INSIDE JEB

Soccer players' trade-offs

Measuring a soccer player's agility as he dribbles a ball around cones. Photo credit: Robbie Wilson.

Animal performance biologist Robbie Wilson has an unconventional take on life: when he watches a soccer match, instead of seeing sportsmen competing, he sees crayfish fighting. 'Animals are fighting for the game of leaving their genes in the next generation, and on the sporting field it is the same sort of thing, just the currency is different', explains the former semi-professional soccer player turned University of Queensland scientist. According to Wilson, animal performance biologists are very good at measuring maximum performance – speed, stamina and strength. However, quantifying other aspects of performance, such as fine motor control, is much trickier, and this was where Wilson's past caught up with him. Realising that he could accurately quantify the precise motor skills of soccer players, Wilson asked his former team, the University of Queensland Football Club, if he could turn their star players into lab rats to test his theories on how animals trade off characteristics – such as size and agility or speed and endurance – against each other (p. 545).

Designing 10 tasks that tested everything from the players' endurance and sprint performance to their ability to manipulate and control a soccer ball, Wilson turned up at the university's pre-season training field with his own soccer team of helpers, including Amanda Niehaus, Gwendolyn David, Andrew Hunter and Michelle Smith, ready to put 40 of the team's top athletes through their paces. 'The guys were hypercompetitive', Wilson recalls. 'They wanted to know their results in each one of their tests immediately… so it was really difficult to say "No"', he chuckles.

Then, after three gruelling days of recording each athlete's performance, Wilson was faced with the daunting task of sifting through the data to see whether he could find any trends in each individual's performance that might suggest that they were trading off one characteristic against another. But first he had to combat the problem of inter-individual variation. Essentially, everyone is different, and unless you take account of the natural variation of ability across a population, you might miss trade-offs that are swamped by the fact that some people are more or less talented than others. To overcome this problem, Wilson averaged out each of the athlete's performances so that all of the sportsmen were performing at the same standard, and when he did that, correlations began leaping out of the data.

'It was very clear to see the trade-offs between speed and endurance,' says Wilson, explaining that after standardising the results, the soccer players that performed best on the 1.5 km endurance run faired least well in the tests that required power, such as the long jump and performing squats. And when he compared each athlete's overall performance with their general ability across all of the tasks, there was a clear trade-off between generalisation and specialisation. 'Individuals that were very good at a few specific tasks were not necessarily good when we averaged across all the other ones: you can't be fantastic at everything,' he says, smiling.

So based on his experiences of working with soccer players, what does Wilson recommend that comparative physiologists do to take account of the natural variation in ability when looking for performance trade-offs in animal populations? He advises that, where possible, comparative physiologists should incorporate aspects of how an animal can control its body; they also need to measure more than just one or two aspects of an animal's performance. And, having ventured into the world of sports science and figured out how to quantify individual performance, Wilson is keen to adapt his approach to use it for talent spotting.

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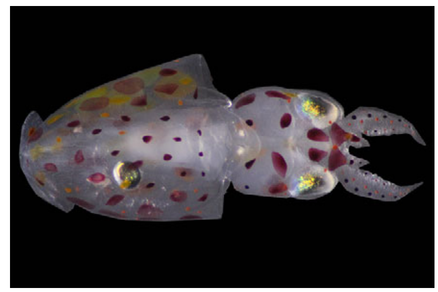
Wilson, R. S. , Niehaus, A. C., David, G., Hunter, A. and Smith, M. (2014). Does individual quality mask the detection of performance trade-offs? A test using analyses of human physical performance. *J. Exp. Biol.* **217**, 545-551.

Kathryn Knight

Squid embryos suffer in future summer



Newly hatched squid paralarvae acclimated under present-day conditions. Photo credit: Rui Rosa.

As humans pump more CO_2 into the atmosphere, the planet is changing. Not only are temperatures rising, the pH of the oceans is gradually falling; it is expected to drop by 0.4–0.5 units to pH 7.5 by the turn of the century. Rui Rosa and colleagues from Portugal and Germany explain that the majority of studies into the impact that these changes will have on marine species are conducted on adults over relatively short exposure times. But they say, 'Early life stages (e.g. embryos, larvae) of marine organisms are expected to be the most vulnerable to such climatic shifts…[and] this vulnerability may become a serious bottleneck for species' survival'. Concerned about the impact such environmental changes will have on European squid embryos and hatchlings, Rosa and his collaborators began a large-scale study to look at the effect of future conditions on the young animals (p. 518).

Collecting recently laid squid egg masses from the Atlantic Ocean off the coast of Portugal, the team transported them back

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to the lab at the Laboratorio Maritimo da Guia, where they installed the eggs in tanks simulating present and future environmental scenarios – present and future winter temperatures (13 and 15°C), present and future summer temperatures (17 and 19°C) and present and future CO_2 levels (~430 and 1650 ppm). Then they watched the eggs' progress as they developed.

Monitoring the embryo's survival, the team saw that the youngsters survived well in the present ocean (pH 8) during both the summer and winter, and even the future winter embryos (pH 7.5) survived reasonably well (71%). But when they looked at the survival rates of embryos developing in the future summer scenario (19°C at pH 7.5), the population was decimated, with only 47% of the embryos surviving. And when the team investigated the youngsters' growth rates, they found that the embryos grew faster in the present day (pH 8) summer ocean, but suffered a setback in the lower pH conditions of the future summer seas. The warmer embryos also hatched sooner than their present day siblings, and the team noticed an increase in the number of developmental abnormalities in the embryos reared in the future summer tanks, with deformed eyes, bodies and mantles. The lower pH also reduced the amount of energy that the youngsters could expend and their ability to withstand high temperatures.

Whichever way you look at it, the future is bleak for European squid spawning in the summer, but more encouraging for youngsters born in the winter. Although the team offers a glimmer of hope by pointing out that the squid have already adapted their spawning behaviour in winter to take account of the harsher conditions – they produce smaller eggs in larger numbers – they add, 'It is hard to predict if in the future they will continue to display these two main spawning seasons or if they will be able to take more advantage of the less-stressful winter prevailing conditions'. We can but hope.

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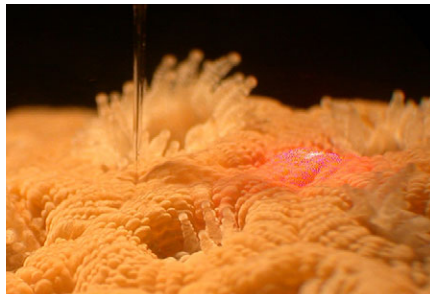
Rosa, R., Trübenbach, K., Pimentel, M. S., Boavida-Portugal, J., Faleiro, F., Baptista, M., Dionísio, G., Calado, R., Pörtner, H. O. and Repolho, T. (2014). Differential impacts of ocean acidification and warming on winter and summer progeny of a coastal squid (*Loligo vulgaris*). *J. Exp. Biol.* **217**, 518-525.

Kathryn Knight

Corals trap light for algal lodgers



A microscopic light sensor measures light transport through coral tissue. Photo credit: Daniel Wangpraseurt

Corals have struck up a remarkable partnership with minute algae, resulting in some of the most dazzlingly beautiful organisms on the planet. They provide the photosynthesising algal lodgers – which reside sandwiched in the thin layer of animal tissue covering a calcium carbonate skeleton – with shelter and a ready supply of nutritious waste products, which can be scarce in the barren waters surrounding most coral reefs. The algae, in turn, provide their hosts with sugars and oxygen. But there is one more essential factor that the animal host must provide for algae lodging within its tissues, and that is light. Daniel Wangpraseurt and his supervisor Michael Kühl from the University of Technology Sydney, Australia, explain that plant leaves actively trap and redistribute light to improve photosynthesis. Could corals do the same for their algae? Teaming up with Anthony Larkum, Jim Franklin, Milan Szabo and Peter Ralph, the duo set about finding out how light travels through coral tissue (p. 489).

'We have a research station on the Great Barrier Reef – Heron Island Research Station – and that is where we go to collect corals', says Wangpraseurt, who brought three types of brain coral back to Sydney where he could begin to investigate them more closely. By shining four different colours of laser light (near infrared, 785 nm; red, 636 nm; green, 532 nm; and violet 405 nm) onto the coral samples, Wangpraseurt measured the amount of light transmitted through the animal to different depths when he gently inserted a minute light sensor into the delicate tissue. He moved the sensor with microscopic precision in 100 μm steps down into the tissue and repeated the measurements through the coral at distances ranging from 2 mm to 2 cm from the light beam. However, working with the corals was far from easy. Wangpraseurt says 'Once the coral moves its tissue the data cannot be used, so you have to redo the measurement,' and he adds, chuckling, 'People that work with plant leaves have it much easier'.

Next the team investigated how red and near-infrared light travel through the coral tissue, and they were pleased to see that red light, which is absorbed by the algal photopigments, was trapped and horizontally transported through the tissue. However, near-infrared light, which is not used by the algae, was mainly reflected back into the animal tissue by the supporting calcium carbonate skeleton below. And when the team analysed how blue and violet light moved through the coral tissue, they found that it was also transported horizontally, increasing the amount of light carried through the tissue to fluorescent pigments in the coral.

But would the captured light improve algal photosynthesis? The team flicked the red laser beam on and off and found that the pulse of light increased the algae's oxygen production by more than 10% at a distance of 6 mm from the laser beam, so horizontal light transfer through the coral tissue can increase the symbiont's photosynthesis.

Having discovered that the thin layer of coral tissue is capable of augmenting the light field that it supplies to its algal lodgers, the team is keen to build a more detailed understanding of the optical properties of each layer of the coral's tissue to find out exactly how they propagate light. And Wangpraseurt adds that corals are not simply static. He says, 'It seems likely that the animal is able to dynamically modulate the light field', explaining that they contract to shield the algae in bright light and expand to improve light provision in dim conditions – so the team hopes to found out how much the animal can modify the light field it provides for its algae.

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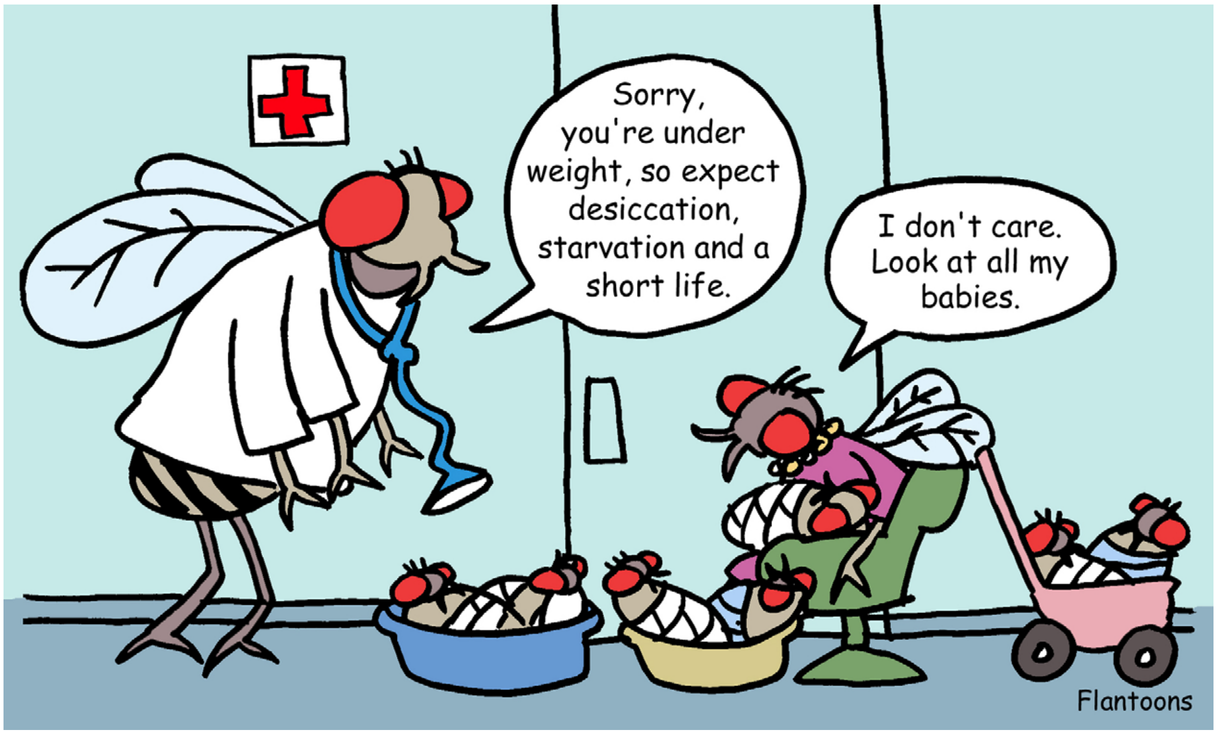
Wangpraseurt, D., Larkum, A. W. D., Franklin, J., Szabó, M., Ralph, P. J. and Kühl, M. (2014). Lateral light transfer ensures efficient resource distribution in symbiont-bearing corals. *J. Exp. Biol.* **217**, 489-498.

Kathryn Knight

Fast-developing fruit flies pay fitness price



Let's face it, if you choose to make your home in a piece of rotting fruit, it might not be around for long, so the pressure is on for fruit flies – *Drosophila melanogaster* – to live their short lives fast. Pankaj Yadav and Vijay Sharma from the Jawaharlal Nehru Centre for Advanced Scientific Research, India, are intrigued by the trade-offs that fast-developing fruit flies, which emerge as pre-adults in just ~216 h (29 h faster than normal flies), make to accelerate their development. So, they investigated the impact of shortened pre-adult development on the fitness of these specially bred populations of fruit flies to find out what compromises they have made (p. 580).

Testing the flies' ability to survive pre-adult development, their adult lifespan, mass at emergence as adults, fecundity, size and ability to withstand starvation and desiccation, the duo found out that the flies had made significant compromises to reduce the time it took them to emerge as fully formed adults. Although the fast developers survived their period of development as well as regular flies, their adult fitness was significantly compromised: they were smaller and weighed less at emergence than regular flies, they lived shorter adult lives, they were less resistant to starvation and desiccation and the females produced fewer eggs. However, when the duo reanalysed the flies' fecundity relative to their body mass, they found that the smaller, fast-developing flies produced more eggs for their body mass than the larger, regular flies.

So, the faster developing flies had traded-off their fitness against their accelerated development, and – as they run on a faster body clock than their regular cousins – Yadav and Sharma say, 'our results can be taken to suggest that pre-adult development time and circadian clock period are correlated with various adult life history traits in *D. melanogaster*, implying that circadian clocks may have adaptive significance.'

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Yadav, P. and Sharma, V. K. (2014). Correlated changes in life history traits in response to selection for faster pre-adult development in the fruit fly *Drosophila melanogaster*. *J. Exp. Biol.* **217**, 580-589.

Kathryn Knight
kathryn@biologists.com