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CONVERSATION

In the field: an interview with Harald Wolf

Harald Wolf has recently retired as a Professor at the University of Ulm, Germany, where he investigated navigation, locomotor control and sensorimotor integration in invertebrates. After completing his diploma in biology in 1980 at the Technical University Darmstadt, Germany, he undertook a PhD with Otto von Helversen at Erlangen University, Germany, and postdocs with Keir Pearson at Edmonton University, Canada, and Werner Rathmayer at Constance University, Germany. He then received a Heisenberg Fellowship to complete research at Constance University and the California Institute of Technology, USA, before completing a 2-year lectureship at the University of Zurich, Switzerland.

When did you discover your passion for science?

At high school I was probably most interested in physics and geology, but also biology because we had a good teacher. In the end, I decided to study biology at the Technical University of Darmstadt and I was supported by the German Academic Scholarship Foundation, which provided additional teaching during the summer break in a resort in the Alps, where I met Otto von Helversen, a nectar bat researcher then at Freiburg University, Germany. At that time, it was common for many biology students in Germany to go on to do a PhD, so I joined his group, which was also working on grasshopper acoustic communication. Most of my PhD research was based in the lab, but I did some experiments out in the field, although recording the communication calls of grasshoppers in Germany doesn't feel like 'proper' fieldwork.

Then, in 1982, I had a really great experience in Venezuela. Otto went to a congress in Caracas and the group joined him later. We stayed in the cloud forest for 6 weeks to study flower-pollinating nectar bats. Being high up in the mountains was a great experience. It's foggy, which provides moisture for the trees and vegetation, and it was close to the coast. The station where we stayed was called Rancho Grande and it was close to a pass high in the mountains. There was an old hotel that was never finished; part of it had been turned into a museum and field accommodation. We lived in the abandoned hotel rooms, but we stayed in our tents with sleeping bags because the rooms were never completed. At least we were sheltered from the rain. The hotel had two stories but the staircase was never built and there were just steel girders that were intended to carry the concrete, so we had to balance across the beams to go to the rooms where we kept the bats, which we had captured elsewhere in the forest, in net cages.

We had to balance across the beams to go to the rooms where we kept the bats

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What questions were you investigating in Venezuela?

Otto wanted to know about the metabolism and water balance of these nectar-drinking bats, but you cannot just put them into a closed chamber to measure carbon dioxide production, so we injected the animals with doubly labelled water – that is water with O^{18} instead of O^{16} and deuterium (H^2) for hydrogen – because we wanted to measure metabolism during normal foraging. Water is excreted by the animal through the kidneys, so we knew the water balance of the animal and the oxygen that was used by the metabolism to produce carbon dioxide. To find the bats, we crawled around places where they might be during the day and collected them by hand. Sometimes we also used mist nets in front of caves. Then we would mark them and take a small blood sample, which is difficult using syringes; even the smallest cannulas are too large for these tiny animals. Instead, we used bugs, and I mean true bugs that suck blood. Once the bug was full, we cut off its head and squeezed out the blood to get a blood sample.

We discovered that the bats have to pee more than their body mass per day. That field trip opened my eyes to the fact that if you want to investigate an animal to understand how it works, you have to look at what it's doing in its natural environment, because it's adapted to that lifestyle. Then you can ask the right questions about the animal and why it is working in that way. For example, how much nectar does a bat need to drink to support its metabolism in flight, can it rid itself of that amount of water, and how far does it have to fly to acquire that nectar in the first place? I think this field trip really changed my view of things.

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Harald Wolf at the Chott el Dherid saltpan with a *Cataglyphis fortis* nest in the background. Photo credit: Matthias Wittlinger.

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How did you end up working on scorpions in California?

I started working on scorpions in the late 1990s during a visit to the lab of Gilles Laurent, who was working on grasshoppers at the California Institute of Technology (Caltech), USA. I stayed there for almost a year as a postdoc. At that time, I was working on inhibitory motor neurons in insects, investigating them from an evolutionary perspective, and I thought it would be interesting to have an outgroup comparison; nobody had looked at that before. I decided to look at chelicerates and then I thought of scorpions, because I was in California and they are quite easy to catch and handle. A friend showed me how to use 'black light' (UV-A) in the desert to find scorpions because it makes them fluoresce. The main risk when you are hunting for scorpions is that rattlesnakes do not fluoresce, so you really need to wear high boots and make sure you don't step on a snake. Then, when you find a scorpion, you use a long forceps with a little fluorescent pigment on the tips to catch the animal at the stinger, so you don't injure it, and you put it in a little box or a ziplock bag to make it feel safe. My colleague helped me to catch about 100 scorpions and then I infused a marker substance into severed neuronal axons to backfill the motor neurons for later microscopic inspection at Caltech. I also brought approximately 150 scorpions back to Germany in my backpack to continue the experiments. Back then, transporting them on the plane was not exactly prohibited and the scorpions were not dangerously poisonous, but I certainly kept my backpack under tight control during the flight!

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At what point did you become interested in desert ants?

I have to credit Rüdiger Wehner from the University of Zürich, Switzerland, for my interest in desert ants. He is a *Cataglyphis* desert ant researcher and, at the time, I was wondering whether I should stay in science; the chances of being successful were, and still are, slim. He offered me a guest professorship for a year. I joined him in Zurich and my interest in desert ants started then. I think he was interested in my research because I had been working on motor control in locust and stick insect walking, so I guess he thought I might fit in and elaborate a little on the odometer that the insects use for navigation, which is what I did.

How do you travel to your field site in Tunisia?

We travel to the small village of Mahres, which is south of the port of Sfax, Tunisia's second largest city. There are two ways to get to Mahres. One is to fly to Tunis and take a train or taxi, but when the group travels as a whole we take a large car, such as a VW Caddy Maxi – Rüdiger used to have a Jeep – and we put all the stuff from the lab into it. Then we depart in the late evening and drive down through the Alps to Genoa in Italy. The ferry then leaves around noon, so we sleep on the boat and then it arrives the next morning in Tunis. After that, there is another 3 to 4 h drive. We transport the equipment that we can't leave in Mahres because we need it at home; things such as the high-speed camera and the paints that we use to mark the animals, which dry up in the desert heat, so we always buy new ones. And we take the things we need to live there, such as sleeping bags, and stay in a rented apartment. We also keep a lot of equipment in Mahres in a garage. We have been leaving stuff there for about 50 years. For example, we keep the metal channels that we use for measuring the ants' distance gauge – their odometer – there.

Can you describe a typical day in the desert?

You have to make sure that you drink enough because you're out in the sun, so you have to check that you are peeing enough. You should drink at least 4, possibly 6 litres a day when working outside. And, of course, you need good sunscreen, light long-sleeved tops, long trousers and a hat, too. Typically, we get up early, because the ants leave their nest and start foraging at about seven o'clock in the morning. We prepare most things the evening before, such as the experimental paraphernalia and our food and drink. We do our experiments through the hottest part of the day at high noon, because the ants are diurnal foragers and they are most active when predators such as lizards and geckos are hiding in cooler places. Also, there aren't many competitors around then for the insects that succumb to the desert heat and other small carcasses. The ants live in a heat niche.

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When we set up an experiment, we might lay out the aluminium channels between a nest and a feeder, say 20 m north of the nest. We mark the ants visiting the feeder through the channel with a paint dot, so we know who they are and what their experience of the experiment has been at any stage, and then we start with the experimental manipulations. We may alter leg length to study odometry, or cover part of the eyes, because optic flow also plays a role in gauging distance. Usually, we finish work at about four or five in the evening. One species that we study, *Cataglyphis bicolor*, lives in town, so we just go to the outskirts of the village, but the real saltpan desert ants, *Cataglyphis fortis*, live close to the coast where it is very flat and gets flooded by the sea. Strong winter winds drive

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water 50–100 m onto the land, producing conditions like those in a saltpan, so we only have to go a few kilometres out of town to locate the perfect habitat.

How do you capture the ants?

Catching them without killing or injuring them is the main problem. We cut the bottom out of a plastic bowl to make a 30–50 cm ring that we can place around an ant to trap it. Then we pick it up with our fingers by a couple of legs; they try to bite, but they aren't strong enough to do anything to our skin. Then we apply little coloured dots of paint to the abdomen using a staple. If we cover the eyes, we need a dissection microscope and we secure the animal with dental wax while we apply the paint. We never cover the eyes completely, because then the animals would not leave the nest, because they think it's dark outside. We leave the dorsal rim area of the eye open, so that they can read the pattern of polarised light in the sky, which they use as a compass. Then they are fine and they behave and navigate quite normally.

How large are your field teams and when do you go to the desert?

There may be between two and five students, depending on their experience, and then there is always an experienced postdoc, such as my colleague Sarah Pfeffer. Usually, I try to join the group for a brief time. The number of experiments that we can do depends on the number of PhD students that join the group. Usually, we go to Mahres during the summer, although we can start as early as May, but that is the earliest because occasionally it can still rain at that time of year. Then we can't use the field site for a few days, because it is muddy, so we waste some of our fieldwork time. We stay until late August or the beginning of September. After that, it starts to rain again and the animals begin retreating underground for winter, so that's the end of the season.

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What contingencies do you prepare for before embarking on a field trip?

You need to plan for worst-case scenarios. You have to have health insurance, of course, but there are supermarkets and garages to fix your car if something goes wrong, so it isn't too bad. You should also have all of your vaccinations. I'm diabetic, so I always have lots of glucose with me plus the usual diabetic medication. I contracted the disease when I was 40, which is late for juvenile diabetes. I have been lucky so far. I have mild hypos (hypoglycaemia) once a week, but nothing serious, and my team is aware of my condition. We don't use any particularly special equipment for our experiments. We have a few high-tech things, the high-speed camera and GPS, but otherwise we mainly use a compass, to draw a grid on the desert to record the ants' tracks. We lay out all of our grids along a north–south line for consistency, so that each of our experiments is comparable, even if they were recorded in different locations or different years.

How did you locate the world's fastest ants?

We knew that Saharan silver ants (*Cataglyphis bombycine*) live in dune areas, so we drove to Tozeur and Douz, two major oases in the most southern part of Tunisia, and looked around. They are quite common once you find the right habitat, although they were initially hard to find. The animals move really fast, are small and slightly camouflaged by their reflective coat, but humans are very good at detecting movement, so if you look across the desert and see a little speck dashing across the sand then it's a desert ant. I always carry a little vial with morsels of food that I give to the tiny beasts so that we can follow them to find the nest.

Have you noticed changes in the locations where you do research over the years?

A few things have got better. People used to use many disposable black plastic bags. They would just drop them and then the bags would be blown across the desert so that anything that stuck up, each little twig and stiff blade of grass, was covered in black plastic, which was horrible. That's gone now, because people are more careful, so that's positive. The main change that I have noticed is that the rain is more unreliable, but stronger than it used to be, so it destroys our field site, washing away the grids that we paint. I love being in the desert because I like to be alone for a day or two. It's great, observing nature and seeing how things work, what they look like. There's a saying in German, 'to dangle your soul'; personally, I find being in the desert a satisfying and relaxing experience.

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