All animals can tailor their morphology, physiology and behaviour (their 'phenotype') to changing environmental conditions. This phenotypic plasticity entails a reinterpretation of an animal's genetic information. Paradoxically, however, animals are surprisingly unperturbed by environmental challenges such as bouts of heat, cold, and starvation - they have to be in order to survive in their often unpredictable environments. Change (plasticity) and stability (robustness) are both universal to life, yet the underlying mechanisms are little understood.

Environmental change is stressful for animals, and their apparent stress-resilience results from intricate and highly dynamic response mechanisms. These include a family of proteins known as Heat Shock Proteins (HSPs), which maintain, protect and coordinate most other proteins inside cells. Heat and many other stressors trigger a so-called 'heat-shock response,' which entails dramatic increases in the amount of HSPs inside cells. One such HSP in particular, HSP90, acts as a stress sensor to coordinate the heat-shock response. It is also thought to 'buffer' animals against destabilising mutations and environmental events, but little is known about the role of HSP90 in behaviour.

In this project, you will test the exciting idea that HSP90 stabilises behaviour, but also allows behavioural change to occur in response to specific environmental triggers. You will test this idea in desert locusts, because they have evolved a particularly pronounced ability to change in response to stressful conditions. Locusts can reversibly change between two dramatically different forms, one of which is configured for a life in migratory swarms. This transformation, or 'phase change', is driven by large fluctuations in population density. At low population densities locusts occur in the 'solitarious' phase, where they are camouflaged in appearance, behaviourally shy and, most importantly, actively avoid other locusts. When locusts are forced together, they transform into the 'gregarious' phase. Gregarious locusts look very different and are highly active, but crucially are attracted towards other locusts so that they can eventually aggregate into devastating swarms.
You will manipulate the amount and activity of HSP90 to investigate whether this makes solitarious locusts more likely to change into swarming gregarious animals, or whether we can facilitate the return to non-swarming behaviour. You will also investigate how crowding and other stressors, such as hunger and heat, affect a locust's ability to change phases, and whether their responses to crowding and other stressors share common molecular mechanisms. The key outcomes of your work will be: (1) an increased understanding of the processes leading to the formation and dissipation of locust swarms; (2) new insights into how crowding and other stressors interact to affect plasticity and stability; and (3) increased understanding of the molecular mechanisms that confer stress resistance and plasticity, and their possible overlap.

References


**Techniques that will be undertaken during the project**

- Use of selective inhibitors and RNAi to down-regulate HSP90 activity and expression.
- Repeated behavioural assays of the same individuals and variance estimation in Bayesian multilevel models to reveal whether HSP90 stabilises individual behaviour.
- Behavioural pharmacology and RNAi will also be used in combination with crowding or isolation to test whether suppression of HSP90 facilitates bidirectional plasticity from solitarious to gregarious behaviour and back.
- RT-qPCR and Western blotting will permit us to link behavioural change to concomitant changes in neural HSP expression.
- By combining HSP90 knockdown with analyses of density dependent changes in body colour and morphometrics, we will test whether HSP90 co-ordinates phenotypic plasticity and integration across multiple phenotypic dimensions.