CONVERSATION

In the field: an interview with Glenn Tattersall

Glenn Tattersall is a Professor at Brock University, Canada, where he investigates the mechanisms of animal adaptations to extreme environments. After his undergraduate degree in 1994 at the University of Guelph, Canada, he completed his PhD in Comparative Physiology at the University of Cambridge, UK, with Bob Boutilier, before undertaking postdoctoral research at NEOMED College of Medicine, USA, and Kent State University, USA, with Steve Wood, and at University of British Columbia, Canada, with Bill Milsom. Tattersall talks about his experiences using a thermal imaging camera in South Africa, the Galapagos Islands, Scotland and Brazil.

Where did you grow up and how did you become interested in animals?

I grew up in Canada. We moved around a lot until I was about 6 years old, as my father worked for the federal government. Then we set up a little farm in a town called Mar, on the Bruce Peninsula, which juts out into Lake Huron in the middle of the Great Lakes, and we had 100 acres of land. It was a hobby farm, that turned into a lot of work. There were three rivers running through the property, so I got to explore the natural world right there in my back yard. When we weren't working, my summers were spent catching frogs and finding salamanders under logs; winters were spent doing chores on the farm, ice-skating and winter camping. My dad wanted to give us the childhood experience that he'd had growing up in northern England.

At what point did you decide which direction your career would take you in?

Initially, it wasn't clear that I would become a zoologist. I thought of medicine for a period – or becoming a veterinarian or a scientist – so I compromised by going to a university that I wanted to go to. That was Guelph and I chose a programme, Environmental Toxicology, that might give me a job at the end. After my second year, I realised that toxicology wasn't what I thought it was, but I didn't want to switch programmes and spend 5 or 6 years doing an undergraduate degree, so I took physiology, comparative physiology and population biology courses. Pat Wright was my fourth-year advisor and, in my last summer, she and Don Stevens set me on the path towards Bob Boutilier's lab at the University of Cambridge, UK. In Bob's lab, we worked on ecophysiology, taking measurements on animals in a redesigned simplistic version of their environment.

When did you realise that thermal imaging is such a powerful tool?

After my PhD I did two lab-based postdocs. The first at NEOMED College of Medicine, USA, with the comparative physiologist Steve Wood, where I worked on pygmy marmosets in collaboration with James Blank at Kent State University. My second postdoc was with Bill Milsom at the University of British Columbia (UBC), Canada. I knew from my work on the marmosets that we could detect how much heat they were losing; if you put a small thermocouple in the respirometry chamber with the animal, you could measure crudely how the heat that the animal gave off changed over time. When I joined Bill's UBC lab in 2000, I knew we wanted to do some thermal imaging of hibernating ground squirrels. I was talking with Bill one day and he said, 'I think someone retired in the Physiology Department and they had a thermal camera'. We went over and they had this old liquid nitrogen cooled thermal camera that nobody remembered how to use. I hauled it out and played with it. Initially it looked like it didn't work, but as soon as I poured liquid nitrogen into it, suddenly, this ghostly white image appeared on the screen and then I could see a ground squirrel or I could see my hand, although it was very crude. We managed to get a paper in *Journal of Experimental Biology* on the hypoxic thermoregulatory response in golden mantled ground squirrels from it. Then, in 2003, I got a new Mikron thermal camera as part of my Natural Sciences and Engineering Research Council of Canada grant when starting my own lab. Around the same time, Bill introduced me to Augusto Abe and Denis Andrade (both from Universidade Estadual de São Paulo-Rio Claro, Brazil) and I started going to Brazil yearly to conduct research in comparative respiratory and thermoregulatory physiology.

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What was your first experience of research in Brazil?

The first study where we used one of our thermal cameras was a *Journal of Experimental Biology* study on thermogenesis in rattlesnakes. Basically, we were trying to work out if digestion of large meals leads to any substantial capacity to generate heat. While we were visiting, Augusto was always very hospitable; we'd go out for meals and once he said, 'Glenn, you really should study toucans', and I said, 'OK, why?'. He had kept toucans years ago and he knew that the bill was hot to the touch, at least in the juvenile birds that he had as pets. At that time, I was going to Brazil every year to do work on caiman and snakes, and one year he took me to the Zoo Americana, Campinas, Brazil, and they allowed me to get into an enclosure with five birds. I pointed the thermal camera at the adult toucans, but none of them had warm bills, which was initially disappointing. I spent 20 minutes trying to get pictures, but one of the birds was moving around a lot. He didn't like having his picture taken, so it was difficult to focus, but after about 10 minutes of the toucan hopping back and forth, I could see that the bill was hot. Essentially, at room temperature, the bills are mostly vasoconstricted, but it turns out the blood flow is variable and under reasonable control; they can turn the heat up – they can turn the blood flow up or down – when they want. We published this work in *Science* in 2009, and this 'accidental' discovery led to a lot of ongoing investigations into avian thermal biology.

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How did you end up working in the Galapagos Islands?

Out of the blue in about 2011, Russell Greenberg, a famous ecologist and ornithologist who was head of the Migratory Bird Center at the Smithsonian Institute, contacted me. He had read the toucan bill paper and said, 'Let's talk. I want to see if this applies in my sparrows and smaller birds with much smaller bills', because he had been curious about why bill size differed in Atlantic song sparrows that lived between environments of different water availability. His primary background was ecology and evolution, so he wanted to translate what I had done in the field. In the end it was a 2 year journey to get there, with lots of phone calls between Russ and myself. Eventually, we put together a National Geographic Society grant to test this idea in Darwin's finches – which have fairly similar body sizes, but vastly different bill sizes – to examine whether we could see any signatures of differential use of bills or the legs in this habitat.

During the first year of the grant, Russ's postdoc Ray Danner (currently at University of North Carolina Wilmington, USA) and I would take our thermal cameras out in the field near the Charles Darwin Research Station, set up the cameras and we'd see the finches foraging on the same patch of gravel or the road or pathway every day. We wanted to get high-resolution images, but they're often difficult to capture in focus when you're walking, so we had to set up the camera on a tripod in the heat of the sun with a long cable connected to a laptop in some shade. Then, I could capture images with me hiding only about 10 m away. I did that every day for about 3 weeks. We captured as many images as possible and collected information about the birds in the field each day until I overheated and came back to our accommodation to get shade and a shower. The air temperature wasn't that bad, but the sun was intense and I'm not a heat tolerant person.

In the second year, we flew two huge boxes of equipment as excess baggage to the islands to do respirometry. Essentially, I took my lab, packed in duplicate, because we were only there for 5 weeks and we needed to collect as much data as possible. We had two thermal cameras, environmental chambers for the birds that we could film through, two FoxBox gas analysers and water vapour meters, high-precision flow meters and all the necessary gas scrubbing chemicals. When we arrived, the taxi wasn't allowed to drive the last 1 km to the research station, so they dropped us at the end of the road and we had to haul the boxes the rest of the way at high noon in the Galapagos sun. Once we'd settled into the lab and set up the equipment, Ray, and Julie Danner and Jaime Chaves (San Francisco State University, USA) caught the birds – four different species of Darwin's finches – by mist netting. Sometimes I helped get the birds out of the nets, but often I was back in the Galapagos National Park lab setting up the equipment and running experiments with Danielle Levesque (University of Maine, USA). Handling the birds was nerve racking, because they're wild and we didn't want to hurt them. Fortunately, they responded well. We kept them in a separate room from the lab where we did the experiments, to stop them from being disturbed. Also, we only captured males, because we didn't want to get any females that were on nests or remove juveniles while they were learning to forage, to minimise our impact on the population. Then, we simultaneously measured the birds' oxygen consumption, CO_2 production and water loss, and captured thermal image videos to see whether they would start to vasodilate and/or vasoconstrict as we warmed them up in the environmental chamber and whether the bills would start to get warmer. At night, when the birds were sleeping and not hopping around and moving, we could see the limbs and the bills dilate in time lapse, ebbing and flowing like our initial toucan video from our 2009 paper.

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What is the most dangerous place where you have used your thermal camera?

Queimada Grande island off the coast of San Paolo, Brazil; everyone in Brazil has heard of this island. It is often called the most dangerous island in the world, because legend says there's roughly one snake every metre and they're highly venomous. Researchers from the Butantan Institute – an immunology and herpetology institute in San Paolo – invited Denis [Andrade] to go out and study the golden lancehead pit viper, a beautiful pit viper that is only found on the island and is under pressure from poaching for the pet trade. Denis let me tag along for the ride, since I had the thermal camera in Brazil for another study, so we could get the temperature of the animal to learn more about its heat-orienting behaviour in the wild. We camped on the island for five nights. My colleagues were surveying the pit viper populations and I was following at the back of the group with the thermal camera. When they found a snake, I had to keep a safe distance, no closer than 2 m, but they're not going to chase after you, so it was quite safe. Also, they didn't seem to be bothered by us, even though there were so many people around. But, at the end of one day, I needed to get back to our main camp before the group, because I wanted to try to get some night-time thermal images of the birds that were nesting on the island.

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That's when it dawned on me that I had previously been the guy at the end of the line and everybody else was finding the snakes. Walking back on my own, I was now the one discovering the snakes at my feet and it was like they were coming out of the woodwork. After that, I got out my flashlight to make sure I didn't step on any pit vipers. That wasn't as much fun.

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How difficult is working with thermal cameras in the field?

The battery life is limited; they only hold 2 hours of charge, so you keep it in standby mode most of the time. But then, when you need it, you have to let it warm up and go through a self-calibration mode and that usually takes 2 or 3 minutes. It's not difficult to use once it's warmed up, but you often miss events waiting for it to reach temperature, which is frustrating. Usually, you have to have an idea of where the animals are going to be, so you can set your rig up and wait for them to come there. In May 2019, I went to the Isle of May, Scotland, to do some puffin imaging. I spent 2 days on the island, observing the puffins from a bird hide to let them behave naturally, so I could capture images and see the beak light up when they got back from flying. I used some of the images in a recent paper, where I outlined how to use thermal imaging in the field and pointed out some of the basic pitfalls, how to avoid them, and commonly ignored problems. The other limit with the cameras is that the further away you are, the worse the data quality; you can't correct for that after you've taken the image, so you have to be reasonably close. That is because you can't use normal closeup camera lenses; you need special thermal camera lenses, which are insanely expensive and not interchangeable between cameras.

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What are the pitfalls to this sort of research?

I think about this all the time. This tool is still much like a camera, but it is just measuring radiation that we convert into temperature, using physical algorithms and assumptions. You can't really measure blood flow directly, but we can estimate surface temperature, which is a partial proxy for blood flow, but typically only possible to observe in endotherms (so-called warm-blooded animals). So we've gained by being less invasive, but we have to have a handle on all of the other things going on around these animals to make sense of the thermal image data. The cameras are powerful tools; they provide really compelling images, but we have to carry a bunch of other smaller devices with us, so we can measure the prevailing solar radiation, air temperature and wind speed, to model the heat that's being transferred from the animal to the environment, and then compare that to their estimated heat production. This information is key to understanding thermal balance.

What is the most rewarding field project where you've used your thermal camera?

I would say getting to work in the Kalahari Desert with meerkats. We were only a metre away from the animals for 2 weeks, capturing thermal videos and digital audio of them. Meerkats communicate by calling, but they're very polite and seem not to interrupt each other; something stops them from speaking over the top of one another. Vlad Demartsev from the Max Planck Institute of Animal Behavior, Germany, came to me and asked whether thermal imaging could be used to measure breathing frequency and depth and how they change. Fortunately, the meerkats wake up at a civilised hour, about 8 o'clock in the morning, so we were up for breakfast at 6.30 am and we'd go out to the site where they were last seen the night before; the University of Cambridge, UK, runs the Meerkat Project, so they know which hole the animals went down the night before. Then, we set up the camera on a tripod near their burrow entrance and basically waited. Vlad has a big microphone, so we would just film and simultaneously record audio. When the meerkats emerged from their burrow they would 'stand to attention' and we could get up to 5 minutes of video, although they got very upset if we stood in front of their sun. Each day, we'd get a total of about an hour's worth of usable data before the meerkats would go off foraging. After that, I spent the rest of the day converting files, backing them up, working on my laptop, while Vlad would synchronise the video and the audio data files. This field work was rewarding because we had a clear mission; we had to synchronise the video data and the audio data for a bigger purpose. This seemed a challenge that nobody else was working on and it was rewarding because I got to learn something new and work on a new problem.

Glenn Tattersall was interviewed by JEB News & Views Editor Kathryn Knight. The interview has been edited and condensed with the interviewee's approval.