Ask-a-Biologist Vol 044 (Guest: Rüdiger Wehner)

Cataglyphis Versus Saharabot

Imagine a David and Goliath battle between a tiny desert dwelling ant and a monster robot. What can we learn from these two unlikely characters? Dr. Biology gets the chance to talk with biologist Rüdiger Wehner about his amazing study subject *Cataglyphis fortis* and his robot incarnation. Did we mention these ants do geometry - maybe you could use one as a tutor?

Transcript

Dr. Biology: This is "Ask-a-Biologist," a program about the living world, and I'm Dr. Biology.

On the show, we often talk about how biology relies on creativity as much as it does on, well, say, math or chemistry. Our guest today is a great example of how scientists use some pretty interesting and, yes, creative ways to answer the many questions of life on earth.

We'll be talking about how contact lenses, stilts, and several other devices such a desert-dwelling robot, are letting us learn about an amazing animal found in the Sahara Desert. What's the animal? It's an ant.

And it's an ant that can survive in unbelievably hot temperatures. But it's not the ability to withstand extreme temperatures that has this scientist interested. Instead, he's been learning how these ants forage for food far from home and still find their way back. In other words, how do they navigate? Do they have a built-in GPS system? Or is it something else?

My guest is Rüdiger Wehner, Professor of Neurobiology with the University of Zurich and the Director of the Institute of Zoology. Today, we're going to get a chance to talk about his favorite study animal that makes its home in the Sahara Desert. Welcome to the show Dr. Wehner.

Dr. Ruediger Wehner: Thank you, Dr. Biology.

Dr. Biology: All right, let's first learn the basics about your animal. What is its scientific name?

Rüdiger: The scientific name is *Cataglyphis*. It's a Greek name and a nice name. You would like to name your daughter after it...

Dr. Biology: *Cataglyphis*?

OK. And what's the common name?

Rüdiger: There is no common name because it lives in the Sahara and no one has given it a common name yet - no English name, no German name. But I call it just "the desert ant".

Dr. Biology: The desert ant - I like that. Now, I mentioned that *Cataglyphis* can live in very hot temperatures. Just how hot is hot'?

Rüdiger: So, the internal temperature of *Cataglyphis* might get up to 55 degrees centigrade. So Dr. Biology, you might translate this into Fahrenheit?

Dr. Biology: Yeah, that's going to be well over 122 degrees. I actually did a little bit of research and I got this range of where it could go from 50 degrees centigrade up to 70 degrees centigrade. And that range is 122 degrees Fahrenheit up to 158 degrees Fahrenheit?

Rüdiger: Yes, that might be the case. That means the 70 degrees centigrade - the upper limit of what you've just mentioned - is the surface temperature of the sand surface.

But the animals have very long legs, five to six millimeters-long legs and that keeps them above the hot surface. And where their body is, the temperature might be 15 degrees lower than the sand surface. And this is one reason for their long legs -- to keep the body off the hot sand surface.

Another reason is that by these long legs, they have very high running speeds -- up to one meter per second. Imagine, one meter per second. And of course, when you move that fast, you cause wind along the side of your body and this wind will also cool the body.

Dr. Biology: Oh, that is true.

Rüdiger: And there's another reason that - when they run fast, they can return quickly to the nest. And then, they come to the cool and humid underground environment where there is no longer any heat stress.

Dr. Biology: Right, so they can do these quick trips out and back and so they don't have to be in the hot temperatures for long periods.

Rüdiger: Yes, that's the case.

Dr. Biology: All right. Before we talk about *Cataglyphis* and how it finds its way home, let's first talk about how most ants navigate.

Rüdiger: The multitude of ants - have a kind of pheromone. That means it's a chemical substance that they lay down on the ground and then, either they themselves or follower ants use this scent trail for navigation.

Dr. Biology: Right, it's kind of like the old story of the breadcrumbs - laying the breadcrumbs...

Rüdiger: Yes, the breadcrumbs.

Dr. Biology: ... along the trail and find your way back, right. OK, how does *Cataglyphis* do it?

Rüdiger: This way wouldn't work in *Cataglyphis* for two reasons. First of all, most of these chemical substances that are used as pheromones for scent trails evaporate very quickly. And with the hot temperatures in the desert, this trail would not be stable.

And the second reason is that the animals don't follow the same way home they have used to forage. So they forage in a windy way -- many loops. But then they return directly, not by retracing their steps but moving directly back to the starting point. So they move over novel ground where no pheromone trail would have been laid down.

Dr. Biology: They're going to be on surfaces they've never been on before...

Rüdiger: Yes.

Dr. Biology: ...and so, it wouldn't do any good. That's right.

Rüdiger: So even if the trail were permanent and could stay for longer, it couldn't be used.

Dr. Biology: What is *Cataglyphis* doing?

Rüdiger: So this way of moving along the windy path outwards and on a straight path inward is called, scientifically, "path integration". So they integrate all the steps they make and at any one time, they know the direct way back to the start. That means the direction back to the starting point and the distance back to the starting point.

Dr. Biology: OK, so do they have a built-in compass?

Rüdiger: For measuring directions, they must have a compass. And for gauging the distances, they must have an odometer.

Dr. Biology: OK. Well, let's first talk about their compass. I'm assuming they don't pull out a compass like you and I would be able to pull out a compass. What are they using?

Rüdiger: We would use a magnetic compass. It's the usual compass humans use. But they have no in-built magnetic compass. So, they use a visual compass -- they use their eyes for a compass.

Dr. Biology: OK.

Rüdiger: But they use a pattern - they use the sky for this. But for us, the sky is more or less homogenously blue. We don't see any structure in the sky. But *Cataglyphis* is able to see a structure in the sky - in the skylight - that humans are unable to see. And this is what, scientifically, is called the "pattern of polarized light".

Dr. Biology: Oh, now... right. We talked about polarized light in an earlier show. I'm actually kind of curious, how do they use polarized light rather than, say... Well, you actually mentioned green light in part of one of your experiments. And I think that gets into the story about these contact lenses that the ants were wearing?

Rüdiger: Yes. You can, first of all, ask the question, "What colors do they see in the sky?"

They have two types of photoreceptors in their eyes. One type is sensitive to ultraviolet light. We don't have such receptor in our eyes. We can't see ultraviolet light. And the second is sensitive to green light like our green receptor in the eye.

And now we put contact lenses on the eyes of these insects that transmit only particular colors of the sky. And if the contact lenses transmit only the ultraviolet part of the spectrum, then the animals can use skylight very well for navigation. But if the lenses transmit the green part of the spectrum - that means that part we humans can see - then the animals are lost. They can't use their skylight compass in the green part of the spectrum. They can use the skylight compass only in the ultraviolet part of the spectrum.

Dr. Biology: Wow. It's actually fascinating and I do have to say I was a little bit curious. How do you put contact lenses on an ant?

Rüdiger: Maybe the contact lens is not the right expression of it. What we did was we designed fluid lacrosheet, which dried very quickly and then put this lacrosheet onto the eye. And the lacrosheet was designed together with chemists in a certain way that ease off the lacrosheet, transmitted the green part of the spectrum or the ultraviolet part of the spectrum, as I said before.

But the nice thing with these lacrosheets was that you could remove them afterwards and we could use the same animal to do the same experiment again. Now, with the open eyes, to get it as a kind of controlled experiment after the real experiment with the contact lenses had been done.

Dr. Biology: It's a perfect control, actually. I think it's marvelous and it was neat to see. They actually - these scanning EM pictures that you had in your talk - and here is this ant eye and it really did look like a contact lens to me. And you had one with it on and one with it off. I was pretty impressed!

Rüdiger: Oh you liked the picture?

Dr. Biology: Yes, it was very good. All right, so, they're using the particular wavelengths of light, UV, to help them navigate by or create their compass. All right, that helps us tell direction. You also mentioned they have to know how far they are traveling as well. So what do they use for their - to use the term "odometer" - to gauge distance?

Rüdiger: Yeah, the odometer is actually a step counter. So the ant will just count the numbers of steps they have taken. But this, of course, works only if the steps are of a constant length.

So first, by filming the ants - high-speed cinematography we used to film running ants - and we realized that each ant of a given body size has a very constant step length. And if the step length is constant, then you just count. It sounds easy. We don't know how the ants are actually doing it. But they just count the number of steps, multiply it with step length and then you get to the distance covered.

Dr. Biology: This is where we're talking about those stilts. That's the other thing that you did that I thought was pretty amazing - looking at ants that already have long legs with these red stilts.

Rüdiger: Yes that what I mentioned right now, is the hypothesis. To test this hypothesis, we must change the step length of the animals or the stride length, I should say. And this you can do by either lengthening or shortening the legs. But this is more easily said than done. How can you lengthen and shorten legs?

Shorten is easy -- you cut off some part of the leg and then the animals walk on stumps, so to speak. But lengthening is much more difficult because in lengthening, you have to put stilts on the legs. You glue them in, a quite delicate way of lengthening the legs. And then the animal walks on these stilts quite normally. If the stilts get about double length of the legs, they still walk perfectly well.

Dr.Biology: Wow. It's pretty impressive.

Rüdiger: If they get longer, then the ants will stumble and then fall down.

Now comes the experiment. You let the animals run, let's say, for 10 meters in a narrow channel that they can only run along one line and not in a windy way. And they run with their normal legs for 10 meters.

And then you do the operation. You increase leg length by putting stilts on them and let them run back in a parallel channel to the home place. And then you'll see that these animals with stilted legs overshoot their home. I mean, actually, their home is not there in the second channel because the home was in the training channel. So, they cannot reach actual home but virtual home. So they overshoot their virtual home distance.

And the ants which had been at the feeder, manipulated in such a way that their legs were shorter, they under-shot their distance. So actually, we can say when you increase step length and the animals have counted the number of steps, they automatically should walk for a larger distance and vice versa.

And whether this works exactly the way I described it just now, it has to be tested quantitatively. I just said they overshoot and undershoot but do they overshoot and undershoot exactly by the amount by which the step length was increased or decreased?

Then you, again, film these ants which walk on stilts and then you measure how much the step length was increased or decreased. And then you can predict how much they should overshoot and undershoot. And believe it or not, it came exactly out as I just said. You could predict from the increased or decreased step length how much the animal should overshoot and undershoot. And they did exactly as the prediction had told us.

Dr. Biology: Perfect! And that's a way that we're using math and biology. You had to do these measurements, you had to correlate whether they're going to undershoot or overshoot and you had that extra distance that they would travel. Say, for example, put the stilts on - you add more distance that they can make in each step and then you apply that to a nice mathematical model. And you can very easily tell that, yeah, it matched up with their counting of steps.

Rüdiger: So what you do, actually, is a combination of experiments - quite tricky experiments as you’ve just seen with these increasing leg lengths or decreasing leg lengths - and then, mathematical modeling. Because only with this combination of experiment, mathematical model you can come closer to the truth.

Dr. Biology: You also mentioned about their trip paths and this is something - you actually showed the very beginning of your talk. It was interesting because you see this route. The ant starts out a little bit on the straight line and then very soon, it starts curving all the way around. And as you mentioned these are foraging ants so I'm thinking that they're just trying to hunt around to find any kind of dead insects that have basically, probably can't handle the heat, right?

Rüdiger: Yes, yeah.

Dr. Biology: And then, they find this dead insect and instead of coming back that nice twisty path, as you mentioned, they come straight back.

Rüdiger: Yes, that's exactly what happens.

Dr. Biology: All right. Well, now, the question I had is how do they actually tell the difference if they're counting steps -- if they really do count steps? If they're doing the twisty road all the way out, they got a lot of steps going on out, right?

Rüdiger: Yes.

Dr. Biology: How do they know to - how to shorten that out for the trip back?

Rüdiger: OK, that's a very good question, Dr. Biology, because it makes a major point. Misunderstanding, maybe, of this path integration as I mentioned it before -- the animal does not remember in its mind, so to speak, all the windy path it has taken. And once it has found the piece of food, then, makes all the calculation. It makes all these path integration calculation step-wise as it walks.

So, at any one point, the animal determines the direct path back to the starting point even if it has not found food yet. So the animal walks and always walks with the vector, so to speak, the direct vector back from its present position to the starting point. And then they integrate distance and direction to compute a direct distance back in a step-wise way.

So at any one point, they know only the distance from their current position back to the starting point. They make the next step, computes the new distance spec to the starting point so...

Dr. Biology: So are they doing geometry?

Rüdiger: They do geometry. It looks like, when you have a triangle, you have two sides of a triangle and you have to compute the third side of the triangle. This is what one learns at high school and this can be done only - if you later get to high school and get this kind of math - that can be done only by sine and cosine functions.

Dr. Biology: Right but here we have a little ant that has, I think you mentioned, a brain that's a quarter of a size of the head of a pin?

Rüdiger: It's a 10,000th gram.

Dr. Biology: Ten thousandth of a gram.

Rüdiger: Gram, 10,000th of a gram, yes.

Dr. Biology: Wow! OK, well you actually called them ``Mini-brains, Mega-tasks, and Smart Solutions".

Rüdiger: That was the title of the talk, yes.

Dr. Biology: Yeah, it's a marvelous title. Well OK, they're counting and they're doing geometry. I'm impressed already.

Now, when I go out on a trip especially to some place new, I usually use a map to navigate. Now I can use a map and I can read street signs. And I'm guessing that these ants - even though they can do what we think of as math and geometry - they're not reading yet and they're not using maps. But the other thing I do when I go to some place new is I pay attention to landmarks. You know if I'm...

Rüdiger: Yes, certainly.

Dr. Biology: Yeah...

Rüdiger: When I'm on campus, yeah, I rely completely on landmarks...

Dr. Biology: Right, you're...

Rüdiger: ... on path integration.

Dr. Biology: Exactly, had to do landmarks. Some of your ants actually use landmarks as well, don't they?

Rüdiger: Yes, the desert always has some kind of landmark especially for ants -- stones, small shrubs, bushes, tussocks of dried-out grass. And when these landmarks are there, they are used by the animals too.

We went to special parts of the desert which are the rich in such landmarks. So there might be tussocks that form a natural maze - a labyrinth - through which the animals have to walk and take their way. So they could never walk straight from the nest, maybe, to a feeding place. So they must take a windy way around these different landmarks. And they learn these landmarks quite well.

Dr. Biology: And that's how they get back home as they use these landmarks?

Rüdiger: Yes.

Dr. Biology: OK. You also talk about integration because... Let's summarize. We have a compass so we know direction. We have an odometer so we know distance. And then, we also are able to use, in this case, the ants are able to use landmarks. And they integrate these things all together and that's part of the whole story that you were telling.

How do they do this and what's more important than the other? You know, is it more important to have a landmark than it is to have, you know, the distance or the direction of the compass? What do the ants like to do?

Rüdiger: Yeah, these different systems of navigation we have discussed until now are quite of different importance to the animals. If you navigate by path integration - let's say, the desert is completely free of landmarks. It's a flat plane and some parts of the desert, like salt pans, are completely flat so the animals cannot use any landmark. Then they rely completely on path integration.

But this system is a bit of dangerous system because you have to integrate all twists and turns you're making and if you make any error - and errors always occur in measuring distance and directions and computing the mean, the direction, the distance back to the starting point - all those errors occur and these errors sum up. The longer you walk out, the more errors sum up.

And finally, the precision with which you can pinpoint the starting point becomes smaller and smaller and smaller. On no-way-out, you can say, "Now I determine directly where I am at and know my exact way back to the starting point."

Whereas when you have landmarks, in addition, then you can say - if you have a map, for instance, as you mentioned Dr. Biology before, use a map. Then you can say, "Now I'm at this building and this building is where I'm going to follow this street for so many meters and then turn right, in another street for so many meters. Then, I reach my destination."

That is the kind of a system that is stable. And whenever you have landmarks, you would like to build up such a map of your surroundings. And then you have a really quite precise way of navigating.

Dr. Biology: You also mentioned that the ants are - seemed to me - did you actually think of them or hint at the fact that they might have a photographic memory and that's part of the way that they're able to do these landmark...

Rüdiger: Yes.

Dr. Biology: ...navigation?

Rüdiger: Yes. There is quite a difference to having a map and how the animals do it. They don't have this topographic map. They don't have a bird's eye view of the landscape through which they move. But they just remember what kind of landmark appeared in what part of the eye when they were on what part of the journey.

So let's say you train them - the animals - just in a flat landscape to their destination that has some cylindrical landmarks around. Then they learn the image of these landmarks when they are at their destination. Let's say, one pillar is in front of me and another one is to the left and another one to the right. And when I see this image again, then I know I am at home.

Then we can manipulate these different kinds of pillars and see how the animal behaves in this environment. And from this, we have a hypothesis that the animal, when it is at its goal, stores a photographic image of the landmarks along the skyline around the animal and later moves so as to match the current image it has at any one place, at best, with the stored image it has. And then there's a complete match between the stored image - the memorized image - and the current image, then, the animal knows it is at its goal.

Dr. Biology: Oh, OK, all right. So it just keeps moving in to a place until it says, "OK, this is what was in my brain and this is what I'm seeing right now." And then it keeps doing this until it's basically, superimposes one upon the other and says, "Yeah. Oh, I'm on track."

Rüdiger: Yeah, that's exactly what we have in mind now. And of course, it's quite a difficult - again, computationally it's quite difficult to match one image to another one in a step-wise way. You have to get a better and better and better match and when the match is complete, then, you're at home.

We, again, now use the mathematical model to describe how the match could be achieved as quickly as possible. And this mathematical model now would be, of course, very difficult to describe in words so let's just believe we have this. But if the model works, we can prove by building not only a computer model but implementing this computer model even into a robot.

Dr. Biology: Oh yes, the robot. This is what - the "Saharabot"?

Rüdiger: Yeah, we call it "Saharabot," Sahara robot. So it's short for Sahara robot, so "Saharabot".

Dr. Biology: Yeah, what I find really impressive about this is the fact that this robot's pretty darn big in relationship to an ant.

Dr. Rudiger: Yes, it is. The ant is about 10-milligram body weight and the robot, 10-kilogram.

Dr. Biology: So you had two basic experiments that I recall you talking about. One of them was able to repeat the process of the landmarks, right?

Rüdiger: Yup, yeah.

Dr. Biology: Actually, what was the other one?

Rüdiger: The other one was to steer by this polarized, ultraviolet skylight.

Dr. Biology: Right, the compass.

Rüdiger: The compass, yes. So, one robot mimics the compass and did exactly same thing - what we think goes on in the ant's brain. So we built into the robot by electronic circuits, exactly, is the same strategies we learned from the ant. So the neuro-circuits the ant is using in its cockpit - its brain - was rebuilt, reformed into electronic circuits in that robot. And then the robot did exactly what the animal is doing.

Dr. Biology: Oh...

Rüdiger: It could move in any direction we told the robot to move. Let's say, towards the sun or 30 degrees to the left of the sun or 50 degrees to the right of the sun, and so on.

Dr. Biology: And the other one, the course, was it using - taking pictures, is it? Was going as far as doing its photographic memory?

Rüdiger: Yes, we had a wide-angle lens that picture the whole skyline. That means 360 degrees - the whole panorama - because the *Cataglyphis* ant has so-called compound eyes, which can see the whole panorama at once.

Dr. Biology: Really?

Rüdiger: So these...

Dr. Biology: It has 360-degree vision?

Rüdiger: Yes, 360-degree vision. They haven't to turn around to look backwards. They can look backwards and forwards and sideways at the same time.

Dr. Biology: Oh and that explains a lot because I still was a little bit confused as, we know, when they're walking out - when you and I are walking in a direction, we don't have eyes in the back of our head.

Rüdiger: Oh know. We have to turn around and to look backwards but the animals don't have to do this. They have panoramic vision -- 360 degrees vision at the same time.

Dr. Biology: Oh, OK. As a human, we have a tendency to think everything behaves the same way as we do in the world. And I'm only thinking of looking forward and they're looking all the way around. OK. So, the Saharabot, it's got this 360-degree vision?

Rüdiger: Yes, we use the camera that has auto 360-degree vision and this picture was then put in a digital camera and was stored -- at the goal. So there was, again, the memorized image the ant had is now stored electronically in the robot.

And when the robot moved out, of course, it saw another image because the landscape changes when it - the robot moves out. And then by the same mathematical procedure that we had deduced from the behavior of the ant, the robot would try to match its stored image with the current image and try to improve more and more to get a better and better match.

The robot moved on wheels and not like the ant on legs. So the robot moved on these wheels to get a better and better match. And when the match was complete, the robot was at the goal and stood still.

Dr. Biology: And it stood still, right! Well, that's really, very cool because we're taking a combination... Again, as we started the show we're talking about creativity. So you have very creative experiments that manipulate either the surroundings or the animal itself. And then, based on what you get back for information on how the ant is behaving, you're able to then create a model - a mathematical model - test it, and I'm assuming you tested this on a computer at first just to see how...

Rüdiger: Yes, yes, yes...

Dr. Biology: And then you go one step further. You build your giant *Cataglyphis* robot ant to go out and test this theory.

Rüdiger: Our research is quite a ping pong game between behaviorists who do the behavioral experiments out in the desert. Then, neurobiologists who do the work in the lab and study the brain of the ant and the eyes of the ants and how these works in the, actually, in the software, so to speak, of the animal or the wetware, we should say, because it's a brain that's wet - and then, the roboticists and the computer scientists who do the modeling. And only the combination of these different people -- the physiologist in the lab, the behaviorist out in the desert, and then the computer people -- we can get closer to what the animal is doing.

Dr. Biology: OK.

Rüdiger: But still, the ant, *Cataglyphis*, out-competes all robots we have constructed until now.

Dr. Biology: Oh really? Still winning, huh?

Rüdiger: Still winning so we have lots to do.

Dr. Biology: Before I let you go today, I like to ask three questions - the same three questions of all my scientists that are on the show. And they're not difficult ones, it's not like I'm going to give you a quiz. The first one is -- when did you first know you wanted to be a scientist or a biologist? Do you remember when the spark was? Was there any particular time?

Rüdiger: That was very early in my life. I was about seven years old when I watched breeding birds, songbirds near our house in Germany. And I followed these birds - how often the parents came to feed their youngs, I counted the time how long the young stayed in the nests. And so, I wrote these all down in a small notebook. And then I thought I would become a naturalist, I would study nature.

Dr. Biology: Oh, now did you have parents that were scientists?

Rüdiger: No, my parents were all into humanities. My father was in the humanities and my grandfather, my uncle, they're professors of history and of linguistics. So, I am the first scientist in the family - kind of a black sheep, [laughter] always considered to do science.

But then when I went to school, I got more interested in mathematics. And when I studied, of course, neurophysiology was the topic of the day so I came into neurophysiology. And only later, I went back to nature and discovered, so to speak, *Cataglyphis* -- discovered it for myself.

Dr. Biology: Right. And so you had a natural evolution. And you started off with - one of the most important things for a scientist is the ability, or the interest in observing nature, how things are behaving. So, you did this with the birds and your notebook. This is...

Rüdiger: For a long time I was an ornithologist, a field ornithologist.

Dr. Biology: Uh-huh, now are you still...

Rüdiger: Only when I started university then I realized - oh, this was a kind of, in those days at least, considered to be old-fashioned. Physiology, especially neurophysiology was a big thing and I was always a bit mathematically inclined. So I found neurophysiology and lab work very interesting and dismissed off work down in the field. And only after I came across this ant, I revived my interest in fieldwork.

Dr. Biology: OK, now I'm going to have you shift here. We know when you started, what the spark was for you to become a scientist but I'm going to take it all away. You can't be a scientist and you can't be a biologist, what would you be?

Rüdiger: Good question. I often thought about this question by myself and I think I would be an archeologist because archeology also or even more so, than what I'm doing now, allows you to combine interests in science work.

Real fieldwork. We have to do exact empirical science work. We can't do experiments but you excavate things and you have to plot out things as a pure nature. But then you have to go back and do history. So it has a nice combination of the scientist and the humanities in one type of work.

Dr. Biology: All right. So you could be an archeologist. What advice would you have for someone who wants to become a biologist or a scientist?

Rüdiger: Just when I had lunch discussion with the grad students. At the end, I told the students follow your own line of thinking. Have an idea. Because nowadays, the techniques in biology are so diversified and you can easily be tracked away by following just one method for a long time as a Ph.D. student and as a post doc, you do the same thing in another lab and so on. And then comes a time when you have to decide, "What is, now, my own track in science?"

And so students should - even though if they are very much involved nowadays is learning special techniques - should always think, "What is, now, my field of work - what I can do especially what others have not done yet? Where is my passion?" There's always passion in science, otherwise, you can't do science at all.

When I started with *Cataglyphis*, all my scientific gurus, my supervisors in former times warned me not go on to this animal because it might be dangerous. You might be lost as a scientist. No one has worked on this *Cataglyphis* before. It lives in a strange part of the world. Stay with the honeybee - with which I had done research before. But I was, so to speak, brave enough or maybe risky enough to try it out with *Cataglyphis*.

So I gave myself maybe two years - if it works well. I kept my bee work alongside as a safety line, so to speak. But then, after two years, I was completely convinced we could solve these problems of path integration by the technical means that were available in those days. And then, we went on with this.

But once in your scientific life, you have to decide - this is what I want to do and now I do it even if other people warn me and tell me, "Oh, stay on track on your thesis project -- that's safe ground." You have to go out, reach out to new areas. Otherwise, science would not evolve.

Dr. Biology: To use another type of career, if you're a writer, they often say you need to find your own voice, your own...

Rüdiger: Yes, exactly.

Dr. Biology: And so, you had to find your own scientific voice, your own...

Rüdiger: No one told me. You had to feel it by yourself. Now, I tell it to my students, ``Find your own *Cataglyphis*."

Dr. Biology: Well you found your *Cataglyphis* in the Sahara Desert and the pictures I saw of the Sahara Desert and the description of the temperatures - between 122 to 158 degrees... It doesn't look like a really fun place to be doing a lot of research. What's it like?

Rüdiger: I mean first, of course, it's a bit hard to do this kind of work. But you have to love the desert. And of the students I took with me in the early days, we could group them into two parts: one who love the desert and the others who hated the desert.

Of course, many of them later did lab work so I showed most of the behavioral work out in the desert yesterday. But 96 percent of the work was done in the lab, as you have seen from the results I described. But the work out in the desert... the more you do it, the more you like it.

You get really addicted to desert lifestyle. You get addicted also to the landscape, to the birds and the other animals around, to the ecology of the animals, to the evolution of these animals. How could they evolve in this desert habitat? How did these animals evolve to fill this particular ecological niche? And, what were the questions evolution had asked them to solve through their evolutionary time?

Dr. Biology: Dr. Wehner, thank you so much for sitting down with me.

Rüdiger: Dr. Biology, I thank you for your interest in *Cataglyphis* and the type of *Cataglyphis* work we have done.

Dr. Biology: You've been listening to "Ask-a-Biologist" and my guest has been Professor Rüdiger Wehner from the University of Zurich.

The "Ask-a-Biologist" podcast is produced on the campus of Arizona State University and is recorded in a Grassroots Studio housed in the School of Life Sciences which is an academic unit in the College of Liberal Arts and Sciences.

And remember, even though our program is not broadcast live, you can still send us your questions about biology using our companion website. The address is askabiologist.asu.edu or you can just Google the words "ask a biologist".

I'm Dr. Biology.