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.

BEES USE THREE-PHASE LANDING STRATEGY

Mandyam Srinivasan is an electrical engineer that is intrigued by bees. 'I have been fascinated for a long time how a creature with a brain the size of a sesame seed can do all of the things that it does,' says Srinivasan. Over the course of his career, Srinivasan has discovered how insects negotiate the world by analysing how images of the surroundings move across the eye rather than using stereovision. Having discovered how bees use this 'optic flow' information to negotiate the environment, regulate their flight speed and control their approach during landing, Srinivasan began wondering what happens in the final moments of a touchdown. Flies landing on a ceiling simply grab hold with their front legs and somersault up as they zip along, but Srinivasan knew that a bee's approach is more sedate. Curious to know more about bee landing techniques, Srinivasan teamed up with Carla Evangelista, Peter Kraft, Marie Dacke and Judith Reinhard and used a high-speed camera to film the instant of touch-down on surfaces at various inclinations (p. 262).

First, the team built a bee-landing platform that could be inclined at any angle from horizontal to inverted (like a ceiling); they then trained bees to land on it and began filming. Having collected movies of the bees landing on surfaces ranging from 0 deg. to 180 deg., and every 10 deg. inclination between, Evangelista began the painstaking task of manually analysing the bees' landing tactics and saw that the bees' approach could be broken down into three phases.

Initially, the bees approached from almost any direction and at any speed; however, as they got closer to the platforms, they slowed dramatically, almost hovering, until they were 16 mm from the platform, when they ground to a complete halt, hovering for anything ranging from 50 ms to over 140 ms. When the surface was horizontal or inclined slightly, the bees' hind legs were almost within touching distance of the surface, so it was simply a matter of the bee gently lowering itself and grabbing hold with its rear feet.

However, when the insects were landing on surfaces ranging from vertical to inverted 'ceilings', their antennae were closest to the surface during the hover phase. When the antennae grazed the surface, this triggered the bees to reach up with the front legs, grasp hold of the surface and then slowly heave their middle and hind legs up too. 'We had not expected the antennae to play a role, and the fact that there is a mechanical aspect of this is something that we hadn't thought about,' admits Srinivasan.

Looking at the antennae's positions, the team realised that the bees held them roughly perpendicular to the surface in the final stages when approaching inverted surfaces. 'The bee is able to estimate the slope of the surface to orient correctly the antennae, so it is using its visual system,' explains Srinivasan. But this is surprising, because the insects are almost completely stationary while hovering and unable to use image movement across the eye to estimate distances. Srinivasan suspects that the bees could be using stereovision over such a short distance and is keen to test the idea.

Finally the team realised that bees are almost tailor-made to land on surfaces inclined at angles of 60 deg. to the horizontal. 'When bees are flying fast their bodies are horizontal, but when they are flying slowly or hovering their abdomen tilts down so that the tips of the legs and antennae lie in a plane that makes an angle of 60 deg.' explains Srinivasan: so the legs and antennae all touch down simultaneously on surfaces inclined at that angle. 'It seems like they are adapted to land on surfaces tilted to 60 deg. and we are keen to find out whether many flowers have this natural tilt,' says Srinivasan.

10.1242/jeb.041483

Evangelista, C., Kraft, P., Dacke, M., Reinhard, J. and Srinivasan, M. V. (2010). The moment before touchdown: landing manoeuvres of the honeybee *Apis mellifera*. *J. Exp. Biol.* **213**, 262-270.

SEA URCHINS USE WHOLE BODY AS EYE

Sea urchins don't seem to have any problems avoiding predators or finding comfortable dark corners to hide in, but they appear to do all this without eyes. So how do they see? It appears that sea urchins may use the whole surface of their bodies as a compound eye, and the animals' spines may shield their bodies from light coming from wide angles to enable them to pick out relatively fine visual detail. Divya

Yerramilli and Sönke Johnsen from Duke University explain that if this is the case, sea urchins with densely packed spines will have better vision than sea urchins with sparsely packed spines, so they decided to test the vision of *Strongylocentrotus purpuratus* sea urchins, with tightly packed spines, to find out how well they see (p. 249).

Placing individual urchins in a brightly lit arena with a 6 cm or 9 cm diameter dark disk on the arena's wall, the team viewed the shadows of the moving animals from beneath the arena's white floor. Would the sea urchins see the disk and respond to it, or would they be oblivious to the disk's presence? Recording 39 urchins' responses to the disk at different positions around the arena's perimeter, the duo saw that the urchins wandered randomly around the arena when the 6 cm diameter disk was in place; they didn't respond to it. But it was a different matter with the 9 cm diameter disk; the urchins either raced toward it or fled in the opposite direction.

Calculating the visual angle of the 9 cm diameter disk from a sea urchin's perspective, Yerramilli and Johnsen suggest that the sea urchin's visual resolution is at least 10 deg. And when the pair calculated the sea urchin's visual resolution based on the animal's spine density, they found that it could be as good as 8 deg., but not good enough to see the smaller 6 cm diameter disk.

But why did some of the sea urchins career toward the disk while others turned away? Yerramilli and Johnsen suspect that it depends on the sea urchin's interpretation of the dark object. Some of the animals may interpret the object as a predator and flee, while others identify it as shelter and head towards it. What is more surprising is that the urchins' vision is as good as *Nautilus* and horseshoe crab vision, which is quite impressive for an echinoid that has turned its whole body into an eye.

10.1242/jeb.041715

Yerramilli, D. and Johnsen, S. (2010). Spatial vision in the purple sea urchin *Strongylocentrotus purpuratus* (Echinoidea). *J. Exp. Biol.* **213**, 249-255.

TIMEFRAME AFFECTS SNAKES' ABILITY TO COPE WITH CLIMATE CHANGE

We're all at risk from climate change, but cold-blooded animals (ectotherms) that depend on the environment to maintain their body temperatures could be at more risk than most. And with weather patterns becoming more unstable, it may not just be a case of adapting to a warmer or cooler climate, but to more hot and cold snaps too. Curious to find out how ectotherms adapt to short- and long-term temperature changes, Fabien Aubret from the CNRS à Moulis, France, and Richard Shine from the University of Sydney, Australia, decided to find out how hatchling tiger snakes respond to cool and warm conditions (p. 242).

The duo built three habitats, each with an incandescent light bulb at one end to create a temperature gradient in the enclosure, and allowed the snakes to thermoregulate by basking where ever they found the temperature comfortable. The light bulb in one enclosure switched off when the ground temperature reached 22°C to create a cool environment, the bulb in the second enclosure switched off when the top temperature reached 26°C (warm environment), and the bulb in the third enclosure was on continually between 06.00 h and 21.00 h to make it really hot.

Monitoring the young snakes' health, growth and body temperatures over 14 months, the duo was surprised to see that, despite the snakes' dramatically different environments the young animals' ability to maintain similar mean and maximum body temperatures was impressive. The snakes had adapted their behaviour to ensure that they all maintained a similar body temperature, and the snakes in the cold enclosure had compensated for the cooler climate by basking for longer. However, the cold-adapted snakes seemed to have paid a price for survival in the cold: they were smaller than their warm-adapted siblings.

Aubret and Shine put the differences in the snakes' sizes down to several possibilities. They suggest that the cold snakes may be smaller because they have to devote more energy to finding warm basking spots, or it may simply be easier for small snakes to get warm compared with larger snakes. Alternatively, the warmer snakes could have grown larger because digestion is more efficient in warm conditions, allowing them to make the most of mice dinners.

So, young tiger snakes seem to be able to adapt to long-term environmental change, but how would they manage during a warm or cold snap? Could they adjust their behaviour to take account of a sudden change in temperature?

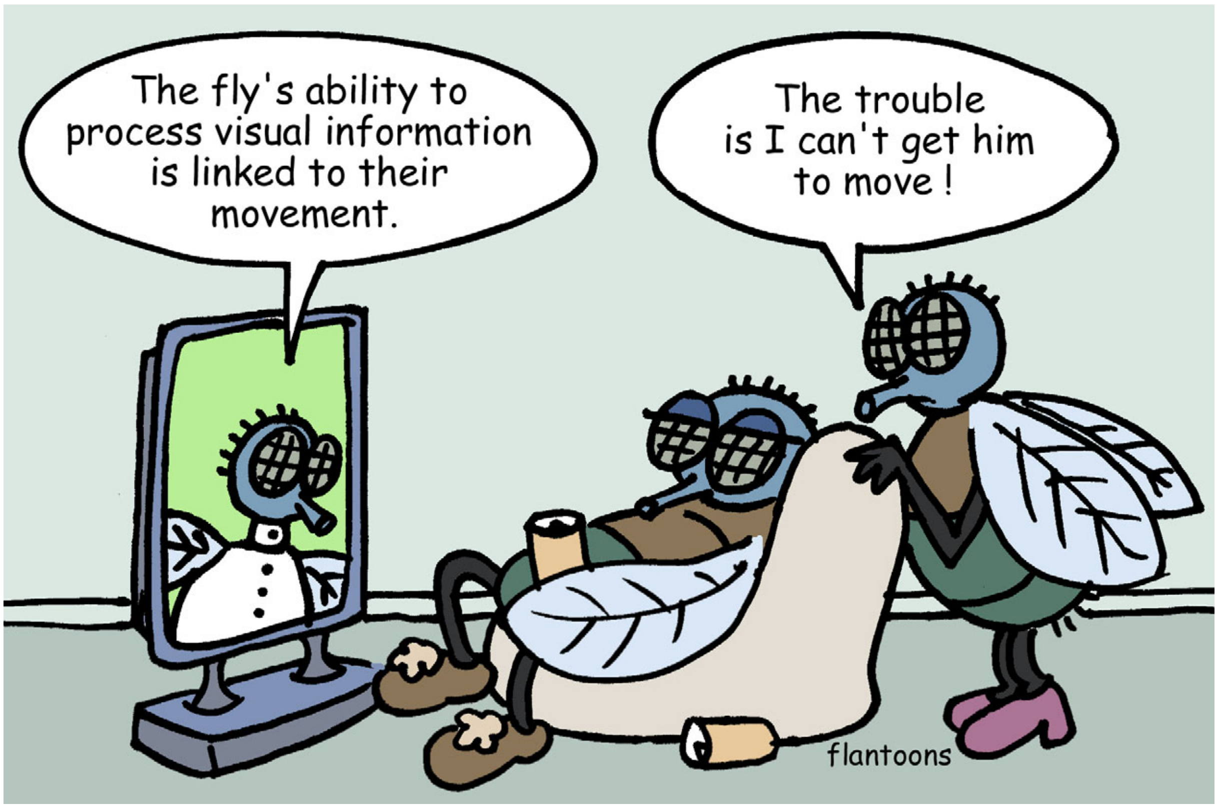
Aubret and Shine switched on all of the bulbs over the enclosures to warm all three climates as much as possible and watched how the snakes responded. Would they adjust their basking habits? They did not. The snakes that had grown up in cold conditions basked for longer than snakes that were used to the heat; and their body temepratures were warmer by 2.1°C. And when the team took away the lamps and plunged the snakes into a cold snap, the hot-adapted snakes' temperatures fell on average by 1.5°C because they basked for a fraction of the time that the cold-adapted snakes basked.

Despite adapting well to long-term climate conditions when they were young, the snakes were unable to adapt to short-term climate fluctuations when they were older. 'Our data provide a striking example of how an ectotherm's thermoregulatory tactics and mean selected body temperature can depend more upon previously encountered conditions than upon current thermal challenge,' say Aubret and Shine.

10.1242/jeb.041467

Aubret, F. and Shine, R. (2010). Thermal plasticity in young snakes: how will climate change affect the thermoregulatory tactics of ectotherms? *J. Exp. Biol.* **213**, 242-248.

MOVEMENT AFFECTS FLY'S VISION



Flies have remarkable vision. Their compound eyes are superbly adapted to their high-speed lifestyle. But what effect does a fly's motion have on the way the insect processes visual information? Ronny Rosner, Martin Egelhaaf, and Anne-Kathrin Warzecha from the Universität Bielefeld, Germany, explain that an insect's nervous system can be in a completely different state when it is immobile and when it is active and that this may affect the way that sensory information is processed. Knowing the role of lobula plate tangential cells in flight and head control, due to processing the moving surroundings' visual information, the trio decided to find out what effect the insect's movement has on the way that the cells process visual information (p. 331).

Allowing tethered flies to beat their halteres (hind wings that have evolved into moving stumps) as if the insects were walking or flying, the team recorded the electrical activity from the lobula plate tangential cells in response to images of bright and dim dots and blank screens. The team found that the flies' lobula plate tangential cells generated membrane potential changes when it was dark and the halteres were active: so activity does seem to modify the lobula plate tangential cells' output. And when the team played images of dim and bright dots to the flies, haltere activity enhanced the lobula plate tangential cells' membrane potentials, especially when the images were dim. So the flies' activity levels do affect their ability to process visual information, and Rosner and his colleagues suspect that this could allow the flies to respond faster when moving around.

10.1242/jeb.041475

Rosner, R., Egelhaaf, M. and Warzecha, A.-K. (2010). Behavioural state affects motion-sensitive neurones in the fly visual system. *J. Exp. Biol.* **213**, 331-338.

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