says. Instead, the equipment frees up researchers to focus on the most important work at hand, and it also allows them to monitor from a distance, which is especially helpful during a pandemic.

BCI Director of Endangered Species Interventions Dr. Jon Flanders trains Nyungwe National Park Rangers in Rwanda to deploy bat detectors to survey for rare forest bats, including the critically endangered Hill's horseshoe bat. (This photograph was taken before social distancing requirements.)

Photo: Dr. Winifred Frick

"Twenty years ago, this just wouldn't have been possible," says BCI Director of Endangered Species Interventions Dr. Jon Flanders. "The equipment was far too expensive, far too heavy; you weren't able to stick it out for days on end. Whereas now, it's waterproof, it's robust, it's really easy to use. So, the rangers are able to stick it in their backpack and take it on part of their normal duties."

But recording bat calls isn't just for bat biologists anymore. Less expensive, consumer-focused ultrasonic sensors are also available to translate echolocation calls to a human audible range and then create a spectrogram, suggest a species from a database of bat calls, and even show a little photograph of the identified bats.

BCI Chief of Strategic Partnerships Mylea Bayless says that equipment like this has great potential for involving community scientists and naturalists on Bat Walks, hosted by guides with acoustic detectors.

"It's an opportunity for conservation involving community contributions to science, and because the detectors are so accessible, they also present unique opportunities for outreach and for giving people an in-person introduction to bats through nature walks," Bayless says.

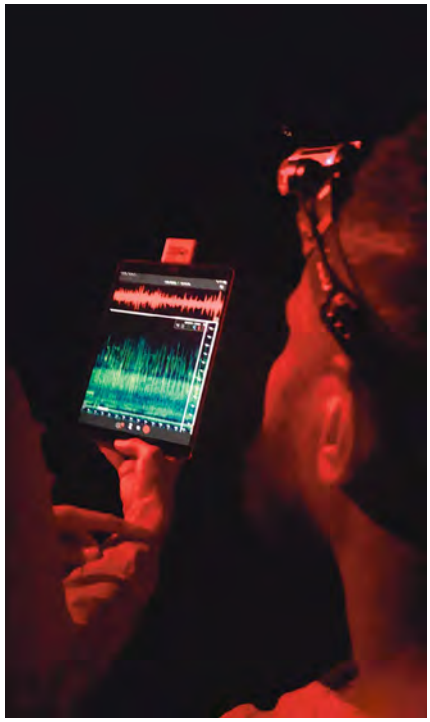


Photo: Dr. Winifred Frick

▲ Bat calls are displayed on an iPad connected to a bat detector in Jamaica while BCI scientists listen for the critically endangered Jamaican flower bat emerging from its last known roost. (This photograph was taken before social distancing requirements.)

> "Twenty years ago, this just wouldn't have been possible. The equipment was far too expensive, far too heavy; you weren't able to stick it out for days on end. Whereas now, it's waterproof, it's robust, it's really easy to use."
> — *Dr. Jon Flanders*

READER IMAGES

Bat Snapshot

Photos from our talented, bat-loving readers

We asked *Bats Magazine* readers to submit their best images of bats, and we were impressed with the wide range of high-quality photos we received. Unfortunately, we weren't able to print all of them in this issue, but here are a few of our favorites.

▶ LAURA M. OSTEEN snapped this image of a few *Artibeus* tucked under a leaf in Roatan, Honduras, in September 2017.

◀ LYNN GOERTZEN spied this short-tailed fruit bat (Genus: *Carollia*) enjoying a few nibbles out of a fruit basket in Calla Creek, Belize, in February 2012.

▶ SARAH SAMAAN captured this image of Mexican free-tailed bats at Bracken Cave Preserve in August 2018. "I loved the eerie aura of the old structure as the bats made their way across the sky near twilight," Samaan says.

◀ RACHEL BATES was visiting the Chi Tunnels, near Vietnam's Ho Chi Minh City, in early 2018 when she encountered this Lesser false vampire bat (*Megaderma spasma*). "We were exploring the tunnels on a tour and there were bats flying around everywhere," Bates recalls.

▶ CHARLIE VANTASSEL photographed this *Leptonycteris* in August 2019 at Madera Canyon, Arizona. VanTassel first noticed the bat as part of a pair that repeatedly came to a hummingbird feeder that night.

◀ STEVEN ROTHENBERG was in the wilds of Boca Tapada, Costa Rica, in November 2018 when he saw this Pallas's long-tongued bat (*Glossophaga soricina*) feeding on a banana flower.

▶ ALYSON YATES snapped this image of a painted bat (*Kerivoula picta*) in a studio in Thailand in November 2019.

◀ ALYSON YATES took a double exposure image of of a horseshoe bat (Genus: *Hipposideros*) in flight while exploring a cave in Thailand in 2019.

bat chat
A conversation with a noted expert

Gene Genius

Researcher and BCI science advisory committee member unveils new knowledge about bat genomes

by Shaena Montanari

Dr. Liliana Dávalos is one of BCI's science advisory committee members and a professor of conservation biology at Stony Brook University in New York. She earned her Ph.D. in ecology, evolution, and environmental biology from Columbia University and now runs a lab focused on the study of molecular evolution and tropical biology. Dr. Dávalos is part of the research team that published an article in *Nature* focusing on what high-quality genomes reveal about evolutionary adaptations of bats.

Photo: Dr. Winifred Frick

▲ Dr. Liliana Dávalos shows off some of the test tubes used in the sequencing project.

Why did you start researching bats?

Like so many young organismal biologists, I was seduced and enchanted by birds, and that's what I wanted to study. But when I was applying to graduate school, I did not hear back from the ornithologists and instead heard back from one researcher, Dr. Nancy Simmons, who later became my advisor. She said she would work with me if I would consider a project about bats instead. I already had some familiarity with bats from fieldwork. The field of bat researchers was a lot smaller at the time, and there were many opportunities to have a great impact with research.

The *Nature* study you worked on recently compares whole genomes of bats. How does sequencing whole genomes help you understand more about characteristics of bats, such as disease tolerance?

I think the No. 1 thing we can do with whole genomes is study gene content with much greater precision. As we get better and better genomes, we understand that evolution through gene duplication and gene loss is important. To understand more about gene families (sets of similar genes) that are critical for immunity and sensory systems in mammals, we need really good whole genomes to study.

What did you learn about the relationship between bats and viruses in this recent study?

One of the key things that was discovered in this paper is that there are ancient viral insertions in the genome. From that, we can infer that over millions of generations, bats have been exposed to unique viruses that other mammals have never been exposed to before. We find insertions in the genome from viruses that have, as of now, only been found circulating in birds. That is a remarkable finding because it tells us something about the history of what viruses bats have been dealing with for a long time.

What types of themes and questions do you think will guide your future research?

I think we are going to take the bats in the lab. In some cases, that means the whole bat, but also through immortalized cell lines for bats, which are still uncommon. These types of resources exist in mouse models—you can order particular mouse cell lines from a catalog that mimic a particular disease to study in a lab. Future research will entail the development of a much greater variety of these cell lines for bats. Outside of the lab, we also want to do more field studies like track and monitor bat metabolism, health, and disease, all of which used to be difficult to do but are now becoming less expensive.

bat squad
For the young conservationist

Backyard "Bativists"

BCI Intern Sophia Seufert inspires young bat lovers with video series

By Laurel Neme

Anyone can be a backyard 'bativist'," says Sophia Seufert, BCI intern and Brandeis University junior. Seufert spent her summer creating a series of videos for BCI to help young people connect with bats and create "bativists"—that is, bat activists.

The virtual internship started after Charles Chester, BCI's Board Chair and professor at Tufts and Brandeis universities, checked in with BCI about possible opportunities for students. COVID-19 had prompted the cancellation of most internships, so he was wondering if BCI could provide opportunities.

"It was a perfect chance to do something we didn't really have the bandwidth for," says Erin Cord, BCI's Bat Walk network coordinator. BCI had suspended Bat Walk trainings due to the pandemic, and Cord and others at BCI had been thinking about other ways they could help teach people about the importance of bats. With so many kids at home, educational videos immediately came to mind.

> "Now, I see bats everywhere and have new opportunities to talk to people about bats."
> — *Sophia Seufert*

"We wanted to create some content that would bring bats to kids in a fun and virtual way," Cord says. Working with Seufert, who has a background in both teaching and art, the two brainstormed ideas for a series of short, homemade videos with bat-related activities. The plan was to release them on BCI's newly designed website and share them on social media.

Seufert then got to work. She developed activities. She wrote scripts. She filmed and starred in the series of five episodes, and she animated and edited them each to five minutes in length.

The first video focuses on "ecosystem services and how bats are important pollinators," Seufert explains. In the video, she shows kids how to make a Bat Pollination Field Guide. The second video includes a demonstration about how to make a fruit salad from some of the many plants pollinated by bats. In the video, Seufert mixes a syrup from agave and lime, then adds guava, mango, and bananas—all foods pollinated by bats.

In the third episode, Seufert shifts gears by showing off bats' cool anatomy and aerial abilities with a flying bat puppet. In the fourth, she highlights the precarious status of bats with endangered bat passports, where each page focuses on one of the species that BCI helps, including a QR code that links to BCI's website. The fifth (and, for now, last) episode explores bats' social behavior by making a cotton ball bat family.

Sophia Seufert worked on creating a series of educational videos during her summer internship with BCI. *Below:* One of the projects Sophia Seufert focused on was creating an "endangered bat passport" to teach kids about endangered bat species.

Photos: Annaleah Seufert

Seufert revels in how much she learned from her internship—from video production to conservation. "I had little knowledge of bats before this," she says. "Now, I see bats everywhere and have new opportunities to talk to people about bats."

Watch the videos and you'll agree that the real winners are the bats!

Check out the video series on BCI's YouTube channel: YouTube.com/BatConservation

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Build a Legacy for Bats

Photo: Yushi Osawa

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