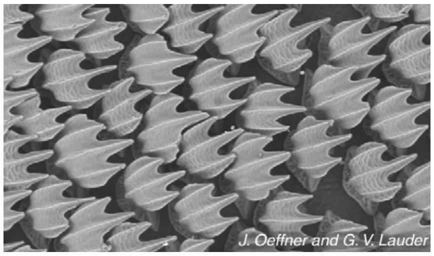
Inside JEB highlights the key developments in *The Journal of Experimental Biology*. Written by science journalists, the short reports give the inside view of the science in JEB.

Inside JEB

SHARK SKIN PRODUCES PROPULSION


J. Oeffner and G. V. Lauder

Streamlined sharks are legendary for their effortless swimming. George Lauder from Harvard University explains that the fish have long inspired human engineers, but more recently attention has focused on how the fish's remarkable skin boosts swimming. Coated in razor sharp tooth-like scales, called denticles, the skin is thought to behave like the dimples on a golf ball, disturbing the flow of water over the surface to reduce the drag. But something didn't quite sit right with Lauder. 'All of the shark skin studies were done on flat shark skin mimics that were held straight and immovable. But shark skin moves', recalls Lauder. So, when Masters student Johannes Oeffner joined his lab, Lauder suggested that they take a look at the fluid dynamics of shark skin and its analogues to find out how the fish's motion affects fluid flowing over the rough surface (p. 785).

But first the duo had to get hold of some fresh shark skin, so they went to a market in Boston where they found several large makos. Back in the lab, Oeffner carefully removed sections from a mako's skin and attached them to both sides of a rigid aluminium foil. Then he immersed the foil in a flow tank, reproduced the swimming motion of a fish by wiggling it from side to side and measured the rigid 'swimming' foil's speed by matching it with the flow of water moving in the opposite direction.

Having measured the foil's swimming speeds with intact skin – complete with denticles – Oeffner carefully sanded off the denticles and set the foil swimming again. However, instead of slowing down – as the duo had expected – the denticle-free foil speeded up. So the shark skin's denticle surface impeded the rigid swimmer. 'But then we remembered our premise that the sharks aren't rigid', remembers Lauder, so how would the shark skin perform when flexing like a real fish?

Gluing two pieces of shark skin together to produce a flexible foil, Oeffner repeated the swimming experiment, and this time the denticles had a dramatic effect. The intact skin foil swam 12.3% faster than the sanded skin. The shark's rough surface improved the swimming performance spectacularly. However, when the duo tested the swimming performance of two shark skin mimics – a sharp-edged riblet design and the famous Speedo® Fastskin® FS II fabric – they were in for a shock. Although the riblet surface improved the flexible foil's swimming speed by 7.2%, the dented surface of the Speedo® fabric had no effect at all. However, Lauder points out that figure-hugging Fastskin® swimming costumes probably enhance the swimmer's performance in other ways.

After proving that the denticles on shark skin significantly improve the fish's propulsion, Lauder and Oeffner were keen to find out how they affect fluid flows around the body. Returning the flexible shark skin foil to the swim tunnel, Oeffner and Lauder captured the water's swirling motion with laser light and realised that in addition to reducing drag, the skin was actively generating thrust.

'That's the number one surprise. It's not just the drag-reducing properties, but the denticles alter the structure of flow near the shark skin in a way that enhances thrust', explains Lauder. He is now keen to design physical models to see how altered denticle arrangements affect fluid flows over the skin and to build a computational model to tease apart the beneficial effects of the skin's thrust and drag reduction.

10.1242/jeb.070698

Oeffner, J. and Lauder, G. V. (2012). The hydrodynamic function of shark skin and two biomimetic applications. *J. Exp. Biol.* **215**, 785-795.

Kathryn Knight

OLD FLIES LOSE SEX APPEAL

Let's face it, growing old isn't appealing. Stiffer joints, wrinkly skin, senior moments; it's all just a matter of time. But, to add insult to injury, it seems a dwindling sex life is unavoidable too – at least if you're a fruit fly. That's the inescapable conclusion of work by Tsung-Han Kuo and Scott Pletcher of the University of Michigan and Baylor College of Medicine and their colleagues (p. 814).

For any animal, reproduction is top of the to-do list. But since only the fittest attract a mate, it seems reasonable to assume that animals become less attractive as they grow older. Fruit flies use pheromones to entice the opposite sex, so Kuo, Pletcher and colleagues wondered how flies' pheromone profiles and sex appeal alter with age. To examine the link between attractiveness and age, the team used mass spectroscopy to take a closer look at pheromones on the


Tatyana Fedina

cuticles of flies aged between 7 and 65 days. Males and females differed in their specific pheromone profiles, but as the team had expected, they saw that profiles shifted with age in both sexes. Elderly males and females produced a higher proportion of heavier pheromones compared with younger flies. 'The results were remarkably consistent across different strains of flies', says Pletcher, which suggests that pheromone profile changes are strongly regulated throughout the lifespan and unlikely to be a random by-product of ageing.

Next, the team tested whether these changes affect how desirable the flies are. When the team presented males with a choice between young and old females, the males courted the younger specimens more vigorously, suggesting that they were more attractive to the males. This was backed up by video analysis, which showed that males spent more time close to younger females.

But were age-related changes in the females' pheromone profiles responsible for the males' waning interest in elderly ladies? To rule out the possibility that beauty was in the eye of the beholder, the team tested males' preferences in the dark – but males still ardently pursued younger females, so they weren't relying on visual cues to pick a partner. Next, the team washed females' pheromones off their bodies and retested their sex appeal. Sure enough, males could no longer tell the difference between young and old females. As a final test, they sprayed pheromones from young and old females onto genetically modified flies who couldn't produce pheromones of their own, and saw that the males preferred flies covered with young females' pheromones. And it wasn't only males who favoured youthfulness; when the team tested female flies' preferences, they saw that females fancied younger males.

The team concludes that both male and female flies become less alluring with age, and this is caused by changing pheromone profiles. Speculating about the reasons for this, Pletcher points to the possibility that heavier hydrocarbons help prevent older flies from drying out. 'If these changes are simply reflective of an ageing physiology,' he notes, 'flies may have evolved the ability to read these signals as honest indicators of health.' These findings pave the way for an exploration of the molecular nature of attractiveness, says Pletcher. 'We know that ageing is conserved across species, so we want to examine the exciting possibility that the mechanisms underlying attractiveness are also conserved across species.'

10.1242/jeb.070714

Kuo, T.-H., Yew, J. Y., Fedina, T. Y., Dreisewerd, K., Dierick, H. A. and Pletcher, S. D. (2012). Aging modulates cuticular hydrocarbons and sexual attractiveness in *Drosophila melanogaster*. *J. Exp. Biol.* **215**, 814-821.

Yfke Hager

OESTROGEN KEY TO FEMALE SNAKE'S SEXINESS


Chris Friesen

Every spring, the Interlake region of Manitoba, Canada, is the scene of a mating frenzy. Lured by female sex pheromones, 'Tens of thousands of red-sided garter snakes bubble out of the ground', says chemical ecologist Rocky Parker. 'Male mate choice comes down to a matter of tongueflicks. But we don't know what triggers pheromone production.' Parker teamed up with Robert Mason of Oregon State University to decode the secrets of chemical signalling in red-sided garter snakes. Knowing that the hormone oestrogen activates sexual signal expression in birds, and given that snakes and birds are closely related, Parker and Mason wondered whether oestrogen triggers the production of a snake sexual signal: the garter snake sex pheromone (p. 723).

The pair reasoned that, if oestrogen was the key to their puzzle, exposing male snakes to oestrogen should make them smell like females and therefore irresistible to other males. To find out, they collected male red-sided garter snakes in Manitoba and brought them back to Oregon, where they surgically inserted oestrogen implants into the males' body cavities. The next spring, they took the snakes back to Manitoba to test whether oestrogen had made them alluring. Placing the altered males in an outdoor arena, the pair was delighted to see that wild males courted the implanted males. But, seeing that the altered males tried to avoid their love-struck suitors, Parker and Mason devised an additional test. Starting a mating ball composed of a female surrounded by courting males, they placed an altered male near the mating ball and counted how many males lost interest in the female and began wooing the altered male instead. Again, wild males were keen to court implanted males; they believed that they were pursuing females. Parker and Mason also found that the effects were entirely reversible, as wild males were no longer fooled by altered males once their implants were removed. The hormone functions as an 'on/off switch' for female pheromone production.

So far, Parker and Mason's suspicions had been confirmed. But when they laid scent trails in a Y-maze – by rubbing male and female snakes' bellies along the maze's arms – they were astonished to find that implanted males were more attractive than small females. 'Longer females have more babies, so it's best to court large females', says Parker. 'For some reason, oestrogen made males as alluring as large females.'

To find out why, the pair collected altered males' skin lipids and examined their pheromone composition using mass spectrometry. Garter snake sex pheromones are made up of light and heavy methyl ketones, with large females producing mostly heavier ketones. When Parker and Mason plotted the pheromone profiles, they saw that altered males had a heavy pheromone composition, just like large females. 'It turns out that oestrogen triggers the production of the heaviest, and therefore sexiest, methyl ketones', Parker concludes.

So, in red-sided garter snakes, oestrogen triggers female pheromone production. This may offer an explanation for the puzzling existence of 'she-males' – wild males who naturally produce female sex pheromone but have negligible circulating oestrogen levels. 'Exposure to oestrogen-mimicking pollutants could explain the presence of she-males', says Parker; bad news for a species whose reproduction depends solely on chemical cues. 'But the good news is that the changes are at least reversible', he adds.

10.1242/jeb.070706

Parker, M. R. and Mason, R. T. (2012). How to make a sexy snake: estrogen activation of female sex pheromone in male red-sided garter snakes. *J. Exp. Biol.* **215**, 723-730.

Yfke Hager

HOW THE ZEBRA GOT ITS STRIPES

If there was a ‘Just So’ story for how the zebra got its stripes, I’m sure that Rudyard Kipling would have come up with an amusing and entertaining camouflage explanation. But would he have come up with the explanation that Gábor Horváth and colleagues from Hungary and Sweden have: that zebra’s stripes stave off blood-sucking insects (p. 736)?

Horseflies (tabanids) deliver nasty bites, carry disease and distract grazing animals from feeding. According to Horváth, these insects are attracted to horizontally polarized light because reflections from water are horizontally polarized and aquatic insects use this phenomenon to identify stretches of water where they can mate and lay eggs. However, blood-sucking female tabanids are also guided to victims by linearly polarized light reflected from their hides. Explaining that horseflies are more attracted to dark horses than to white horses, the team also points out that developing zebra embryos start out with a dark skin, but go on to develop white stripes before birth. The team wondered whether the zebra’s stripy hide might have evolved to disrupt their attractive dark skins and make them less appealing to voracious bloodsuckers, such as tabanids.

Travelling to a horsefly-infested horse farm near Budapest, the team tested how attractive these blood-sucking insects found black and white striped patterns by varying the width, density and angle of the stripes and the direction of polarization of the light that they reflected. Trapping attracted insects with oil and glue, the team found that the patterns attracted fewer flies as the stripes became narrower, with the narrowest stripes attracting the fewest tabanids.

The team then tested the attractiveness of white, dark and striped horse models. Suspecting that the striped horse would attract an intermediate number of flies between the white and dark models, the team was surprised to find that the striped model was the least attractive of all.

Finally, when the team measured the stripe widths and polarization patterns of light reflected from real zebra hides, they found that the zebra’s pattern correlated well with the patterns that were least attractive to horseflies.

‘We conclude that zebras have evolved a coat pattern in which the stripes are narrow enough to ensure minimum attractiveness to tabanid flies’, says the team and they add, ‘The selection pressure for striped coat patterns as a response to blood-sucking dipteran parasites is probably high in this region [Africa]’.

10.1242/jeb.070680

Egri, Á., Blahó, M., Kriska, G., Farkas, R., Gyurkovszky, M., Åkesson, S. and Horváth, G. (2012). Polarotactic tabanids find striped patterns with brightness and/or polarization modulation least attractive: an advantage of zebra stripes. *J. Exp. Biol.* **215**, 736-745.

Kathryn Knight
kathryn@biologists.com

© 2012. Published by The Company of Biologists Ltd