however, needs to be investigated in future work.

Many bacteria besides *B. subtilis* form spores, some of which are important sources of food spoilage and human disease [1,15]. This raises the question of whether bet-hedging strategies based on stochastic germination times are also used by other species. The observation of similar rates of spontaneous germination in three other *Bacillus* species suggests that this might indeed be the case [10], although more work is required to assess the generality of this mechanism.

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Evolutionary Ecology: Insect Mothers Control Their Egg Colours

Martin Stevens
Centre for Ecology & Conservation, University of Exeter, Penryn Campus, Penryn, Cornwall, TR10 9FE, UK
Correspondence: martin.stevens@exeter.ac.uk
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Animal egg coloration has long provided a valuable testing ground for evolutionary ideas. A new study shows that female stink bugs can flexibly control the colour of their eggs depending on the prevailing conditions, including for protection from ultraviolet light.

Adaptive coloration in animals has a long and rich history of study, stemming back to many of the first evolutionary biologists [1]. Ever since, it has been an important area for testing theories of adaptation, behaviour and ecology. Of this, the study of animal egg colours has played an important role [2,3], with suggested functions ranging from camouflage, warning signals, thermoregulation, brood parasitism, to even sexual signalling [4]. However, much of this work has focussed on a few select groups (especially birds), whereas the possible adaptive function of egg coloration elsewhere has been comparatively neglected. Furthermore, most research has explicitly or implicitly investigated the evolution and function of egg colours over multiple generations, or simply as correlated with traits such as parental condition. In contrast, we know little about how mothers may directly control egg colour depending on prevailing or predicted environmental conditions. However, a new study in *Current Biology* by Abram *et al.* [5] shows not only that egg coloration in an insect seems to be adaptive in protecting embryos from harmful ultraviolet (UV) light, but also that mothers can selectively control egg appearance depending on where the eggs are laid, and hence risk of UV exposure.

Abram *et al.* [5] investigated egg coloration in a stink bug (*Podisus maculiventris*), in which egg clusters vary in appearance from pale yellow to dark brown or black. They made a number of important findings regarding how the colour of eggs arises. First, females tend to lay darker coloured eggs when offered substrates that were dark, and lighter

Figure 1. The colour of some invertebrate eggs can act as a warning signal to predators.
Some invertebrates have brightly coloured eggs. In the case of ladybirds (top; image: Sarah Paul) and apple snails (*Pomacea canaliculata*, bottom; image: Horacio Heras), these contain defensive compounds and seem to act as warning signals.

eggs when given white substrates to lay on. Second, egg clusters laid on the topside of plant leaves were darker than those laid underneath the leaves. Third, by subjecting egg masses to different levels of UV light, the authors showed that embryos were more likely to survive when the level of UV light was lower, and when the eggs were more darkly pigmented. Finally, the authors found evidence that egg pigmentation is not controlled directly based on overall light levels, but rather instead on the visual characteristics of the background itself.

Previous work has demonstrated individual variation in egg coloration in insects and especially birds, and a signalling function has been suggested for both. For example, in birds, blue-green egg coloration might be a signal of female quality used by males to determine investment in the young [6,7], although this idea is contentious [8]. In ladybirds, perhaps the only previous study where an adaptive function of egg coloration in insects has been tested, orange-yellow egg appearance (Figure 1) relates to egg toxin levels and is likely to act as a warning signal to predators, with both coloration and toxin content being influenced by maternal investment [9]. Earlier work has also shown that some aquatic apple snails produce bright pink eggs laced with a proteinase inhibitor that may limit a predator's ability to digest the egg nutrients, in addition to a neurotoxin [10]. As a result, the snail eggs have few predators.

Egg coloration, therefore, may have adaptive functions in both vertebrates and invertebrates. However, what sets the study of Abram *et al.* [5] apart from previous work is the direct evidence that female stink bugs selectively control the colour of their eggs. In birds and ladybirds, selective control is possible but past findings can be explained through egg coloration being correlated with maternal attributes such as condition. In contrast, stink bug mothers directly alter the colour of their eggs depending on the context, specifically the laying environment (light conditions or background), such that individual females are making a direct 'decision' about how to control egg colour based on an environmental variable that determines egg fitness (in this case, embryo viability). This of course raises the question of how common selective control of egg coloration might be in animals. There is undoubtedly considerable within-species variation in egg colours, and so we might now expect that the phenomenon is more widespread than appreciated, and influences a range of possible functions of egg coloration.

Some of the other fascinating findings from Abram *et al.*'s [5] study concern the mechanisms by which stink bug mothers control egg coloration. They found that mothers lay lighter eggs on the undersides of leaves, and darker eggs on the topsides. Given that protection from harmful UV light seems to be the main driving force, one might assume that the overall level of light, either perceived by females or directly reaching the eggs, would affect egg colour. However, there was little evidence for this. Instead, the authors found that egg coloration seems to be determined by the relative darkness of the background where the eggs are laid. They suggest that because the undersides of the leaves are in darker light conditions, but some light passes through, this makes the undersides of the leaves appear relatively lighter. In contrast, the topsides of the leaves are illuminated brightly from above, yet because light also passes through the leaf, it appears darker. Thus, the perceived brightness of the leaf given the light conditions may explain egg colour.

Many animals can change their colour and brightness over timescales ranging from seconds to hours, days, and weeks for camouflage. The likely mechanism stink bugs seem to use shows parallels with how a variety of these species are thought to do this; it has long been suggested that it is not the overall light levels that matter, but rather the ratio of reflected light from the background to that of the level of incident light around it [11,12]. For animals that use colour change to modify their camouflage, this approach makes sense because if they simply measured overall light levels then they may become lighter on a dark background on a bright day, whereas they should remain dark. Comparing the light around them to that reflected from a surface allows the individual to calculate how dark the substrate is. Abram *et al.*'s [5] suggested mechanism could explain the stink bug results, but for the bugs it is not the brightness of the surface *per se* that is key, but actual light intensity. So why do the stink bugs also apparently use a measure of reflected light rather than just judging light intensity directly? First, as Abram *et al.* [5] note, fluctuating weather conditions would affect illumination significantly, and be relatively hard to predict. Instead, whether eggs are laid on top of or below a leaf has more predictable effects on how much harmful UV light hits the eggs. An additional possibility is that UV damage does not just depend on the intensity of light from the sun, but also how much light is reflected from the substrate itself.

In animals that change colour for camouflage and in stink bugs that alter egg brightness for UV protection, we have much to learn about how assessment of the background gets translated into colour change. First, the idea that it is the relative level of reflected to incident light that dictates appropriate colour change requires formal testing. Second, the mechanisms and pathways of how visual information is translated into colour change is still largely a black box. In crabs and some other crustaceans, visual feedback somehow influences hormone systems based in either the eyestalks or main body, affecting changes in chromatophore cells [13–15]. However, how exactly this works remains unclear. Finally, Abram *et al.*'s [5] biochemical analyses raise questions about what the pigments are that cause changes in egg brightness. Clearly, we have much left to discover regarding both the functions and mechanisms of colour change and egg coloration in nature.

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Auditory Perception: Attentive Solution to the Cocktail Party Problem

Simon Carlile
Starkey Hearing Research Centre, 2110 Shattuck St #408, Berkeley, CA 94704 USA and School of Medical Sciences, University of Sydney, NSW 2006, Australia
Correspondence: simon_carlile@starkey.com
http://dx.doi.org/10.1016/j.cub.2015.07.064

A recent study has demonstrated how the focus of auditory attention can rapidly shift to follow spectrally dynamic speech-like sounds in the presence of a similar interferer. This requires multidimensional variation in sound features and a minimum spacing in spectral feature space.

Enquiries, directions, an invitation or warning, a plea, a command, a heated brainstorming or a convivial cocktail party: all important pieces in the way in which humans interact with each other. In fact, any animal that enjoys hearing shares some aspects of this communication banquet. Evolution has had plenty of time to fine-tune this interactive channel, which is not a bad thing as it presents the nervous system with, in computational terms, a very ill-formed problem. Essentially we have one receptor surface (the inner ear) that receives the sounds from many concurrent sources, such as the chorus around the pond at night, and 'multiplexes' all this information into a single channel (the auditory nerve). The computational challenge then is to sort out which parts of the encoded sound belong to which source and then group them together in a way that allows the nervous system to extract the information of interest against the background of other sounds [1]. The most interesting sounds, especially speech, vary rapidly over time so that this problem begins to look like a Rasta dreadlock! How does the system track the rapid dynamic variations in the distinguishing features? What are the critical acoustic features that enable this process? What is the frequency-temporal resolution of such a system? These are the questions that Woods and McDermott [2] have addressed in their study published in this issue of *Current Biology*, using a simple but highly innovative perceptual experiment with human listeners.

In solving this problem, one advantage for the auditory system is that it has evolved in a world of physically sounding objects, and the patterns of sound energy from individual sources conform to simple

