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

LONG-LIVED WINTER BEES PROVIDE CLUES ABOUT AGEING

Life is tough for young worker bees, who spend their short adult lives diligently rearing their queen's offspring. First, they lavish their queen's progeny with nourishing jelly, before switching to a foraging role, where they quickly age and die after just 2 weeks. In total, while queens can live for up to 5 years, most workers will live for a mere 2 months. However, during winter, workers can live longer, with bees born in autumn living for 6–7 months before spring arrives. These dramatic differences in lifespan in otherwise genetically related bees offer scientists crucial insights into how ageing and its unwanted symptoms, such as cognitive decline, develop. Many researchers have focused on summer workers, but Daniel Münch from the Norwegian University of Life Sciences, Norway, was more interested in the long-lived winter bees: 'We know that they live quite long, but the big question is, do they show functional decline? Do they stay healthy over time? Could we transfer a long-lived phenotype that showed negligible ageing into a short-lived phenotype?' Working in a country with cold, snowy winters, Münch had the perfect conditions to answer these questions and so, with the help of his mentor Gro Amdam and the lab's excellent beekeeper, Claus Kreibich, he began his study (p. 1638).

First, the team collected bees from their hives during early, mid- and late winter to test for functional learning decline over time – could they learn to associate a carnation oil aroma with a sugary reward? To do this, Münch took advantage of the characteristic bee feeding mechanism, where the proboscis (the insect's tongue) automatically extends when it's presented with something tasty. Münch presented each bee with the flowery perfume for 3 s before rewarding it with a sweet treat. In subsequent trials he looked for bees that extended their proboscis following scent release but before the tasty treat appeared – a sign they'd learnt that the reward was on its way. Despite increasing in chronological age, Münch found that the winter bees' learning capacity did not decline as winter went on. In fact, their ability for associative learning was on par with that of a young, 9 day old bee reared indoors; most bees learnt to extend their proboscis in response to the perfume after just two rounds of scent presentations.

Münch then wonder whether he could speed up ageing by transferring some of the winter hives indoors, where he mimicked summery conditions. Sure enough, the hives began brood rearing and after just 1 or 2 weeks of foraging these ex-winter bees aged rapidly and showed a decline in learning ability, unlike their compatriots of similar chronological age that had remained outside. Furthermore, when the team looked at the pattern of lipofuscin – aggregates of lipids and proteins that accumulate with age in all animals – in the brain, they found that lipofuscin accumulation was greater in specific areas in foragers.

As a shortening in life expectancy coincided with brood rearing, Münch wondered what would happen if the brood were taken away. 'What we observed was surprising; after 2 weeks there were still a lot of foragers left and they didn't show any functional [learning] decline. So we waited for a period of 70 days and we still couldn't detect any functional decline, any ageing, in these colonies', recalls Münch. So despite having adopted forager status they lived longer and, again, chronological age didn't automatically correspond with functional decline. By speeding up or slowly down ageing in bees, Münch and his colleagues hope to identify what causes functional decline, and suggest that lipofuscin accumulation in specific brain regions may be partially responsible.

10.1242/jeb.086736

Münch, D., Kreibich, C. D. and Amdam, G. V. (2013). Aging and its modulation in a long-lived worker caste of the honey bee. *J. Exp. Biol.* **216**, 1638-1649.

Nicola Stead

THE ABDOMEN: THE SECRET TO STABILISING FLIGHT

The ability to fly has always fascinated mankind and while we can now safely get a gigantic double-decker Airbus A380 airborne, the production of efficient small flying robots is still in its infancy. 'If we want to make little things that fly, we're not even close to achieving what animals can do, in particular small animals', points out Jonathan Dyhr, a researcher at the University of Washington, USA. It is no surprise, therefore, that many scientists like Dyhr are studying insects in the hope of discovering their aeronautical secrets. While the wings are clearly central to flight control, it was the abdomen's role that interested Dyhr. As he explains, 'It has been known for years that when insects are restrained for tethered flight preparations they have very exaggerated abdominal movements. While there have been a lot of theories as to how the abdomen could control flight, there had not been any firm tests of whether these theories were true or if the abdominal movements were simply an artefact of

tethering the moth'. With the help of Tom Daniel, Kristi Morgansen and Noah Cowan, Dyhr set out to understand whether the abdomen had any role in flight control (p. 1523).

First, *Manduca sexta* moths were tethered in a circular arena of LED displays, which spanned 220 deg of the moth's visual field. The team then created a grating pattern of green and black bars on the displays. The team oscillated this grating pattern with the pattern moving up and down the screen, giving the insect the impression it was rotating upwards or downwards. The oscillation varied and occurred in one of two modes each lasting 40 s. In one mode, the pattern oscillated with an irregular but periodically repeating motion, with the pattern moving up or down the screen to different degrees and speeds throughout the 40 s. In the other mode, the grating pattern moved up and down with increasing frequency, moving smaller and smaller distances up and down as time went on, giving the moth the impression of accelerated tumbling. For 5 min the two modes were presented in a pseudo-random order while Dyhr filmed the moth's reaction using high-speed cameras. Regardless of the exact mode of oscillations, the team found that the moth responded the same way, with the abdomen moving in the same direction as the pattern, so if the pattern rotated upwards the moth would bend its abdomen upwards and likewise when the pattern moved downwards the abdomen flexed down. In addition, this flexing movement was in sync with the pattern. Dyhr explains, 'If you look at low frequencies, the animals are very good at matching the motion of the pattern as it moves up and down, but as you go to much higher frequencies, the moth lags behind and it's not fully able to keep up with the oscillation'. However, the question remained, how exactly is abdominal movement altering flight?

Using the data collected from the LED display, the team could answer this by creating a model of how the moth moves its abdomen in response to the world spinning around it as it flies and the impact that these movements have on the aerodynamic forces that keep the insect aloft. Their model suggests that two things are happening. First, flexing the abdomen shifts the moth's centre of mass to counteract the rotation. In addition, this causes the thorax to bend, re-directing the aerodynamic forces produced by the wings and so correcting the loss of stability. So, while the wings are still central to keeping insects aloft, it seems that the abdomen also plays a key role in flight control.

10.1242/jeb.087494

Dyhr, J. P., Morgansen, K. A., Daniel, T. L. and Cowan, N. J. (2013). Flexible strategies for flight control: an active role for the abdomen. *J. Exp. Biol.* **216**, 1523-1536.

Nicola Stead

HOW NOISE POLLUTION BATTERS BELUGA HEARING

The ocean is no longer the silent haven that it once was. Massive ships churn the sea; submarine explosions and ear-splitting construction can wreck the peace. Alexander Supin from the Russian Academy of Sciences explains that aquatic mammals are particularly vulnerable to noise pollution as they depend on their hearing for orientation, navigation and communication. Even a temporary loss of hearing could cause disoriented animals to beach in shallow water. 'It is very important to know how severe the influence of noise is on cetacean hearing and which restrictions are necessary to minimise the impact and to speed recovery', says Supin. However, sound can damage hearing in many different ways: a continual low-volume squeal can be as harmful as an explosion if the animal's hearing is particularly susceptible. Supin, Vladimir Popov and their colleagues explain that measuring the impact of multiple acoustic factors on cetaceans is challenging. They decided to measure the electrical activity in an animal's auditory system at the surface of the skin (auditory evoked potential) to rapidly assess the effect of various acoustic factors on the hearing of two captive belugas and to find out how quickly they recover from loud noise pollution (p. 1587).

Supin and colleagues travelled to the Utrish Marine Station, situated on the Russian Black Sea coast, to test the animals' hearing. 'The belugas were very cooperative, otherwise it would hardly be possible to perform the study', he recalls. Gently lowering each animal into a small tank, the team measured the electrical activity produced by the animal's auditory system as it listened to soft sounds over frequencies ranging from 8 to 128 kHz to establish the minimum sound intensity that the animal could hear. Then, having established the whale's hearing threshold, the team played a loud sound – to simulate the kind of noise pollution that the whale might encounter – before monitoring the temporary effect that it had on the whale's ability to hear and the animal's recovery.

Repeating the experiment while varying the pitch of the simulated noise pollution from 11.2 kHz up to 90 kHz, the intensity from 145 dB to 165 dB, and playing the sound for periods lasting from 1 to 30 min, the team found that the whales' hearing always recovered completely within a day. However, unexpectedly the whales' hearing took longer to recover after experiencing the lower pitched noises (11.2 and 22.5 kHz) than the higher pitched noises (45 and 90 kHz). 'A commonly adopted point of view is that high frequencies are the most susceptible to any influence causing hearing loss', says Supin, 'but in our experiments, the middle frequency range [20–30 kHz] displayed the largest post-exposure loss of sensitivity'.

In addition, the whales found it harder to hear sounds that were half an octave higher than the noise that they had just experienced, and when the team tracked the whales' recovery, they found that the longer the noise exposure, the longer it took the animals' hearing to recover. Finally, the team compared the impact that noise had on the two animals and they were surprised to find that the hearing of one of the animals was much more sensitive to noise than the other's, even though they were the same age and their initial hearing was equally good.

Having discovered that the hearing of belugas is particularly sensitive to noise of specific frequencies, Supin is optimistic that the team's discoveries will help us to design better regulations for aquatic noise reduction in order to protect the hearing of marine mammals better.

10.1242/jeb.088807

Popov, V. V., Supin, A. Ya., Rozhnov, V. V., Nechaev, D. I., Sysuyeva, E. V., Klishin, V. O., Pletenko, M. G. and Tarakanov, M. B. (2013). Hearing threshold shifts and recovery after noise exposure in beluga whales, *Delphinapterus leucas*. *J. Exp. Biol.* **216**, 1587-1596.

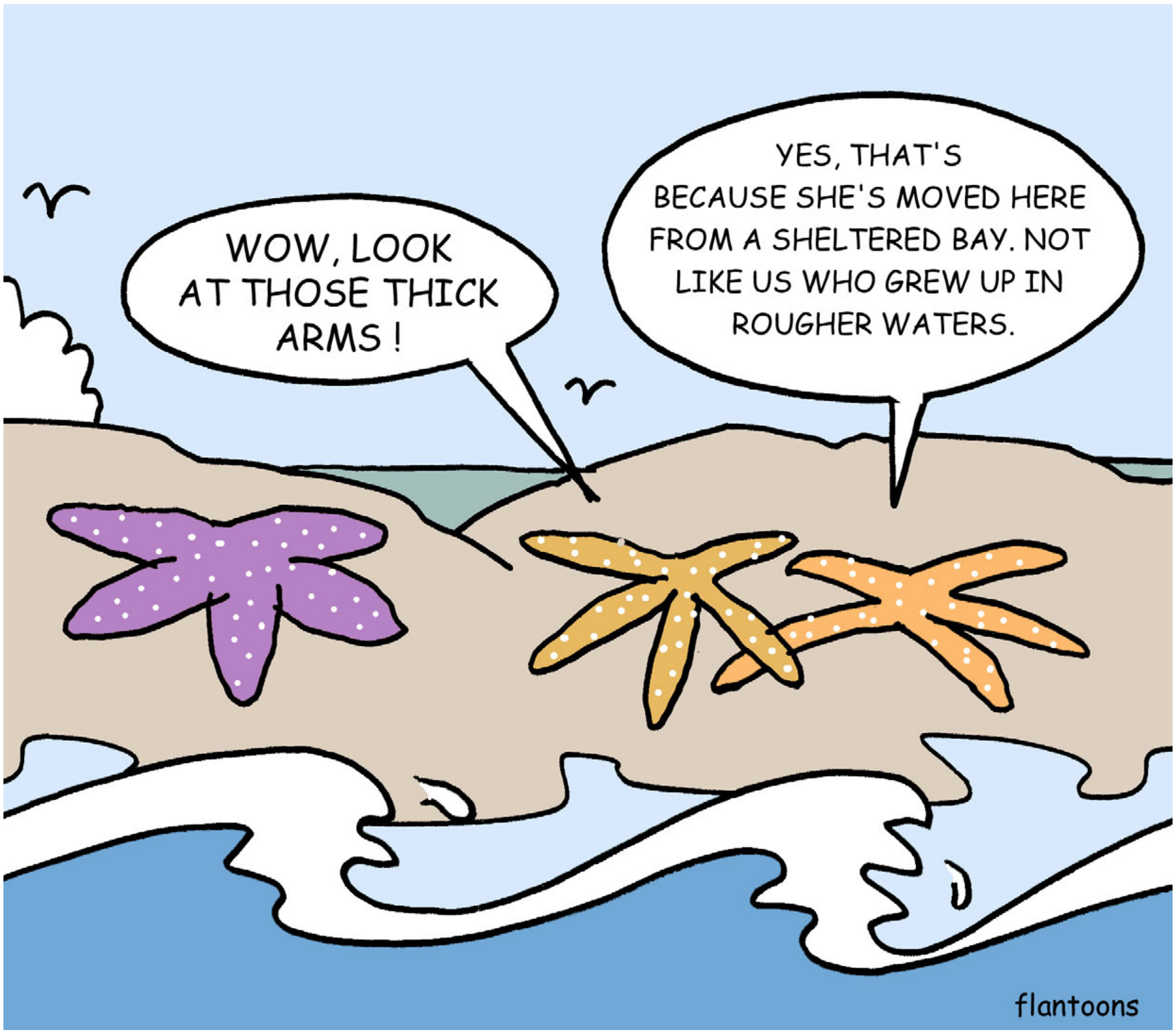
Kathryn Knight

CORRECTION: THE ART OF FINDING PREY: A BAT'S PERSPECTIVE

In the article entitled 'The art of finding prey: a bat's perspective' (doi: 10.1242/jeb.085530) published online on 13 March 2013 the phrase 'Hiryu and his students' should read 'Hiryu and her students'. The JEB would like to apologise for this mistake and any offence caused.

10.1242/jeb.089185

SLIMMING DOWN KEY TO SURVIVING WAVES



With waves crashing at break-neck speeds of up to 15 m s^{-1}, life on the rocky coastline isn't easy, and residents of this intertidal zone continuously face the risk of wave-induced damage or death. Furthermore, they have to remain adaptable to ever-changing conditions arising from storms or seasonal changes, and may also move to new, potentially even harsher, shorelines in search of food. *Pisaster ochraceus*, the northeastern Pacific sea star, is amongst the largest of the intertidal inhabitants and Kurtis Hayne and his supervisor Richard Palmer from the University of Alberta, Canada, wondered how they might cope with changes in wave force (p. 1717).

To investigate, Hayne set out from the lab's second base at the Bamfield Marine Sciences Centre, British Columbia, Canada, to collect sea stars from both exposed and sheltered shorelines on nearby islands. Back at base, Hayne then weighed and photographed the sea stars, using the images to measure the length and width of the sea stars' arms. Hayne found that, on average, sea stars collected from exposed sites had arm widths that were 12% narrower. They also had shorter arms and overall had a decreased mass per unit arm length.

So, in exposed areas with fast, breaking waves, sea stars had thinner arms, but would they maintain their spindly shape if they were moved to a more sheltered spot? To find out, Hayne painted identifying marks on the sea stars before transplanting them onto new shorelines, moving sea stars used to the rugged sea to quieter locations and, *vice versa*, transplanting plumper sea stars with long, thicker arms onto more exposed spots. When Hayne returned after 3 months, he found that those he had moved to new neighbourhoods had changed to fit in with the new environment: previous inhabitants of sheltered shorelines reduced the width of their arms, while sea stars transplanted from exposed spots to calmer waters grew fatter arms. By changing their body shape according to their environments, sea stars may reduce drag and lift and thus the risk of dislodgement in exposed areas, while growth in calmer shores may help them to resist overheating and aid reproduction.

10.1242/jeb.087791

Hayne, K. J. R. and Palmer A. R. (2013). Intertidal sea stars (*Pisaster ochraceus*) alter body shape in response to wave action. *J. Exp. Biol.* **216**, 1717-1725.

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