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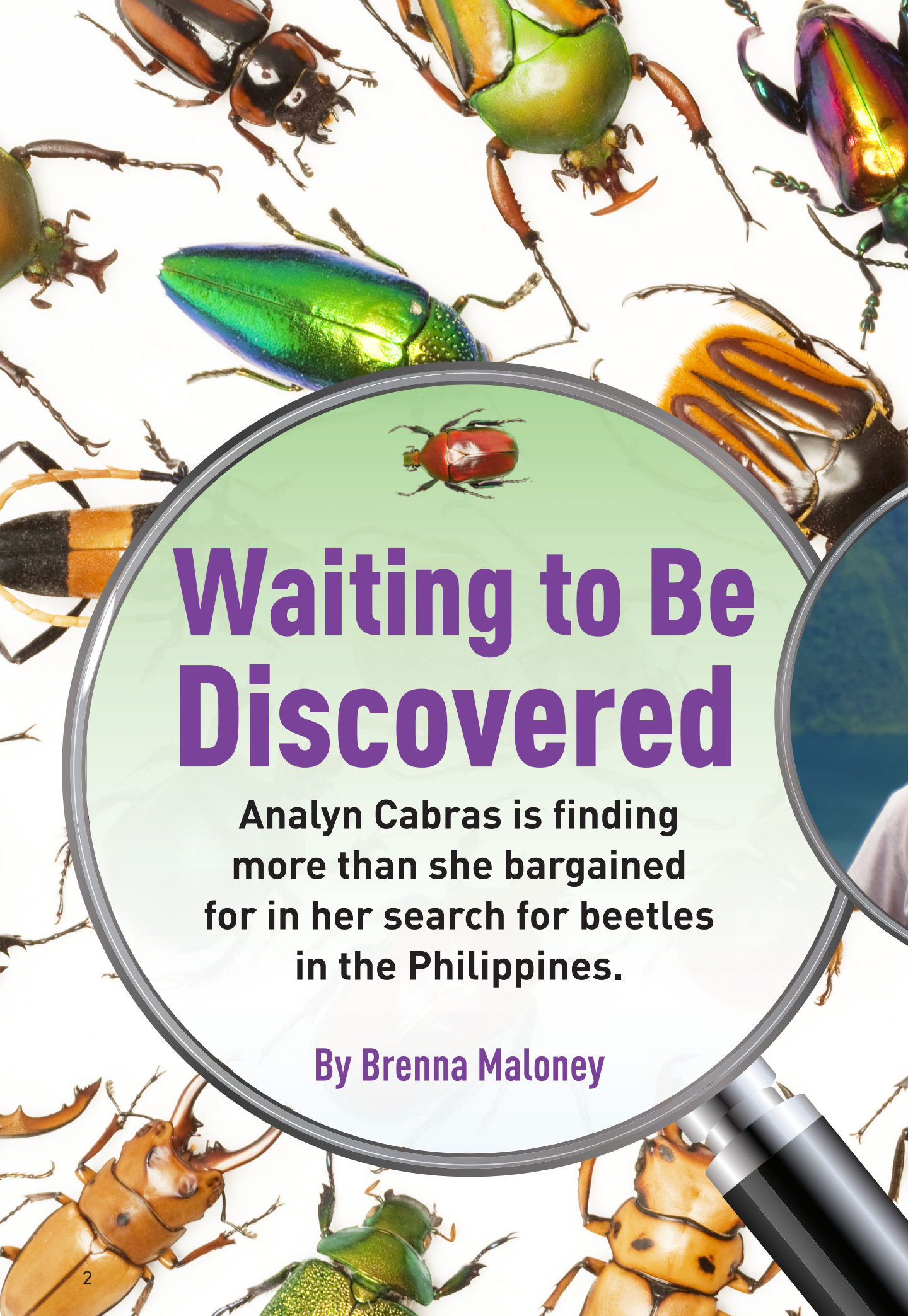


Waiting to Be Discovered

Analyn Cabras is finding more than she bargained for in her search for beetles in the Philippines.

By Brenna Maloney

Wildlife and Wild Places

LIFE SCIENCE

As you read, think about how one scientist's research can impact a field of study.

Analyn Cabras is a woman with a lot of "ists" behind her name. She's a biologist. She's a taxonomist. She's a conservationist. And she's a coleopterist.

Words ending in "ist" denote a person who practices, is an expert in, or who studies a particular subject. In Cabras' case, it means she studies living things, categorizes them, and works to protect them. And the living things she focuses on the most are beetles.

Studying beetles is a pretty big field. Earth is home to more than 400,000 species of beetles. They are the largest group of animals on the planet. Beetles can be found on every continent but Antarctica. They can live where it's hot, where it's cold, where it's dry, or where it's wet. They range in size from the barely visible (feather-winged beetles) to the almost-too-big-to-hold-in-one-hand (titan beetles).

You'll find Cabras looking for beetles on Mindanao, the second-largest island in the Philippines. High up in the rainforests, she spends her days sneaking up on tiny, iridescent beetles from the weevil family.

"You have to be very, very careful in approaching them," Cabras says. Many beetles are sensitive to vibrations. Jewel weevils are no exception. "If they sense you coming, they fall to the ground. Once they fall to the ground, it's almost impossible to find them."

Belly up with legs tucked in, the beetles are tough to see among the leaf litter on the ground. This is just one of the lessons Cabras has learned from many seasons of fieldwork.

Island Surprises

This island keeps her busy because so little is known about what lives there. "A lot of exploration in the late 19th century focused on Luzon, which is the largest island of the Philippines. Here in Mindanao, we have so many mountains which are still unexplored," Cabras says. She sees her job as cataloging what's there and looking at how these beetles relate to each other and the natural world.

So far, her work has been full of surprises. Many scientists spend their entire careers searching for something new. Yet, Cabras can't seem to stop finding things that are new. "It feels like every time we go into the field, we discover at least one new species. It's kind of mind-blowing. In one area of eastern Mindanao, we found four new species in a 1.5-kilometer (less-than-a-mile) stretch."

It sounds simple, but you have to know what to look for. "When you do this kind of work, you have to be really, really patient." Cabras says. "When you first start field research, you will not find [anything]. But as you go more often into the field, you will find so much, you won't know where to begin! You'll find yourself surrounded by beetles."

Know Your Scientist

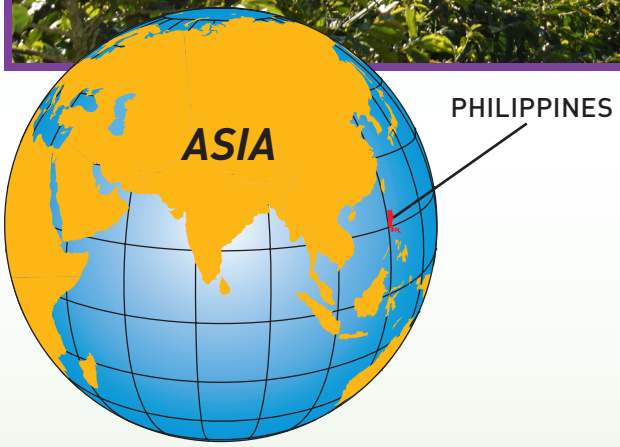
In her work studying beetles, Analyn Cabras plays many roles:

Biologist: an expert in the branch of science concerning living organisms

Coleopterist: a person who studies or collects beetles

Conservationist: a person who advocates or acts for the protection and preservation of the environment and wildlife

Cabras conducts her research in mountainous regions on the Philippine island Mindanao.



Cabras uses a magnifying glass in the field to get a closer look at a beetle.

Ecologist: an expert in or student of the branch of biology that deals with the relations of organisms to one another and to their physical surroundings

Taxonomist: a biologist that names and groups organisms into categories

Finding Something New

Cabras takes great care when she thinks she's found something new. She immediately signals to any teammates around her to stop moving. "I get everybody to freeze!" she says. She doesn't want any sudden movements to scare off a beetle. Before moving any closer, she tries to take a photograph of the scene. "I usually take photos of their food plant and habitat, because it gives new information—not just to the taxonomists but also to the ecologists and conservationists."

Many of the more than 400 species of Philippine jewel weevils have small ranges, some as tiny as just one patch of forest. "A lot of these species are very specific to certain plants. They don't eat a variety," says Cabras. This becomes important if you hope to conserve, or protect, the beetle. "You have to conserve their food plant if you want the beetles to be conserved. "

A Fuller Picture

There's another reason why Cabras tries to record the scene: "For some of my colleagues, this is the first time they are seeing the species alive." A lot of descriptions of new species are based on museum collections. So, the taxonomists categorizing and naming species have never seen those species alive or in the wild. They have never seen their habitats or host plants.

If possible, Cabras then collects a beetle as a sample so that it can be looked at more closely in the lab. "When you are in the laboratory, it's the same thing—you have to photograph them. You examine [their anatomy.]," she says. The lab work requires tremendous patience because the beetles are so small.

That's not all. "It also requires special skills and years of training to do the lab work. You have to train your eyes to look into the microscope, but you also have to train your hands." Beetles must be dissected, or cut apart, so scientists can see their internal structures. That requires good eyes and steady, steady hands.

Yet, even with her good eyes and steady hands, Cabras can't always trust what she sees. Sometimes even she can be fooled.

Weevil Wonders

Jewel weevils are so named because they sparkle like gems. Their elytra, or wing covers, shimmer with an array of colors—from brilliant turquoise and shiny gold to pale orange and pink. With such noticeable colors, you'd think they'd be easy targets for predators like frogs, lizards, and birds. But weevils want to be seen. Their colors act as a warning: *Don't eat me. I taste bad.*

There's a word for this in science. It's called **aposematism.** It is the advertising by an animal to potential predators that it is not worth attacking or eating. Aposematism can take the form of bright colors, sounds, odors, or other characteristics. These signals are helpful to both predator and prey, since both avoid potential harm.

Cabras knew all about aposematism, but she didn't realize how much it was going to affect her weevil research.

Chrysopida sp. is a leaf beetle that looks like some jewel weevils.

This beetle, *Pachyrhynchus reicherti*, would become important to Cabras' research. She soon discovered a new species that looked similar.

Cabras uses a powerful microscope to closely examine beetle specimens.

Mindanao Mimics

There's a species of jewel weevil called *Pachyrhynchus reicherti.* Its black and spotted body has a unique pattern. Its elytra are fused together. It cannot fly. Most predators know to stay away. It's too tough to bite through. Its strong colors and markings indicate that it would be a waste of a hungry predator's time.

When Cabras first spotted *Metapocyrtus willietorresi*—a new species—she mistook it for *Pachyrhynchus recherti.* It has similar colors and markings. It has tough, fused elytra. Neither beetle would make a good meal. So, why was one "copying" the other?

It's all about educating the predators, she says. Warning colors work because predators learn that they represent foul-tasting, dangerous, or even poisonous outcomes. Over many generations, predators learn to stop eating anything that looks a certain way.

In science, this phenomenon is called **Müllerian mimicry.** That's when two equally harmful things have evolved to resemble each other. By having similar colors and patterns, they both stay safe from predators.

It doesn't end there. There's a third beetle to this story: *Doliops daugavpilsi.* This beetle looks a lot like the other two. Except this beetle is not a jewel weevil. It's a longhorn beetle. And though it may look tough like the other two weevils, it isn't. It has a soft shell—one that predators could easily bite through.

By having colors and patterns similar to the weevils, the longhorn stays safe. This is called **Batesian mimicry.** In this form of mimicry, an edible insect with few defenses looks like a dangerous one, so predators stay away.

During her field work, Cabras started finding a lot of beetles that looked similar to each other. "I got fooled many times," says Cabras.

Testing a Theory

Cabras began to wonder if she was the only one being fooled. She wanted to try an experiment. She and her team made fake beetles out of modeling clay. The fake beetles looked like *Pachyrhynchus recherti.* She set them out in places where these beetles were common. She also set them out in places where they were not. Then she set up cameras to see what would happen.

Where the beetles were common, predators avoided the clay beetles. They had learned what those colors and patterns mean. In the places where the beetles were less common, more predators attempted attacks. These predators had not yet learned to stay away.

Cabras still has many questions she wants answers to, and there could be many more new species waiting to be discovered. While her work must be careful and meticulous, Cabras says a lot of land on Mindanao is being cleared away for farming and houses.

"It's really scary for me. As a taxonomist and conservationist, I really do hope to see these beetles in their natural habitats. But in five to 10 years, I'm not really sure if I go back to that area, if I can still find those species. The small area where the four new beetles were found? It is slated to be cleared soon for farmland."

With a sense of urgency, Cabras is doing her best to discover, observe, and document the biodiversity that she sees in Mindanao. She thinks "every taxonomist has a special eye." And for now, Cabras' eyes are trained on weevils.

To test a hypothesis, Cabras used fake beetles made of modeling clay, like the one shown here, to see if predators would react to the beetle's warning colors.

Here are a few examples of the beetles Cabras found during her fieldwork on Mindanao. The mimics strongly resemble their models.

MODEL

Metapocyrtus kitangladensis

MIMIC

Coptorhynchus sp.

Pachyrhynchus tikoi

Metapocyrtus sp.

WORDWISE

aposematism: the advertising by an animal to potential predators that it is not worth attacking or eating; it may use colors, sounds, smells, or other characteristics.

Batesian mimicry: a form of mimicry wherein a harmless species is protected by its resemblance to a species that is harmful to predators

Müllerian mimicry: a form of mimicry wherein two species that are harmful to predators share similar appearances as a shared protected device; if a predator learns to avoid one of the noxious species, it will avoid the mimic species as well.

Seeking Solut

Marissa Cuevas Flores worried about water pollution. She decided to do something about it.

As told to Simone T. Ribke

Q: Let's start by talking about what an environmental scientist is and why you chose to become one.

A: There are two kinds of environmental scientists. Both kinds study the environment to learn how it behaves and how [people] affect it. The first kind just study and observe. The second kind uses the tools of biology, chemistry, and engineering to solve or reverse this damage.

I am the second kind. I needed to have a purpose. If you can't fix the problems you see, it's very hard to stay motivated. For me, science has always been the greatest tool that human beings have.

As you read, think about how people are working to find new ways to protect Earth's resources and environments.

tions

Marissa Cuevas Flores is the founder and CEO of microTERRA based in Mexico.

Q: What environmental problem did you want to focus on?

A: Most of our freshwater—about 70 percent—goes to agriculture. Water runoff from farms is one of the biggest water pollutants on Earth. Yet, we need farms because they provide us with the food we eat. That problem started to roll around in my head because we're not only talking about clean water, we're also talking about feeding 10 billion people.

Agricultural **wastewater** contains high quantities of nitrogen and phosphorus. These **nutrients** are found in fertilizer and animal manure. When they seep into lakes and oceans, they can cause **dead zones.**

Q: What is a dead zone? How can agricultural wastewater cause them?

A: A dead zone is a low oxygen zone in a river, lake, or ocean where nothing can live. [Excess] nutrients from agricultural wastewater cause **microalgae** to grow quickly. Microalgae are tiny plants that live in the water. Like regular plants, microalgae use **photosynthesis** to absorb sunlight and carbon dioxide and turn it into oxygen.

When you add nitrogen and phosphorus to the water, microalgae absorb these nutrients. They quickly grow into a biomass known as an **algae bloom.** Algae blooms turn the water green or red, depending on the strain of the microalgae.

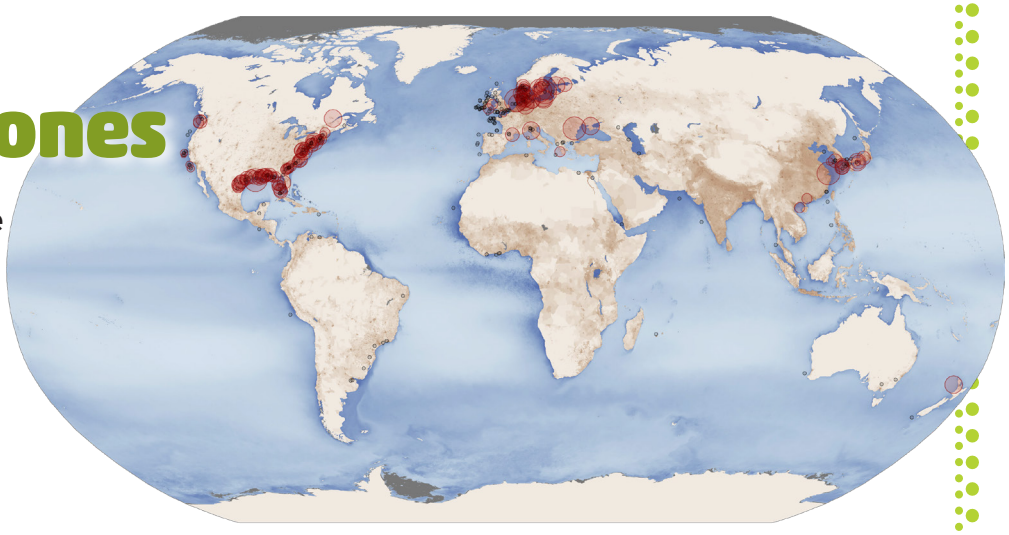
Having so much microalgae in the water is not the harmful thing. The problem starts when these microalgae die. The bacteria that decompose the microalgae absorb a lot of the oxygen from the water. This causes a dead zone.

Q: How did you decide to tackle this problem?

A: I decided that I wanted to find a way to **upcycle** wastewater—to make wastewater reusable. I realized we could use microalgae to clean water polluted by agricultural waste.

FAST FACT:
Each year, 200 million tons of fertilizer are used worldwide on our crops. Yet, it is often applied more heavily than crops can absorb, and it is washed away by rain or irrigation.

Dead Zones



Location and Size
(in square kilometers)
- size unknown
- 1 km²
- 10 km²
- 100 km²
- 1,000 km²
- 10,000 km²

Excess nutrients can lead to excessive growth of algae. Algae can block light that other plants need to grow. When algae die, they decay. Oxygen in the water gets used up as algae decays. Low oxygen levels kill aquatic animals. This cycle can lead to the creation of dead zones. There are **more than 500 dead zones worldwide**.

algae, as seen under a microscope

Q: You started looking at fish farms. What did you learn?

A: I learned aquaculture produces a lot of wastewater. Most fish farmers grow fish in human-made ponds. The fish in these ponds produce so much poop that farmers need to replace all the water in each pond every day. The wastewater they remove from these ponds drains into tributaries, rivers, and oceans.

Q: What else did you learn from the fish farmers?

A: We asked farmers to tell us all about fish farming and learned that 70 percent of their expenses go into feeding their fish. So if there was a way to make fish food cost less, they would be interested.

And that was your aha! moment. You had two environmental problems—aquacultural waste and fish farmers needing cheaper fish food. That's when you created your company, microTERRA.

Fish farms must manage their waste problems as well as keep their fish fed.

Q: You created a company to help solve some of these environmental issues. What does your company do?

A: At microTERRA, we take fish farm wastewater and give it to our microalgae. The microalgae feed on the waste in the water. When they finish eating all the waste, the water can be reused. This saves a lot of water. It also helps stop downstream pollution that will destroy ecosystems.

We use a very particular strain of microalgae. When our microalgae photosynthesizes, it produces protein. We then process the protein from the microalgae into food for the fish.

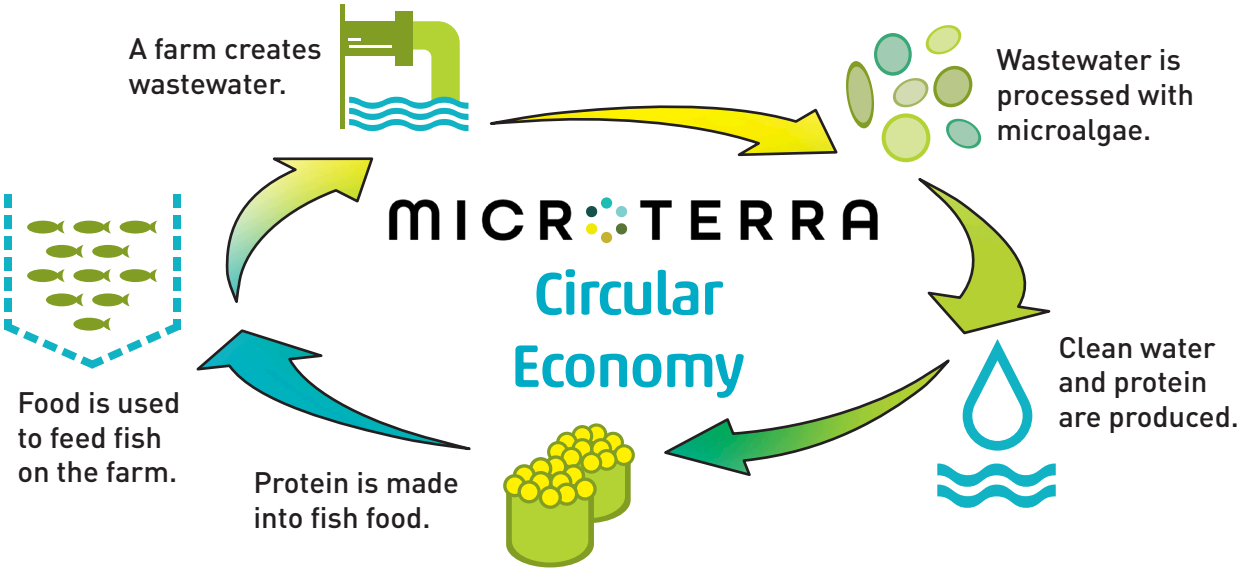
Q: How do you grow the microalgae?

A: Microalgae are microscopic. So, we start in the lab on a small scale. We know from the lab what the microalgae like, what they need to grow, and where they thrive in general. But because we work with farming, we have to scale up a lot because agriculture is huge.

Q: So, to scale it up, you have to grow massive amounts of microalgae?

A: We use a bioreactor. It's basically the house of the microalgae. Our whole system has different parts. We have pretreatment [in the lab]; we have bioreactors where the microalgae grow; and then a harvester to collect the biomass. [Our] challenge was constructing something that can hold large quantities of wastewater. It had to be cheap, easy to manage, and low maintenance.

Flores examines a tank full of wastewater and algae.



Microalgae convert excess nutrients in water into protein and release oxygen.

Q: Is it dangerous to work with wastewater?

A: Wastewater is full of harmful bacteria. We use gloves and try not to touch our faces. We also wear masks. In the lab, we wear gowns in addition to masks and gloves.

Everything [in the lab] has to be disinfected a couple of times. We also use a fancy fan that blows air in one direction so that our microbiology doesn't get contaminated.

Q: Do you have any advice for people who might want to become environmental scientists?

A: I would say to start on small projects. Think of different ways in which you can reduce waste or pollutants. It could be something at home like recycling waste or having a tiny water treatment pond. Every tiny experiment counts! Just remember to tell everyone about what you are doing, because you will find other people are doing similar stuff and maybe you can share ideas and solve problems together.

WORDWISE

algae bloom: a large, harmful amount of algae that suddenly grows in a body of water

dead zone: a low-oxygen area in one of the world's oceans, lakes, or rivers where few organisms can survive

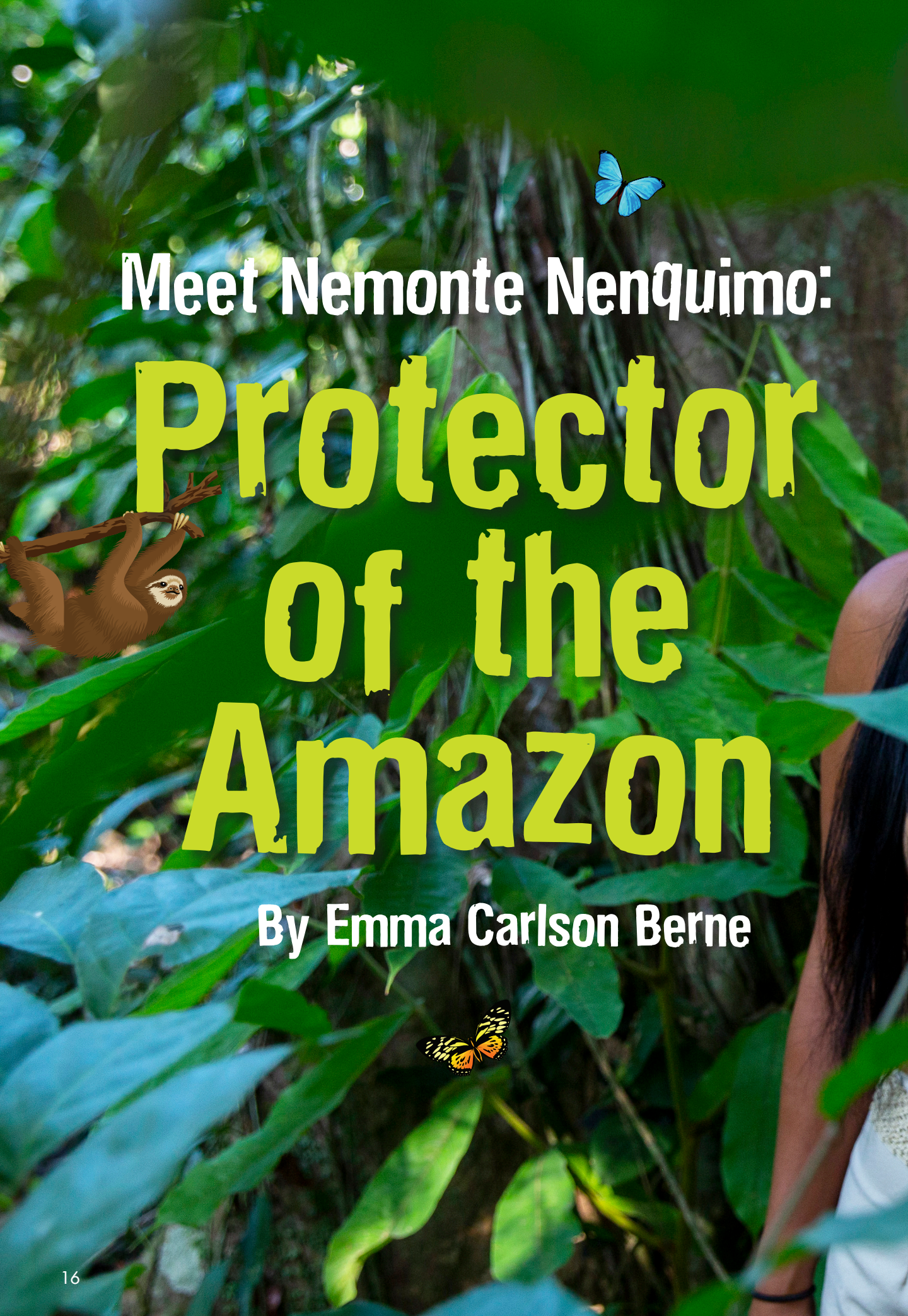
nutrient: a substance that living things need for healthy growth, development, and functioning

microalgae: microscopic organisms typically found in lakes, rivers, and oceans

photosynthesis: the process by which green plants use sunlight to make their own food

upcycle: to recycle a material to make a product that is more valuable than the original

wastewater: any water that has been contaminated by human use



Meet Nemonte Nenquimo: Protector of the Amazon

By Emma Carlson Berne

Human Journey

HUMAN-ENVIRONMENT INTERACTION

As you read, think about the connections the Waorani people have to their land.

Nemonte Nenquimo raises her fist in a sign of defiance at the start of the court hearing in Ecuador.

Nemonte Nenquimo stood under harsh florescent lights in a crowded courtroom in Puyo, Ecuador. She was wearing red face paint and a crown of feathers. Elders carrying spears and large leaves stood beside her. Judges sat at a table in front of them, with lawyers on either side.

Nenquimo is a member of the Waorani nation. For centuries, the Waorani have lived in the rainforests of Ecuador. Now, in 2019, they had journeyed to the city of Puyo to fight for their **culture.** Without their permission, the Ecuadoran government had divided up the Waorani's land. They wanted to auction it off to oil companies who would drill there.

The Waorani fought back. Nenquimo helped her tribe file a **lawsuit** against the government to stop the auction of their ancestral home. The Waorani's lawyers had presented their case. Now, the judges were ready to announce their decision. Nemonte took a deep breath. She squeezed her grandmother's hand. The judge began to speak.

Nemonte Nenquimo is a leader of the Waorani nation.

A Rainforest Home

The Waorani nation are about 5,000 **indigenous people** who live on 2.5 million acres in some of the most biologically diverse rainforest on the planet. Most of their land is in the country of Ecuador, which has the highest number of species by area of any other place on Earth. More than 1,500 species of bird, 300 species of mammal, and more than 840 species of reptile make their home in the forests of Ecuador.

"Our culture comes from the forest," Nenquimo says. "The forest teaches us how to live, and our culture teaches us how to protect the forest." As hunter-gatherers, the Waorani's lives are entwined with the rainforest. Weapons for hunting, such as spears, are made from the wood of peach palm trees. Traditional huts are made of palm leaves and tree trunks. Palm fibers are woven into baskets.

The Waorani have always fought off invaders to their land, as far back as the Inca empire. They kept their distance from strangers. The Waorani did not have significant contact with the outside world until 1958 when an American missionary named Rachel Saint made peaceful contact with them for the first time.

Once contact was established, something was discovered: oil. Namely, deposits of petroleum in the ground under Waorani territory. The oil was valuable and to get at it, oil companies ran roads and pipelines into Waorani land for 50 years. Trees were cut down, destroying ecosystems and animal habitats. For the most part, the oil companies did this without permission from the Waorani.

The Waorani live in the Amazon rainforest.

Drilling Down

In 2012, the government of Ecuador wanted to offer new drilling rights to oil companies. The drilling area included Waorani lands. The government was required by law to explain the pros and cons of oil drilling to the Waorani and other communities. So, government representatives flew into the rainforest and held short, rushed meetings. Many Waorani did not have time to travel by foot or canoe to attend these meetings. The representatives used technical language that was hard for some Waorani to understand. They spoke only about how the oil money would help the community, not hurt it.

Afterward, the Waorani learned that the government had divided up a large section of the Amazon, including their territory. These sections would be auctioned off to oil companies. The Waorani section was number 22.

The Waorani had defended their land from Spanish conquistadores, rubber tappers, and loggers. Now, they needed to defend it again. But first, they needed a leader.

A Leader for Her People

Nemonte Nenquimo is a 35-year-old mother who was born and raised in the Waorani culture. Early in her childhood, her father moved the family to a community deeper in the rainforest. He wanted them to be away from the influence of religious missionaries. Nenquimo's childhood was filled with swimming in the rainforest rivers, picking wild fruit, and listening to her grandmother's and aunt's traditional songs.

Nenquimo's grandfather, Piyemo, was a respected warrior and defender of Waorani territory. Piyemo believed that the rainforest should be protected as an inheritance for his children and grandchildren. From him, Nenquimo learned that the land must be defended against those who do not make their homes there.

Nenquimo learned from her grandmother, too. Women in the Waorani nation have traditionally been the caretakers of the forest. They watch over the plants and animals and tell the men where to hunt and for which animals. Nenquimo was already a community leader. In 2015, she helped lead the Waorani in a project to map their ancestral lands.

Elders, young people, and children worked together to draw and map the sacred waterways, animal breeding sites, burial spots, fruit tree groves, and paintings on their lands. They used both traditional drawing methods, like paper and pencils, and modern devices like GPS and cameras.

These maps would prove to be invaluable in the later fight. They showed the deep relationship the Waorani have to their land and how ingrained it is in their culture.

Twelve communities elected Nenquimo and four other women to lead the lawsuit. It argued that the government had not gotten the free agreement of the Waorani, which was required by law. The planned auctioning of the lands was illegal. "The government tried to sell our lands to the oil companies without our permission," Nenquimo said later. "Our rainforest is our life. We decide what happens in our lands. We will never sell our rainforest to the oil companies."

On February 27, 2019, the Waorani officially sued the government of Ecuador. They did not know if they would succeed. But, they knew they had to try.

Surrounded by her people, Nenquimo speaks to reporters about the court case.

In Court

On April 11, 2019, hundreds of Waorani people marched through the streets of Puyo on their way to the courthouse for the start of the court case. They wore traditional clothes made of palm leaves. Their faces and arms were adorned with paint used for battle and special occasions. They carried spears and leaves from the rainforest.

As they walked, they sang their traditional songs. They wanted people to see their pride in their culture. Nenquimo walked at the front, her arms linked with other women. She was very proud to be a Waorani woman. She felt like a warrior that day, she remembered later. Her face paint, the traditional crown on her head, and the papers in her hand were her weapons.

Inside the courtroom, the Waorani and their lawyers presented their case to three judges. Nenquimo stood up in front of the judges. Her grandmother stood beside her. Their spokesperson presented their maps.

The maps would help the judges understand the Waorani's relationship to their land. Over the next two weeks, elders would give testimony. Proof of the oil pollution in the forest would be presented.

The Ruling

On April 26, the judges were ready to announce their decision. Nenquimo held her grandmother's hand tightly. For five hours, the judge spoke. He said that the government had not tried to understand the Waorani and their culture. The meeting the government had with the Waorani during their short 2012 visit was not enough for the Waorani to give their free consent to the auctioning of the lands.

The judge gave the verdict: The land was to be protected. The Waorani had won their lawsuit. Their land would not be auctioned to the oil companies. Inside the courtroom, the Waorani burst into song.

Nenquimo remembers that the room was filled with emotion and music. Her grandmother began to sing a song celebrating their origins in the rainforest and their joy at a healthy future for their children.

Outside, they paraded through the streets. Rain began to pour down. For the Waorani, rain has always been a sign that nature was celebrating a war victory. Nature gives the Waorani strength, Nenquimo says, and nature was happy for them that day.

The ruling created a precedent, one of the Waorani's lawyers said. Other indigenous Amazonian people could use this case as an example if they wanted to bring lawsuits of their own. It was a great victory, but Nenquimo's work is not done. She is now focusing on the education of the Waorani children. "Let the children learn from their culture, from their roots and language, and let them maintain the connection to the rainforest," Nenquimo says.

She wants to create jobs in their communities, so young people will stay on the land. She wants to protect and teach the Waorani language. At the same time, Nenquimo knows young people must also learn the tools of the outside world. That way, they can carry on the fight to protect the Waorani lands and culture, just as she has done.

WORDWISE

culture: a pattern of behavior shared by a society or group of people; many different things make up a society's culture. These things include food, language, clothing, tools, music, arts, customs, beliefs and religion.

indigenous people: the first people who lived in any region, before later immigrants

lawsuit: a process during which a disagreement between people or organizations is decided in court

Nenquimo and other leaders celebrate their court victory.

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Cover: portraits of Annalyn Cabras, Marissa Cuevas Flores, and Nemonte Nenquimo

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