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ECR SPOTLIGHT

ECR Spotlight – Mads Kuhlmann Andersen

ECR Spotlight is a series of interviews with early-career authors from a selection of papers published in Journal of Experimental Biology and aims to promote not only the diversity of early-career researchers (ECRs) working in experimental biology but also the huge variety of animals and physiological systems that are essential for the 'comparative' approach. Mads Kuhlmann Andersen is an author on 'The freeze-avoiding mountain pine beetle (*Dendroctonus ponderosae*) survives prolonged exposure to stressful cold by mitigating ionoregulatory collapse', published in JEB. Mads Kuhlmann conducted the research described in this article while a postdoc in Heath MacMillan's lab at Department of Biology, Carleton University, Ottawa, ON, Canada. He is now a postdoc in the lab of Johannes Overgaard at Department of Biology, Aarhus University, Denmark, investigating comparative physiology and integrative biology with a main interest in how animals respond, adjust and adapt to different thermal environments.

Mads Kuhlmann Andersen

How did you become interested in biology?

For as long as I can remember I have been fascinated by the wildlife and the natural world, and much of my childhood was spent watching a wide variety of TV shows featuring my personal heroes Steve Irwin and Sir David Attenborough – I suspect that is how I developed my keen interest in biology. In the beginning, my main biological interests were marine biology and exploration, and conservation of marine megafauna – something I thought to myself would work great in combination with my enthusiasm for water sports.

Describe your scientific journey and your current research focus

My road to academia started in the last year of high school, where we were tasked with leading independent research projects: I chose to investigate how climate-change-induced ocean acidification affected mussel feeding performance. After high school, I went to Aarhus University, where I completed my undergraduate and Master's degrees in the labs of Tobias Wang and Mark Bayley, respectively, working on physiology of air-breathing fishes in relation to global warming. It was during this time that I took several courses led by Johannes Overgaard, which was how I first got interested in insect physiology and the other end of the temperature spectrum – something I pursued during my subsequent PhD, under the guidance of Johannes. This work focused on understanding the mechanisms limiting insect cold tolerance with a focus on neuromuscular and renal physiology. During this time, I received a travel fellowship from The Company of Biologists, which enabled me to travel to Canada to work with Andrew Donini (York University, Toronto) and Mel Robertson (Queen's University, Kingston), and two papers were published from this trip – both in JEB (doi:10.1242/jeb.168518 and doi:10.1242/jeb.179598, respectively).

After my PhD, I was able to secure my own research funding and started my first postdoc position in the lab of Heath MacMillan, whom I'd first met when he was a postdoc in Johannes's lab during my time as an undergrad and Master's student. Here, I continued my work on the neurophysiological limit to insect cold tolerance; loss of central nervous system function by a phenomenon known as a 'spreading depolarization'. Some of this work was published in JEB recently (doi.org/10.1242/jeb.244923 and doi.org/10.1242/jeb.246313). Immediately after this, I continued a second postdoc position in Heath's lab to research the physiology underlying the impressive cold tolerance of the mountain pine beetle in Canada. Specifically, I investigated if exposure to extreme, non-freezing cold affects their ionoregulatory capacity, and if their ability to avoid freezing during the cold Canadian winter was associated with adjustments to the osmoregulatory organs – and so far they seem to lose the ability to regulate ion balance and suffer adverse effects as a consequence!

How would you explain the main findings/message of your paper to a member of the public?

Insects generally survive through the frigid Canadian winters by being able to either survive freezing ('freeze-tolerant') or by avoiding freezing altogether ('freeze-avoiding'). However, the third

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A mountain pine beetle larva (*Dendroctonus ponderosae*) being extracted from a log of lodgepole pine. They hatch from eggs and tunnel through the bark, feeding on the phloem of the sapwood, which ultimately kills the tree. Photo credit: Heath MacMillan.

and largest group of insects is unable to tolerate even mild cold and is therefore referred to as 'chill susceptible'; these insects suffer injury in the cold due to an inability to maintain salt and water balance at low temperatures. The ability to maintain salt and water balance is essential for insects no matter the circumstances, so we asked whether more cold tolerant, freeze-avoiding insects (which were thought to survive unless frozen) were able to prevent the loss of balance when exposed to severe non-freezing cold. We decided to investigate this in the freeze-avoiding mountain pine beetle, which was an interesting organism to work on due to its unique physiology and because it is an arboreal pest species limited in its distribution by its cold tolerance. As it turns out, they do lose salt and water balance when exposed to severe sub-zero temperatures for several days, which resulted in a proportion of them succumbing. This is important, because it suggests that the physiological failure that limits the cold tolerance of very cold-sensitive insects also appears to apply to more cold hardy species, even if it occurs at much lower temperatures in these species.

Why did you choose JEB to publish your paper?

I wanted to publish this paper in the Journal of Experimental Biology because it is highly regarded in the field of comparative physiology. Part of this stems from it being a society-led journal that understands, supports and gives back to the community – for example, in the shape of travel fellowships and grants. Furthermore, I have great respect for its open access policies, where everything is made freely available either after a short while (free of charge) or immediately if the authors are affiliated with a partner institution, of which there are many!

What is the hardest challenge you have faced in the course of your research and how did you overcome it?

Having spent the last many years working almost exclusively with fruit flies, it was nice working with another group of insects. The difference in size made it easier to work on mountain pine beetle larvae; however, these beetle larvae being non-model organisms meant that information on their physiology was scarce. Furthermore, its status as an arboreal pest species east of the Rocky Mountains meant that there were strict quarantine requirements that had to be met. Thus, we had to cut trees from a field site a couple of hours drive west of Edmonton and store them at the Department of Biological Sciences at University of Alberta during winter in a way that exposed them to the natural temperature fluctuations, and then ship the logs to the Great Lakes Forestry Centre in Sault Ste. Marie (Ontario, Canada), where they had the appropriate facilities to not only house infested trees, but also extract beetles from the trees and run the necessary experiments. We then had to travel to Sault Ste. Marie on three separate occasions during the winter to collect our data. That being said, the collaborative nature of this entire project was immensely rewarding, and many great moments were shared with colleagues and collaborators at all levels of the academic 'ladder'.

What's next for you?

I have just started another postdoc position at my alma mater (Aarhus University; funded by the Carlsberg Foundation) to pursue insect neurophysiology; more specifically, the previously mentioned spreading depolarization event. This time, the focus is on the role of the Na^+/K^+-ATPase and how variation in its structure and activity might affect thermal tolerance as limited by the spreading depolarization-induced loss of neural function. Furthermore, a large component of this work will be to establish spreading depolarization in insects (mainly fruit flies) as a translational model system for mammalian and human neuropathologies using comparative and evolutionary analyses – something that will inevitably help promote and implement the 3 Rs.

What do you think experimental biology will look like 50 years from now?

With how fast genetic and phylogenetic methods are being developed and made accessible, I think we're going to see more of that type of research in the future. Integrating those methods into comparative and experimental biology will inevitably advance our understanding of everything from thermal limits to biomechanics. However, at the same time I hope that we won't forget where it all started, such that there will still be room for classic, mechanistic studies of animal physiology without having to dig too deeply into molecular biology, genetic or phylogenetic techniques.

Reference

Andersen, M. K., Roe, A. D., Liu, Y., Musso, A. E., Fudlosid, S., Haider, F., Evenden, M. L. and MacMillan, H. A. (2024). The freeze-avoiding mountain pine beetle (*Dendroctonus ponderosae*) survives prolonged exposure to stressful cold by mitigating ionoregulatory collapse. *J. Exp. Biol.* **227**, jeb247498. doi:10.1242/jeb.247498

Journal of Experimental Biology