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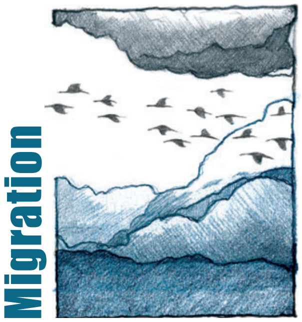
OUTSIDE JEB

Youth lead the way in climate change response



Migrating birds are often considered nature's endurance athletes. The timing of migrations coupled with the fine-tuning of arrival times at breeding grounds is critical for maximising individual fitness. Changes in the timing of spring migration have been widely reported for many species, and advances in migration are among the most commonly reported responses to changes in the climate. Paradoxically, repeated measurements over multiple years show that individuals are highly consistent in their arrival dates. If this is the case, then how are bird populations migrating earlier? A recent study by Jenny Gill, at the University of East Anglia, UK, has identified a mechanism for how migration dates are advancing at a population level, but not at an individual level. The key, it turns out, is in the new young recruits to the population and how they conduct themselves.

The study, published in *Proceedings of the Royal Society B*, uses a 14 year data set to look at arrival dates of individually marked black-tailed godwits (*Limosa limosa*), from a distinct Icelandic breeding population. These 300 g shorebirds migrate 3000 km each spring from wintering grounds in Portugal to breeding sites in Iceland. Gill explains that it is this accessibility of the migration range that enabled individual bird movements and arrival dates to be tracked with the help of over 2000 volunteer birdwatchers. The godwits' handy long legs make them ideal for fitting with individual identification rings and the birds are easily spotted by avid birdwatchers along the migration route as they are blessed with natural good looks.

What Gill and co-authors found was that new recruits to the population were migrating earlier, and the arrival dates of individual godwits that had hatched in recent years were significantly earlier than the arrival dates of their elders.

This earlier arrival at the breeding grounds is highly significant for many reasons. Early arrival has been linked to improved individual fitness, and population declines are most widely reported in species that are not advancing migration. Gill believes it is likely that the change in conditions at the nesting site affects the youngsters and that this is the most likely initial explanation for advanced arrival dates. This suggests that over time, the population as a whole will gradually migrate earlier as there is a decrease in the number of later arriving birds, and an increase in the frequency of early arriving recruits. As long as early arrival continues to confer fitness benefits, the proportion of 'early birds' within the population will continue to increase. This generational change in migration timing will be vital as the environment continues to change and this mechanism may hold the key to the sustainability of the godwit population, which is being used as a model for studying the impacts of climate change on animal migration.

What Gill and her team have achieved is the identification of a mechanism by which a population can respond and adapt to climate change. It appears that having no direct link between parent and offspring behaviour is actually a benefit when it comes to responding to change. Such a mechanism requires neither individual flexibility in annual timing of migration nor changes in gene frequencies. So for godwits at least, it seems that old habits do die hard, but the new kids on the block are paving the way to responding to environmental change.

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Gill, J. A., Alves, J. A., Sutherland, W. J., Appleton, G. F., Potts, P. M. and Gunnarsson, T. G. (2013). Why is timing of bird migration advancing when individuals are not? *Proc. R. Soc. B* **281**, 20132161. doi: 10.1098/rspb.2013.2161

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Female frogs only have ears for their potential mates

In frogs, sexual communication is mainly vocal. Males of a species serenade the females, sometimes in large choruses composed of several species. Amongst all the singing and all the background noise, it is hard to imagine how the messages from the males of one species reach their target without getting garbled amidst all the confusion. This is even more remarkable when taking into account the fact that the sound characteristics of different species calling together sometimes overlap. This is the case of *Eupsophus roseus* and *Eupsophus vertebralis*, two species of frogs that inhabit the temperate forests of Argentina and Chile, whose calls overlap in parts of the frequency spectrum. Felipe Moreno-Gómez and his colleagues at the Universidad Austral de Chile, the Universidad de Chile and the Muséum National d'Histoire Naturelle in France set out to understand how females of *E. roseus* are able to tease out the calls of their lovers from those of *E. vertebralis* males and other noise in the environment.

It has been suggested that in order to improve communication between two organisms, the sensitivity of the receiver needs to be tuned in to the signal characteristics produced by the signaller. Moreno-Gómez and his team decided to put this hypothesis to the test to find out whether this was the case for *E. roseus*. First, they recorded the calls of males and background noise in the field during the breeding season and analysed their spectral characteristics. Back in the lab,

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they recorded the acoustic sensitivity of females at different sound frequencies. They played back tones produced by a sound generator and then recorded the neuronal activity from the torus semicircularis (the auditory nucleus in the brain of a frog) in response to the different frequency tones through an electrode implanted in this area of the brain. Then they compared the sound frequencies to which the females were sensitive with the spectra of male vocalizations and background noise.

Just as expected, the auditory spectral sensitivity of females matched the sound characteristics of male vocalizations. Furthermore, the main components of the male calls had frequencies much higher than the frequencies of abiotic noise, which meant that there was no masking effect from background noise. Furthermore, even though there was some overlap in the sound spectra of the calls from male *E. roseus* and *E. vertebralis*, this overlap was much lower than the high degree of matching the researchers observed between the auditory sensitivity of *E. roseus* females and the main components of the calls of their males. This mismatch between the sensitivity of females to abiotic and biotic noise helps their potential mates stand out as the signal to noise ratio is much higher for them.

Moreno-Gómez and his colleagues showed that female frogs of the *E. roseus* species are tuned in to the serenades of their suitors, filtering out most of the environmental noise including that of a closely related species. This concordance between female sensitivity and male signal helps prevent miscommunication between parties, which could potentially lead to interspecies mating and, therefore, decreased fitness through the production of sterile hybrids. It has been said that love is blind, but in the case of *E. roseus* females, a more accurate description would be that their love is deaf to most sounds but their mate's.

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Moreno-Gómez, F. N., Sueur, J., Soto-Gamboa, M. and Penna, M. (2013). Female frog auditory sensitivity, male calls, and background noise: potential influences on the evolution of a peculiar matched filter. *Biol. J. Linn. Soc. Lon.* **110**, 814-827.

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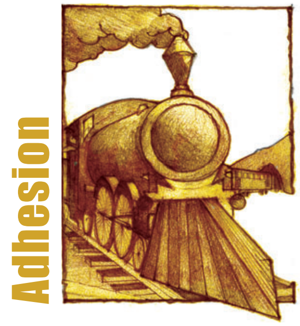
Arboreal locomotion: aye, there's the rub!



A surprisingly diverse array of animals, from spiders to mammals, have adhesive structures on their feet that allow them to run along vertical surfaces, climb high in the canopy, or hang upside down to await their prey. Lizards, particularly geckos, have received a lot of attention throughout the last century because of the incredible weight-bearing ability of their adhesive pads. This ability is thanks in part to remarkable, tiny, hair-like projections on these pads, called setae. Similar structures have been found, and only recently described in detail, on the feet and tail of chameleons. Chameleons are a morphologically unique group of lizards, with tightly grasping, grouped, opposable toes and prehensile tails. The hair-like structures on their feet and tail do not confer adhesive advantages upon the slow and careful chameleon as they do on their cousins the geckos, but Eraqi Khannoon at the University of Glasgow and his international team of colleagues suspected that they might provide some frictional advantages – an additional boost to maintain purchase on the substrate that would likely be advantageous on slippery and narrow branches. In a recent study, they tested whether these tiny structures were the arboreal chameleon's key to locomotor success.

Khannoon and his colleagues first examined the general morphology of the toe pads and tail of five species of arboreal chameleons and then used histology and scanning electron microscopy to compare the morphology of the setae-like structures of these species with the setae of other lizards. They then tested the frictional forces generated by the setae-like structures on the top and bottom surfaces of the front and hind feet of the veiled chameleon, *Chamaeleo calyptratus*, using a specially designed force-measurement probe.

The researchers discovered that, unlike true setae, the chameleon's setae-like structures form a continuous carpet along the bottom surface of the digits and end of the tail; areas that regularly come in direct contact with the locomotor substrate. In addition, the structures are not branched, like setae, and the ends of these structures do not terminate in tiny spatulas, but rather tiny globes, flat plates or pointy tips. As predicted, the frictional forces generated by the surface of the skin were significantly greater on the bottom of the feet than on the top. And once Khannoon and his colleagues removed the seta-like structures and re-tested the skin, the frictional forces of the bottom surface of the foot decreased. It appears that these friction-enhancing filaments work in conjunction with the tightly gripping feet and prehensile tail to form one integrated, arboreal-navigating machine.

Khannoon and his colleagues suggest that the friction-enhancing filaments on the feet and tail of arboreal chameleons have been derived independently of those of the adhesion-enabling true setae found on geckos, anoles and skinks, making it the second derivation of this type of structure in lizards. They propose that the friction-enhancing setae-like structures not only impart a locomotor advantage to arboreal chameleons but also may provide insight into how the adhesion-inducing structures of other lizards have arisen. These results are exciting for biologists and biomimeticists alike. Although much research in the past has focused on adhesion, the evolution of friction-enhancing structures in animals and the functional integration of this trait with other morphological features may provide great new insights into the way we think about whole-animal performance and locomotion in general.

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Khannoon, E. R., Endlein, T., Russell, A. P. and Autumn, K. (2014). Experimental evidence for friction-enhancing integumentary modifications of chameleons and associated functional and evolutionary implications. *Proc. R. Soc. B* **281**, 20132334. doi:10.1098/rspb.2013.2334

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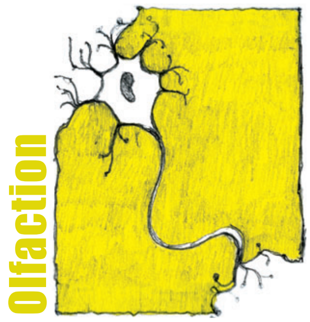
The smell of blood



Many animals use the sense of smell as a guide through life, dividing the world into what is good and what is harmful. Olfaction distinguishes nutritional foods from toxic ones, helps identify appropriate mates, and allows the detection of predators. A lot of effort has gone into elucidating how odours are detected and how they are met with the appropriate behavioural response, processes that are still incompletely understood.

However, evidence is now emerging that, in addition to its roles in acutely sensing odours, olfaction is involved in the regulation of the general physiology of animals. In the roundworm *Caenorhabditis elegans* and the fruit fly *Drosophila melanogaster* the olfactory system regulates life span, as animals that have compromised olfaction live longer than their 'smelling' counterparts. This exciting discovery left many scientists scratching their heads: how on earth could olfaction have such a dramatic effect on physiology?

A chance discovery in a study by a team of researchers led by Utpal Banerjee at the University of California, Los Angeles, USA, recently published in the journal *Cell*, provides a possible answer. This research group focuses on the process of haematopoiesis – blood cell development – in the *Drosophila* larva, trying to elucidate the mechanisms that tightly regulate the generation of differentiated blood cells from a group of stem cell-like progenitors. They noticed that when they interfered with a receptor for the neurotransmitter GABA within blood cell progenitors, most of them differentiated precociously into blood cells. This suggests the nervous system is involved in the regulation of the generation of blood cells. To find out more about how this neurotransmitter regulates haematopoiesis, they set out to pinpoint its exact source.

They found a cluster of cells in the brain that secrete GABA into the larval blood to be responsible, as blocking the production of neurotransmitter within these cells led to precocious differentiation of progenitors into blood cells. This demonstrates the nervous system is indeed directly involved in haematopoiesis, but what could be the function of this regulation?

In order to address this question, the team tried to find the parts of the nervous system that induce the secretory cells to release GABA. They made the key discovery that inhibition of the olfactory system prevents the release of neurotransmitter from the secretory cells. This inhibition subsequently leads to the precocious differentiation of progenitor cells, suggesting that the detection of smells is required for the maintenance of the pre-differentiated state of blood progenitor cells.

What makes this finding particularly interesting is that it provides a possible mechanism for how olfaction affects life span: in the absence of odours, or if the olfactory system is inhibited, the number of blood cells that is being generated is increased. As these cells are involved in many aspects of innate immunity, this increase in number could leave the organism better protected against microbial agents and help the animal to live longer.

The findings suggest that olfaction directly regulates haematopoiesis, whereby the activation of an odorant receptor is required for the maintenance of the pre-differentiated state of the pool of cells that give rise to blood cells. While the evidence presented provides a strong link between olfaction and the regulation of blood cells, and the link to life span extension is an attractive one, don't start blocking up your nose just yet: it is not yet known whether similar mechanisms are present in vertebrates (such as yourself).

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