

## CONVERSATION

## In the field: an interview with Martha Muñoz

Martha Muñoz is an Assistant Professor at Yale University, USA, investigating the evolutionary biology of anole lizards and lungless salamanders. After completing her Biology degree at Boston University, USA, a Fulbright Scholarship at the National Museum of Natural Sciences, Spain, and a PhD with Jonathan Losos at Harvard University, USA, Muñoz worked as a post-doc with Craig Moritz at The Australian National University and then Sheila Patek at Duke University, USA. She joined the Department of Biological Sciences, Virginia Tech as an Assistant Professor, before moving to Yale University in 2019. Muñoz talks about her fieldwork in Indonesia, Costa Rica, the Dominican Republic and the Appalachian Mountains, USA, including a death-defying dash to the top of a 2500 m mountain in the Caribbean through an approaching hurricane.

### When did you discover your passion for science?

I've always been obsessed with nature and science. It goes back as far as I can remember. Some of my earliest memories were in the American Museum of Natural History and the Bronx Zoo in New York. I remember when the hall of biodiversity opened in the Natural History Museum, showcasing how wildly different life forms can be. This hall was not so far from the hall of New York state environment. I was struck that many types of habitats have trees, plants and animals, but can still be very different. I was already starting to think comparatively, in a way that was facilitated by how the museum designed its exhibits. In addition, going to the Bronx Zoo was free one day of the week, so sometimes my mother would let me play hooky from school and we would go there. I would always drag her to the reptile house, because I found the organisms to be the most alien and exotic. I didn't really see reptiles in the city, so I always insisted we go there.

### Can you tell us about your education?

I didn't know that I could be a scientist when I was a child. My family immigrated to the US from Cuba and dealt with poverty, both in Cuba and the US, so there was always a strong emphasis on getting a well-respected, well-paid job. In my home that meant becoming either a doctor or a lawyer. I spent a lot of my childhood watching nature documentaries with my dad, so I wanted to become a wildlife veterinarian, because they often accompany the photographers and videographers on documentaries. But within about 10 days of arriving at Boston University, USA, I dropped the pre-veterinary track and decided I was going to become an evolutionary biologist, which my family initially thought was not a great idea. They didn't know what being a scientist meant and it sounded like a risk, but once I found the role I didn't look back. After I got into a PhD programme, my family saw that I was serious about it and they turned around completely. They always were and continue to be my biggest supporters.



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### What was your first fieldwork experience?

My first expedition was on a live-aboard boat as part of a research team in the Indo Pacific sampling the genetic diversity of the animals at the end of my sophomore [second] year. The PI was Paul Barber, who was on the faculty at Boston University when I was an undergrad. There were about 10 of us and we went around the island of Halmahera, Indonesia, for a few weeks, stopping periodically to go SCUBA diving and snorkelling to collect tissue from coral reef organisms. I had already learned to dive during an elective as part of my undergraduate training and became certified just in time for the trip.

### How much did fieldwork figure in your PhD?

Fieldwork was a huge part of my PhD. I got into Jonathan Losos's lab at Harvard University, USA. I really loved his work on anoles and I thought he was the perfect combination of an ecologist, evolutionary and organismal biologist that was essentially the combination of who I wanted to be. Before I even set foot on the Harvard campus, he sent me off to Costa Rica to join a team of researchers led by Anthony Herrel, a postdoc in his lab. I went

Martha Muñoz works in the Department of Ecology and Evolutionary Biology, Yale University, 165 Prospect Street, New Haven, CT 06520-8106, USA.



Martha Muñoz performing a thermal physiology experiment in a hostel room in the Dominican Republic. Photo credit: M. Stimola.

from having been stuck in a city to living in the rainforest of Costa Rica. It was a dream come true, a completely transformative experience.

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I learned how to do behavioural observations on anole lizards. We were staying at the Organisation for Tropical Studies (OTS) for five weeks or so, but we went to three different sites in the area that varied in their overall forest structure, moisture and temperature, and in the species of anoles found there. On a typical day, we got up pretty early and went out with our gear and video cameras along designated trails to watch anoles. Whenever we spotted one, we would stop, set up the camera, record the lizard and follow it around as quietly as possible for 30 minutes. We dictated our observations onto the video, talking about the things we saw that might not be visible from the playback. Then we always tried to catch the lizard, to bring it back for Anthony to look at. He and other members of the team would record the lizards sprinting at different temperatures and they would get bite force measurements. They also took body size and shape measurements using digital callipers and they also took samples for gut content analysis. I got to see an entire workflow. Afterwards, we released the lizards back at their site of capture. And that was just the beginning of my graduate studies. Fieldwork was, and continues to be, an enormous component of what I do.

### How many field sites do you currently work at?

It depends on the project, but I have maybe close to 20 in the Dominican Republic and dozens in the Appalachian Mountains. The idea behind both of these projects is to understand the behavioural, morphological and physiological diversity of lineages. In order to do that, you need to sample lots of species and often, so no matter how extensive their ranges, we go to find them there. For example, there is a species of salamander that you can only find in Arkansas and Oklahoma, so that's where we go when we need to look at them. Others can only be found in certain mountaintops or chains of mountains, like the Blue Ridge Mountains, USA, while others can only be found at higher latitudes. We go wherever the salamanders are.

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### Why did you choose the Dominican Republic for one of your fieldwork areas?

I became really interested in temperature and thinking about how organisms interact with temperature, so that drew me to the Caribbean because much of the foundational work that had been done on thermoregulation and lizards, in anoles in particular, was done there by Ray Huey, Paul Hertz, Ernest Williams, Stan Rand and Rodolfo Ruibal. I wanted to start walking in the footsteps of people who had already done research in the system to see if I could see what they saw, to go through the sanity check that my ideas were on the right track. Ray Huey and Paul Hertz focused on the Dominican Republic on the Caribbean Island of Hispaniola in the early 1980s and, remarkably, found similar body temperatures between anoles at sea level and more than two kilometres above sea level. I was stunned by this observation. These anoles are tiny little ectotherms and they cannot physically regulate temperature in the way that we do. Maintaining the same body temperature in environments that can differ by more than 20°C in mean annual temperature is dramatic. To get that kind of thermal variation across an island you have to work in Hispaniola, because it's the tallest island in the Caribbean, so that's where the majority of my work has been.

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### How do you setup for fieldwork there?

It would have been lovely to have a lab at the beginning, but I started out with a way lower budget. We were going to the Dominican Republic on a shoestring, so the hostel was the lab. We would bring all of our gear with us and work in the hotel room where we were staying, which led to some hilarious stories. In the early days there would be two of us in a room. We each had a bed and all of our equipment lived wherever it could between us. During the morning the beds became storage spaces and suitcases and coolers would get co-opted into lab benches to do experiments. It was very tight, but we made it work. Fortunately, the experiments that we use to measure the thermal physiology of anoles are incredibly field friendly. With a little bit of planning and relatively simple equipment you can measure lizards in the wild, or a hostel room. That means that we can visit a lot of different sites on a single trip and get data from a lot of species.

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### What sort of equipment do you take with you?

Let's talk about cold tolerance, which refers to the temperature at which locomotion ceases. We measure this is by systematically cooling a lizard by about 1°C min<sup>-1</sup> and then turning the animal onto its back before prodding it with a pair of blunt tweezers to encourage the lizard to flip back over. We record the temperature at which it loses the ability to flip back as its critical thermal minimum,

meaning the temperature at which it loses its locomotor ability. To measure cold tolerance, we need a temperature logger, which records temperature from a thermocouple made of incredibly thin wires that you put into the cloaca of a lizard and hold it in place using a bit of medical tape. The other part of the setup involves an insulated bucket, which we bring to the field with us, and ice, which we have to get there. Honestly, ice is sometimes the hardest thing to find. Often we'll be in villages that do not have ice, no stores that sell it and no infrastructure to maintain frozen water. On one occasion, an assistant, Asa Conover, spent a morning scouring a village for anyone who might have ice. At this point, we were starting to get desperate. Eventually, Asa found a guy who had a freezer and was willing to sell ice, except it came in a gigantic solid block and Asa hadn't brought a sack with him to carry it. So, he took his own shirt, wrapped it around the giant block of ice before running about a kilometre through the town and up the hill to get it to us. The simplest things can be a challenge, but you can almost always find a solution.

### How do you access your Dominican Republic field sites?

We use vehicles and I insist on a four by four, because some of the scariest things that have happened to me in the field have involved vehicles and the difficulties of getting to and from certain sites. We do a lot of scouting beforehand, but we often pop flat tyres or hit vegetation and rocks. Things just happen when roads are terrible, or they don't really exist. But even in the remotest places where you don't think there is a soul around, we always get help. People come out of the mountainside to help. They're farming, you just don't see them, but the minute they see someone in trouble, they come out of absolutely everywhere to try to help. It's amazing.

For a long time, I have been making the case that we should be doing a lot more herpetology on horseback. A mule can get anywhere. I did some horseback herpetology in my free time when I was in Costa Rica. You see animals that you don't see on the ground because you're 10 feet up. For example, I saw a snake in the trees hunting another snake. I would never have seen it on the ground and we wouldn't be popping tyres if we carried all our stuff on mules. If I could get mules in the Caribbean as easily as I can get cars, I would do much more fieldwork by mule.

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### Where do you study lungless salamanders?

We work in all the places where lungless salamanders are found in the eastern US, so our sites range from Connecticut to Arkansas, about 1400 miles apart. We have dozens of locations. Lungless salamanders require access to moisture, they need to stay wet because they're amphibians and their skin is their respiratory surface. They're tied to forest regions, but the sites can vary in overall forest structure and canopy cover. The salamanders are nocturnal, so you have to go out at night, which is quite different from the anoles, which are up with sun and down with last light. In

the right conditions the salamanders will be active on vegetation or the ground, but if not, you can often find them by flipping over rocks and logs, and they love to be under moist vegetation. Usually, before we go on a field trip, we contact colleagues or collaborators at local campuses and ask them if they want to join us or if they have a student that would want to come along. It's a great way to share information and we get to go out with someone who knows the local organisms a bit better. This also helps us get information about which sites we should visit and which we should avoid because salamanders are rare.

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### Have you ever been caught in a tropical storm?

Yes, we try not to do fieldwork in the Caribbean past August, because that's when hurricane season starts to kick into gear. One time, it was early August and I had to get to a site near Valle Nuevo in the Dominican Republic for the last big sampling push to take animals back to the US. Everything was leading up to this. Then, a big hurricane hit and we had to rush up the mountain on the arriving edge of the storm. The rain had started, but we weren't near the full intensity of the winds yet. By the time we got to the mountain, the road that had been there two weeks earlier had been washed out in the centre, creating a gully a few feet wide and about a foot and a half deep. My collaborator, Miguel Landestoy, was driving. We made it up the mountain by having our tyres on either side of this big gulf while water was flowing through it at full force. It was terrifying because what if the gully didn't end? We had to trust that at some point the road would link back up again, or else how do we turn around? We went all the way to the top, got the animals we needed, turned around and came back down the same road. It was one of the most terrifying experiences and the longest six hours of my life, but at the time I was 25 and invincible. I would have told you I wasn't risking my life. In retrospect, I think that what we did was wild, but at the top of the mountain was a species of anole lizard, *Anolis shrevei*, that can only be found there, nowhere else, and that's what we were searching for. I've gotten more cautious with age.

### Does speaking a second language help when you're working in the Caribbean?

Immensely. My family is Cuban and I grew up in New York City in a community with many Dominicans and Puerto Ricans. Caribbean culture in NYC is amazing and is a huge part of who I am and how I approach the world. In addition to already knowing the language, working in the Dominican Republic feels, in a way, like coming home. Everything feels familiar and comfortable. Sometimes I feel more at ease doing fieldwork in the Caribbean than I do on a university campus.

Martha Muñoz was interviewed by Kathryn Knight. The interview has been edited and condensed with the interviewee's approval.