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

PREGNANCY IS A DRAG FOR BOTTLENOSE DOLPHINS

Shawn Noren

Lumbering around during the final weeks before delivery is tough for any pregnant mum. Most females adjust their movements to compensate for the extreme physical changes that accompany the later stages of pregnancy. However, no one had been able to find a distinct gait change – such as a change in stride length or frequency – associated with the latter stages of pregnancy. Intrigued by the ways that newborn dolphins learn to swim after birth, Shawn Noren from the Institute of Marine Science, University of California Santa Cruz, realised that she had the perfect opportunity to find out how pregnancy affects female dolphins. Joining a pod of dolphins at Dolphin Quest, Hawaii, just before two of the females gave birth, Noren analysed the impact of pregnancy on the animals' streamlined shape and mobility (p. 4151).

'The pregnant females had huge protrusions where the fetus was sitting towards the back end of the body', says Noren, who donned SCUBA gear and spent a large portion of the final fortnight of the dolphins' pregnancies filming under water as they swam parallel to her camera between their trainers. Noren also filmed the dolphin mothers immediately after their calves were born and at regular intervals until the calves were 2 years old. Comparing the footage before and after delivery, Noren realised that pregnant females were slower. Their top speed was restricted to $3.54\,\mathrm{m\,s^{-1}}$, whereas they were able to swim at much higher speeds after giving birth. 'Two to three metres per second is a comfortable speed for most bottlenose dolphins,' says Noren, 'but these pregnant animals did not feel comfortable going beyond that.'

She also measured the animals' girth and calculated their frontal surface area, and realised that the pregnancy had a colossal impact, increasing their frontal surface area by an enormous 51%. And when Noren measured the drag experienced by the animals as they glided through the water, she discovered that it doubled when the mothers were close to delivery.

The pregnant dolphins also had another problem: their increased fat stores in preparation for lactation had also increased their buoyancy. 'The buoyancy issue is going to be problematic when you are going down on a dive to capture prey and they are going to need extra energy to overcome that buoyant force', says Noren. So, pregnancy had a dramatic effect on the dolphin's hydrodynamics, but had it changed their swimming style? Did the pregnant dolphins move with a different gait?

Manually digitising the position of the animals' flukes (tail fins) as they beat up and down, Noren discovered that the pregnant females were unable to sweep their flukes as far as they could after birth. They had reduced the amplitude of their tail beat by 13% and they compensated for the reduced propulsion by beating their flukes faster. The pregnant dolphins had changed gait.

Having found how pregnancy affects soon-to-be dolphin mothers, Noren outlines the additional risks that the females face. Unable to outrun predators, heavily pregnant dolphins are more vulnerable to attack and they may not be able to keep up with the pod if pursued by fishing vessels. Explaining that tuna are still fished using massive nets in the eastern tropical Pacific, Noren says, 'Here is a fast speed event, so it is possible the near term pregnant females are being left behind in the chase. They are reliant on a large pod for protection and cooperative feeding and once the animal is separated it would be hard for it to find the pod again.'

10.1242/jeb.068056

Noren, S. R., Redfern, J. V. and Edwards, E. F. (2011). Pregnancy is a drag: hydrodynamics, kinematics and performance in pre- and post-parturition bottlenose dolphins (*Tursiops truncatus*). *J. Exp. Biol.* **214**, 4151-4159.

Kathryn Knight

SHOVELNOSE RAYS SEE IN COLOUR

Most bony fish have remarkably good colour vision. Not only can they see many of the colours that we take for granted, but their visual spectrum extends into the ultraviolet and they even see the effects of polarisation. But other species may not be so lucky. Sarah Van-Eyk from The University of Queensland, Australia, explains that little is known about the visual system of cartilaginous fish. Even though giant shovelnose rays were recently discovered by Nathan Hart to have three types of cones – the cells in the retina that detect colour – she adds, 'You need to do a behavioural experiment to confirm that they use colour vision and the logistics of doing behavioural studies on rays is difficult.' However, Ulrike Siebeck had recently successfully trained damselfish to distinguish between different colours, so

maybe Van-Eyk could do the same with shovelnose rays to find out whether they also have colour vision (p. 4186).

Walking out onto the Moreton Bay sand banks with a seine net, Van-Eyk and her colleagues successfully caught two juvenile rays and transported them back to the lab. Then the hard work began. 'We had to learn to train the rays. The training is important to be sure the animals understand the task before you start the experiment', says Van-Eyk. She explains that there could be two reasons why a ray cannot distinguish between two colours: either it cannot see the difference and so does not have colour vision, or it does not understand the task. Van-Eyk had to be sure that the rays knew exactly what they were being asked to do before she could test their vision.

First, she trained the rays to eat from a feeder dispensing tasty fish-mash, and once the animals were comfortable with the feeder she positioned a bright blue laminated sheet of paper next to the feeder, so that the ray had to touch the blue object before the feeder would dispense a snack. Next, Van-Eyk took away the feeder and only gave the ray a food reward when it touched the blue object. Finally, Van-Eyk trained the ray to distinguish between the blue object and another that was grey, rewarding the ray when it correctly touched the blue object.

After 3 months of painstaking training, Van-Eyk was convinced that the rays understood the question and would tap the paper when they saw a colour that they had been trained to recognise. However, she had not proved that the ray had colour vision; they could have been using some other visual cue, such as brightness or contrast, to distinguish the blue object from the grey. To be sure that the rays see in colour, Van-Eyk had to set the animal a really hard puzzle: could the ray pick out the blue object from three grey objects, one of which was equally as bright as the blue object and would be indistinguishable from blue if the animal lacked colour vision?

Teaming up with Connor Champ and Justin Marshall, Van-Eyk designed grey colours that were as bright as, dimmer than or brighter than the blue object, and then offered the ray a choice between the four to see whether the ray could still pick out the blue one. Remarkably, it did: the ray successfully tapped the blue paper. So, shovelnose rays do use their three cones for colour vision and Van-Eyk is keen to find out if the ray's close cousins, bamboo sharks, also have colour vision.

10.1242/jeb.068031

Van-Eyk, S. M., Siebeck, U. E., Champ, C. M., Marshall, J. and Hart, N. S. (2011). Behavioural evidence for colour vision in an elasmobranch. *J. Exp. Biol.* **214**, 4186-4192.

Kathryn Knight

HOW LONELINESS AFFECTS SNAILS' MEMORIES

Loneliness isn't good for you. Sarah Dalesman from Hotchkiss Brain Institute, The University of Calgary, Canada, says, 'Isolation has been shown in the past to act as a stress that often has negative effects on the ability of mammals to learn and form memories.' But how does isolation affect the memory of an animal with a much simpler brain: the great pond snail, *Lymnaea stagnalis*? According to Dalesman, isolation does affect the mollusc's behaviour. She explains that the snails – which are hermaphrodites, having both male and female sexual organs – usually engage in reciprocal sex, taking it in turns to adopt the role of the male. However, after 8 days of isolation, the snails only take on the male role. Given the dramatic effect of isolation on the snail's simple behaviour, Dalesman and her principal investigator, Ken Lukowiak, wondered how loneliness might affect the mollusc's ability to from long-term memories (p. 4179).

However, when Dalesman tested the snails' long-term memories after 8 days of isolation, they seemed unaffected. According to Dalesman, pond snails can be trained to keep their breathing tubes closed when they are in oxygen-starved water by giving them a gentle tap when ever they try to extend it to breathe. With the correct training regime, the snails can remember the lesson for over a day. Having expected that 8 days in solitary confinement would prevent the snails from laying down the long-term memory, the duo were surprised when the molluscs successfully remembered to keep their breathing tubes firmly shut 24 h after training. 'We almost stopped there,' admitted Dalesman, adding, 'sbut we were fairly sure the snails were aware of lack of contact with other individuals, so we thought that changing the context in which they experience isolation might alter our results.'

Knowing that low calcium water concentrations and predator odours are stressful for the snails – low calcium concentrations prevent the snails from forming long-term memories, a whiff of predator odour improves their memory, and a combination of the two leads to normal memory formation as if there was no stress – the duo decided to find out how combinations of the stresses in association with isolation affected the molluscs' memories.

Amazingly, isolation improved the memories of the molluscs in stressful low calcium conditions. Meanwhile, 8 days of isolation did not affect the memories of snails experiencing the scent of a predator. However, when the duo combined all three stresses – solitary confinement, low calcium and the scent of a predator – the snails were unable to from the long-term memory after training. 'This is the first time that we have found that kairomones [predator odour] don't enhance memory formation; instead their presence seems to result in memory being blocked', says Dalesman.

So isolation did affect the ability of the snails to form long-term memories, but it was entirely context dependent, with isolation improving memory in some situations while abolishing it in others.

Dalesman and Lukowiak suspect that the snails' behavioural response to isolation – adopting the male role during mating – may make the low calcium situation less stressful because they require less calcium when reproducing as males than they do when producing eggs as females, freeing the isolated snails to form better memories. However, they suspect that a combination of all three stressors might push the snails over the edge. 'Several different environmental stressors may just be too much to cope with and they are no longer able to pay enough attention to training to form long-term memory', suggests Dalesman.

10.1242/jeb.068049

Dalesman, S. and Lukowiak, K. (2011). Social snails: the effect of social isolation on cognition is dependent on environmental context. *J. Exp. Biol.* **214**, 4179-4185.

Kathryn Knight
kathryn@biologists.com