WARNING SIGNALS IN INSECTS

MARIE ELISABETH (MARIELLA) HERBERSTEIN

I completed my Ph.D. at the University of Vienna, Austria and took up a post-doctoral position (Erwin Schrödinger Fellowship) at the University of Melbourne before starting a continuing position as a lecturer at Macquarie University, Sydney. I promoted to Professor in 2012 and have held a number of administrative roles, including Head of Department, Deputy Dean, Chair of Academic Senate, and now Deputy Vice-Chancellor (Academic). My research investigates the behavioural ecology of invertebrates, including spiders and insects, within an evolutionary framework. I am interested in establishing spiders as significant models in behavioural and evolutionary research. I have published over 150 papers and an edited book on the behaviour of spiders. – Address: Department of Biological Sciences, Macquarie University, NSW 2109 Sydney, Australia.
E-mail: marie.herberstein@mq.edu.au.

Many species of toxic prey advertise their distastefulness with conspicuous warning colours such as red and yellow dots or stripes. Naïve predators quickly learn to associate warning colours (aposematic signals) with an unpleasant taste, and they avoid future encounters with such prey. Stronger, more visible signals facilitate faster avoidance learning than do weaker signals. Certain colours that contrast strongly against the natural background are commonly observed in warning signals: yellow, orange, and red in combination with darker colours, such as black and blue.

While theory predicts conspicuous and invariable warning signals, surprising variation exists not only within populations, but also between populations and species. The existence of signal polymorphisms or less conspicuous warning signals in toxic prey is a puzzling and unresolved question in evolutionary biology, despite the intense research on warning signals.

The aim of my time at the Wissenschaftskolleg was to understand global patterns of warning signals and delve into the evolutionary and ecological factors that contribute to the frequency of warning signals in a prey community. This project was part of the Focus Group together with Johanna Mappes (University of Jyväskylä), David Kikuchi (University of Arizona), and our visiting guest Bob Holt (University of Florida). While my and Johanna Mappes' time in Berlin was cut short due to the pandemic, we generated three publications and one research grant application that was submitted to the Australian Research Council.

Our first paper discusses the concept of a mimicry ring, which is a phenomenon often found in insects bearing warning signals. Mimicry rings describe a group of species that gain protection from predation by sharing similar warning signals. Early descriptions of mimicry rings focused on the colourful tropical butterflies, but more recent descriptions include catfish, nudibranchs, and millipedes. To date there is no clear definition of the term "mimicry ring" and no agreement on how to test if a species is a member of a mimicry ring. We propose a definition of "mimicry ring" with a focus on the requirement that all members must be protected from the same predator because the predator generalises between them. We describe how predator generalisation tests can be used in the context of mimicry rings and advocate their use to discover more undescribed rings and to verify the membership of established mimicry rings.

Our second paper is a broad review of the ecological limits to warning signals in populations. Despite the wide distribution of warning signals, they are relatively scarce as a proportion of the total prey available, and more so in some biomes than others. Given that warning signals are governed by positive frequency-dependent selection, i.e. they succeed better when they are more common, this scarcity is puzzling. In this review, we explore factors likely to determine the prevalence of warning signals in prey assemblages. These factors include the nature of prey defences and any constraints upon them, the behavioural interactions of predators with different kinds of prey defences, the number of responses by predators governed by movement and reproduction, the diversity and abundance of undefended alternative prey and Batesian mimics in the community, and variability in other ecological circumstances that favour warning signals.

In our third output, we apply mathematical modelling to understanding the population dynamics between predators and their prey that broadcasts warning signals. Using ecological factors identified in our review above, we examine the effects of prey handling time, fluxes in predator populations, availability of alternative prey, and costs associated with foraging on toxic prey with warning signals.

Finally, our research proposal aims to test some of the assumptions generated by both our literature review and our mathematical model in a large field survey. Theoretically, there is no limit to the number of species with warning colours, but only about 5 % are estimated to display them. This presents a fundamental and unresolved biological problem – what limits warning colours? Our project addresses this significant biological question by assessing how many butterflies have warning colours and testing three hypotheses that might limit warning colours.

In addition to the core research at the Wissenschaftskolleg, I presented a public colloquium together with Giovanni Galizia on the interactions between honeybees and their crab spider predators, "The Flower's Dinner Guests: Bees and Spiders – Who Will Survive the Meal?"

But life in Berlin was not just about research and insect warning signals. It was also about exploring the dance clubs. From Birgit & Bier to Bohnengold, SchwuZ, SO36, and all the way to Berghain – a perfect way to unwind.