

CONVERSATION

In the field: an interview with Marie Dacke

Marie Dacke is a Professor at Lund University, Sweden, where she investigates visual adaptations and navigation by insects. After completing her BSc in Lund University and a PhD with Dan-Eric Nilsson at the same institute, she worked as a post-doctoral researcher with Mandyam Srinivasan at the Australian National University, before joining the Vision Group at Lund University as an Assistant Professor. Dacke talks about her earliest experiences of working with dung beetles in South Africa, establishing a new field site in Sardinia, Italy, and the pivotal experiments that confirmed that dung beetles can navigate by star light.

How did you first become interested in dung beetles?

Dung beetles are incredibly charismatic, but that is not the main reason why I'm interested in them. When I was a PhD student, I was working on the use of polarised light for navigation in spiders. At that time, one of my colleagues, Peter Nordström, was working on the visual ecology of beetles, and it seemed like the beetles could use polarised light. This was an assumption made after revealing some polarization-sensitive visual cells in their eyes. So, my fantastically adventurous supervisors suggested that Peter and I went to South Africa together to look into this possibility. I joined Peter on a trip in 1998 and found the animals deeply fascinating. Today they are my main model organism to understand navigation.

Can you tell us about your first field trip to work with dung beetles?

We went to work with Clarke Scholtz from Pretoria University, South Africa, who has devoted his career to working in the field and to understanding how dung beetles are related to each other; he was a fantastic person to go with. We went to a very remote part of northwest South Africa called Namaqualand, which is an arid area where we were looking into homing dung beetles; they go out foraging and then return home. We stayed in a house in a mining town and drove out to the desert each day in a big four-wheel drive vehicle so that we were there when the beetles woke up. In the morning it was cold and very wet, but on the second day I thought, 'this is what I want to do'; it was a very distinct moment in my career.

It took about an hour to get to the field in the morning and an hour back in the evening. Driving on sand is a bit like driving on snow, which I have done all my life. Clarke knew where the beetles usually were. We wanted to understand how these flightless dung beetles found their way back to their nest after they had been foraging. Much of this work was inspired by Rüdiger Wehner's work on *Cataglyphis* ants. We used mirrors and shading boards to artificially move the sun to the opposite side of the sky, and we had different obstacles that we put in their path to see how they would react if we forced them to move off-course. All of us were very new to doing these types of experiments; I had zero field experience, Peter hadn't done experiments like this before and Clarke was primarily used to collecting beetles. Over 3 weeks, we learned that we couldn't stand



in front of the burrow, because the beetles wouldn't come out; we had to stand behind the beetles once they were out, so they couldn't see us; and we had to move very slowly, like a slow-motion film. Then, we built big arenas out of plastic garden screens to keep the beetles in and realised that we could inspire them to dig in certain places by watering the ground. We had arrived not knowing what we would be working with to having established an efficient method of working. You build on this knowledge on your next trip. We managed to show that beetles have a compass, they know distance and they use the sun as one of the cues to orient by.

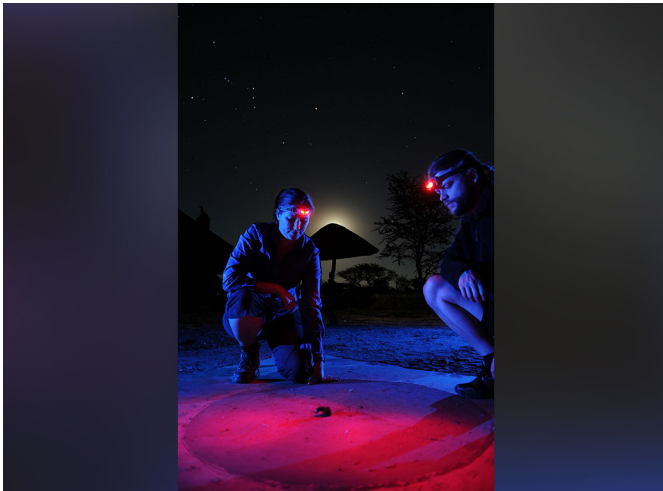
How did you discover the ball-rolling dung beetles that you work with now?

This was through research connections. Eric Warrant, my co-supervisor at Lund University, had been at a conference with one of Clarke's previous PhD students, Marcus Byrne. They had been out collecting beetles together and started to discuss how the dung beetles that they found are able to roll dung balls in such straight lines. Through word of mouth, I ended up in Marcus's office. We have worked together for over 20 years since and are the best of friends, but we still haven't fully answered the question.

How many field sites do you work at?

Currently we have three field sites. We have been going back to Stonehenge, which is a cattle farm near Vryburg in South Africa, for 15 years. And then we started working in a South African town called Bela Bela about 7 years ago. We also have a field site on Sardinia, Italy, which we started working at 2 years ago. Normally we make two 3- to 4-week field trips to South Africa each year and then we go for 3 weeks to Sardinia, which became our backup during the COVID-19 pandemic.

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Jochen Smolka and Marie Dacke watching a dung beetle navigating by star light. Photo credit: Chris Collingridge.

What are the key skills that are necessary to be a successful field scientist?

You need creativity, a love of nature and you have to be able to have fun in the field, even when things go wrong or when the conditions are really horrible. If you can't find new energy by just enjoying it and laughing, it's very difficult to push through. I think there were 14 people on our biggest field trips. The camp is alive 24 hours a day, with researchers doing experiments, bats in the bathrooms, beetles in our pillowcases, rats stealing our food and monkeys taking mangoes. If you're afraid of or disturbed by situations like that, it becomes very complicated.

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How do you prepare for a field trip?

It takes at least 2 months to discuss, design and prepare all the experiments, to decide how many beetles we will need and what we are going to do. We print out all the experimental plans on laminated A3 pages, so everyone can see what everyone else is doing and how we are progressing. Otherwise, you risk forgetting about small, but highly important, details of your data collection when in the field. I start every day by walking through this wall of experimental aims, so I don't lose track of why we are there. It takes a long time to plan before we go, but once in the field we do not want to waste valuable time building equipment and designing experiments. Being organised and having the weather on your side are key for a successful field trip.

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Can you tell me about your camp near Vryburg and the logistics of working there?

Stonehenge, near Vryburg, is the most remote of our field sites and the one that we have been at the longest. It is also a game park, which has a hunters' camp, so there are big army-style tents with concrete floors. We stay there in their summer when hunting is not allowed, because that's when the animals are giving birth. The camp has gas, fridges and solar-powered electricity, as well as toilets attached to the tents. People that work on the nearby cattle farm come to the camp in the morning to clean and make the beds, but then we are alone for the rest of the time, so we do all our own cooking. Normally, we fly into Johannesburg, South Africa, on an overnight flight and then we have a 6–8 hour drive to Vryburg in one or two cars with a trailer. There, we stop at a supermarket, fill several trolleys with enough food for 1 to 2 weeks, before packing the cars and trailer and hoping that the eggs will make it on the gravel roads for the last 80 km. We can only have eight people at this particular camp and it only has a little gas stove. Our other field site in Bela Bela can accommodate more people and is better equipped.

How do you integrate with the community and build contacts?

We get to know the people who live and work on and around the farm and we also go to cattle auctions to make sure we have a good network in the area. By now, we have become part of the local community, which is important, because sometimes we can't find the dung beetle species that we were hoping to study in their usual place. Then, we need to make sure that other farmers and workers in the area know who we are, because we cannot go onto their farms without permission. Our local contacts also help our research in several ways. They repair equipment for us; they clear parking lots if we need big areas without grass; they bring us wood; and they save us from making the 6 hour round trip to the city by lending us the things we need. Being part of this local community saves us time, gives us local knowledge and helps us to locate our beetles. I also get the impression that we provide entertainment in an area where few things happen. We make a point of giving talks at, for example, the local tennis club, so the community knows who we are; that way we get the best possible help from them, and they learn about the nature around them. People might drive 200 km to listen to us.

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What are the main field tools that you use when investigating dung beetle navigation?

We take cameras for documenting the beetles' behavioural responses to our experiments, tripods and batteries are incredibly important and so are headlamps that produce red light, which the animals cannot see. Nowadays you can buy red headlamps but, in the beginning, we used filters to make them red. We often used to get headaches from these headlamps because they were too tight and too heavy. It sounds like a silly thing, but if you carry a headlamp for 12 hours and you get a headache every night, it's a work problem. We also bring blank data sheets, because we can't print anything when we are in the field. It's hot and sandy, so electronic equipment often breaks or shuts down and many times we can't charge computers because we only have solar power. In short, we have to be prepared to work without any electronic support when necessary.

What risks do you face in the field and how do you mitigate them?

There are a few, such as dehydration. To counteract the effects of working in the sun when the temperatures are above 40°C, we all have a rehydration drink at lunch to prevent fatigue or even fainting. The animals around us are a risk too, so we wear long trousers and boots and good mosquito spray. If there is a snake, you walk away from it. Thirdly, we risk getting lost because the paddocks where we collect the animals are big: a kilometre wide. We carry compasses and a whistle around our neck, so we can signal ‘I am lost’, ‘Can you hear me?’ or ‘We are here’, using a very simple code. We can’t use phones because the reception is too bad. I have been lost and found, which was good! And then we are also at risk of crime in South Africa, so we never move around city areas when it’s dark, but out in the countryside it is fine.

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I think we can reduce it somewhat by being in the field for a long period of time, rather than making several shorter visits. In that way we get the most experimental hours per journey. When we are in the field we use mostly natural resources; there are basically no other alternatives, so that is good for our carbon footprint. Taking the train when possible is a given, but unfortunately not to South Africa. We also do not drive back and forth from our camps more than we need.

How was your research affected by the COVID-19 pandemic?

Our first cancelled trip was in November 2020. Luckily, Marcus is based in Johannesburg, and our colleague Claudia Tocco was then a postdoc with him. We decided that they would go into the field, collect the beetles and then send them to Sweden. In anticipation of the travel bans imposed by governments in response to the pandemic, we had expanded our indoor labs in Sweden. After 4 weeks, the beetles arrived on the 20th December. People took Christmas Eve and Christmas Day off, but otherwise we were in the lab with masks and visors throughout the holidays. After that, Marcus and Claudia sent us beetles twice a year throughout the pandemic. That allowed us to approach questions that otherwise would have waited and it revealed amazing results from different perspectives than we would have taken if we could have gone to the field. Our indoor labs are now a fantastic asset for us. Sometimes

change is for the good, even though the reason for the change in this case was horrible. When forced to approach our experimental questions in a different way, this opened new horizons and allowed the PhD students to progress their work throughout the pandemic.

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When we talk about a field station, we are referring to a good place to stay where the owners allow us to work with dung and sand and they don’t mind us being up 24 hours a day. In South Africa, such a place is relatively easy to find, but in Italy, it was slightly harder. Luckily, Claudia is Italian and acted as our interpreter. Once a site for our temporary field station has been located, we need to visit several places in the area to learn where to best find our beetles. Everything that we need for our experiments is brought in trailers and these are currently stored with Claudia’s uncle, who happens to live in Sardinia. Again, a local network is invaluable.

What was your best field experience?

I think it was in 2010 in Vryburg, when we were looking at whether the beetles could orient using stars. We were working every night, which is amazing in itself, but then we needed overcast conditions to make sure that the beetles were actually orienting by the stars themselves. However, we avoid doing fieldwork during the rainy season, so we do not usually experience overcast weather in South Africa. I was sleeping in my tent at night with my head against the net. I woke up and realised that I couldn’t see the moon. It was overcast, so I shrieked. I woke up Emily Baird, who was in my tent, and I said, ‘we need to do experiments’. She just jumped out of bed and we ran yelling into Eric and Marcus’s tent. Two seconds later they were also up and then we all ran around like crazy, setting everything up and running experiments, wearing whatever clothing we could find. We realised that the beetles were lost when they couldn’t see the stars: they needed the image of the stars to navigate. It was just magical, and I realised that if you didn’t enjoy this kind of fieldwork, you couldn’t be out of bed in 5 seconds and make the sacrifices that we do.

Marie Dacke was interviewed by Kathryn Knight. The interview has been edited and condensed with the interviewee’s approval.