Leading Monkeys by the Nose

Most textbooks tell you that primates have a lousy sense of smell, but watch a monkey investigate a piece of food, and the first thing it does is have a good sniff - which doesn't seem like the reaction of an animal with a poor sense of smell. Mattias Laska was intrigued by this apparent conundrum, so he set out to test just how sensitive these animals are to different smells. After testing monkeys with a battery of scents, he's added a selection of alcohols to the primates' repertoire of detected smells, proving that monkeys are better 'smellers' than anyone had supposed (p. 1633).

Laska has spent the last 15 years training animals to detect specific smells, and most of the time, this isn't easy. Even though dogs have some of the sharpest noses on the planet, very few people have successfully trained dogs in order to test their sensitivity to individual scents. Man is probably the easiest animal to train, so more is known about the human sense of smell. Even then, only 300 monomolecular scents have been tested on us. Having successfully trained a variety of creatures from honey bees up to mammals, Laska was confident that he could successfully train primates to tell him when they could detect smells.

He decided to test two primate species' responses to a class of chemicals they encounter in the wild. Ripe fruits emit alcohols at different stages of ripeness, so he tested the animals' sensitivity to eleven alcohol molecules that they might experience in their natural environment.

Laska knew that the best way to get the monkey's cooperation was if he designed a test that was more like a game. First he trained squirrel monkeys to recognise that small cups, labelled with a scent, carried a reward. Then he introduced the element of fun. Laska offered each monkey a choice of 18 small sealed containers, half of which had scent labels, and suspended them half way up a climbing frame so they had to work a bit to earn their reward. Laska tested which of the eleven alcohols they could detect, and the minimum concentration the monkeys needed to pick up the scent.

But when Laska tried the same test on larger macaques, he ran into problems. Instead of making a choice, the macaques stuffed all of the cups into their cheek pouches. Undeterred, Laska completely redesigned the experiment, made the containers larger, added a clasp to the lids and cut the choice down from 18 to two. This time the macaques cooperated, and Laska began collecting more data.

The results were incontrovertible, not only could both species sense all eleven alcohols, but they were most sensitive to the longest alcohol, octanol, even at a dilution of 1 part per billion! Laska also tested whether the primates were sensitive to different alcohol isomers, but neither species responded to the subtle chemical difference.

Laska attributes his success to asking the monkeys to play, rather than setting them a dull chore. Ultimately he's hoping to correlate the monkey's scent-world with the animal's behaviour, so that he can classify how certain smells affect their behaviour. Not bad for an animal with a poor sense of smell!

Size Counts

Creatures that spread their gametes in the sea are gambling with high stakes: get it wrong and your genes are heading towards a dead-end in the evolutionary tree. This is a strong incentive to develop eggs with a high chance of getting fertilized, but only if the advantages come at a realistic cost. One frequently used low cost solution to improving an egg's fertilization odds is to surround the tiny gamete with a gel coat that interacts with sperm in a variety of chemical and physical ways. Up until now, most people had analysed the gel from a chemical perspective, but Robert Podolsky wanted to know how important the gel's size was to an egg's chances of survival. Weighing up the gel's advantages to sand dollar eggs from this alternative perspective, he discovered that 75% of that advantage comes simply from the egg's increased size and buoyancy (p. 1657).

Sand dollars have opted for small eggs so that they can produce enormous numbers of the gametes at little cost to the mother. But each egg's chance of bumping into a sperm drops enormously as its girth decreases, so the sand dollar developed a gel outer layer to compensate for the egg's drop in size.

The egg benefits from the gel in a variety of ways. The gel produces chemicals that encourage sperm to swim faster as well as protecting the egg from multiple fertilizations by blocking late arrivals. But is that the major driving force behind the gel's evolution? The sand dollar egg is more than ten times its original size once its gel coat has inflated. Podolsky realised that the advantages of the size increase would contribute to the development of the gel, but how much of an effect did it have relative to the chemical benefits?

Podolsky set about resolving the physical and chemical components from the evolutionary equation by looking at the effect on the egg's fertility. He removed the gel from freshly laid eggs, and watched to see how many eggs were successfully fertilized by the sperm. As expected, the fertility dropped, but Podolsky was concerned that the eggs might have been damaged when he removed the gel. But after trying an alternative gel stripping technique, he was convinced that the decreased fertility was due to the lost gel.

But were the eggs less fertile because they had lost the sperm enhancing chemicals, or had the eggs' slimmed down size had made it harder for the sperm to collide with them? Podolsky did a calculation, which measured the collision rate for a small and large egg, with the amazing result that the egg's chance of fertilization dropped to half of the value he'd measured experimentally! So size was a significant fraction of the gel's evolutionary driving force.

Podolsky also realised that the gel increased the egg's buoyancy, increasing the length of time an egg remains suspended in a cloud of sperm. When Podolsky factored that into his equation, the egg's increased size and greater buoyancy contributed 75% of the total benefit the egg gained from the coat, proving that big is beautiful if you're a sand dollar egg.

Calcium Keeps Cold Hearts Pumping?

Near freezing temperatures are fatal for most animals. At low temperatures endothermic heart muscle fails when the calcium channels, which release the calcium signal that triggers a contraction, start leaking. But most fish's body temperatures are the same as the water they live in, even if the water is almost freezing. Matti Vornanen explains that some stenothermal fish spend their entire lives at low temperatures. In this issue of J. Exp. Biol, he describes how the stenothermal burbot protects its heart from the cold. Burbot cardiac muscle has a modified calcium delivery system that triggers the muscles contractions, so that the heart continues to function at temperatures when others would have failed (p. 1597).

Muscle fibres are built up from actin and myosin filaments that are linked by a myosin bridge. Each heartbeat is triggered by the release of calcium from a structure in each muscle cell called the sarcoplasmic reticulum (SR). The calcium signal prepares the myosin head to consume ATP, and slide the filaments past each other to drive the muscular contraction. But as temperatures drop, the SR calcium channels begin to leak, draining the SR's calcium store and causing heart failure.

Some cold adapted eurythermal fish survive low temperatures by enlarging their heart muscle, but how have fish that spend their entire life at low temperatures adapted to living in the freezer?

Vornanen decided that the burbot was the ideal species to answer this question. Working with Virpi Tiitu, he set out to characterise the burbot's heartbeat at its cold physiological temperature.

Not surprisingly, the hearts pumped best at 1°C. Vornanen began investigating what kept the heart pumping by looking at the muscle's ATPase that drives the contraction. If the ATPase was the key to keeping the heart muscle contracting, the enzyme's activity would be optimised for very low temperatures. But the burbot myocardial ATPase functioned best at 10°C. So Vornanen began looking to see how the burbot's sarcoplasmic reticulum stood up to the cold.

He tested the muscle's response to ryanodine, a compound that inhibits calcium channels. At low concentrations, ryanodine locks ion channels open while at higher levels, it clamps the channels shut. By inhibiting an increasing number of channels as the ryanodine concentration rises, the muscle begins to lose force as the SR's calcium pulse falls. Vornanen checked how the burbot heart responded to ryanodine at temperatures from 7°C down to 1°C. If the stenotherm's calcium channels behaved like mammalian channels, they would become leaky as the temperature dropped and the heart muscle fail. But if the channels were adapted to continue functioning at near freezing temperatures, the heart would weaken, but continue beating during the ryanodine treatment. The experiments confirmed that instead of becoming leaky, the burbot's channels function perfectly at 1°C.

Having proved that the key to cold survival is held by the SR calcium channels, Vornanen is keen to find out how these stenothermal calcium channels differ from their endothermal counterparts.

Correction: A Clear Message

In the report on Thomas Breithaupt's work I incorrectly attributed the finding that crayfish which couldn't urinate fought longer then crayfish that can urinate. This work was published by Zulandt and coworkers in 2001. I apologise for any misunderstanding this caused.

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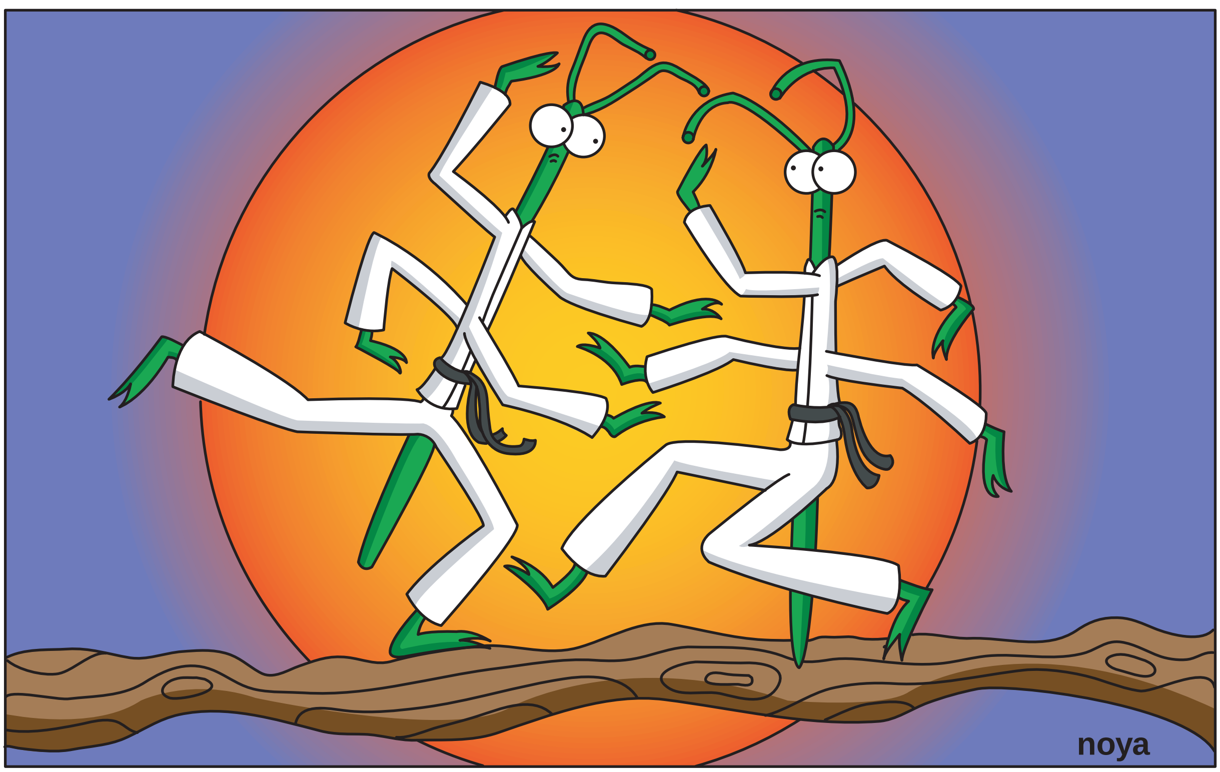
The Journal of Experimental Biology 205 (2002)



False Stick Insects Get Their Kicks

Burrows, M. and Wolf, H. (2002). Jumping and kicking in the false stick insect *Prosarthria teretrirostris*: kinematics and motor control. *J. Exp. Biol.* **205,** 1519–1530.