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Inside JEB

MOTIVATING YOUR FROGS, CALAVERAS COUNTY CAN HELP

Henry Astley

The tiny Cuban tree frog can jump an impressive 1.7 m, but its relative, the larger and more muscular bullfrog, can rarely muster anything farther than 1 m in the lab. Initially, the bullfrog's dismal jumping performance was blamed on a trade-off caused by the need to jump and swim; however, Henry Astley, a PhD student from Brown University, USA, wasn't convinced: 'Other papers suggested that they had a catapult mechanism like the tree frogs, where they stretch an elastic tendon and then quickly recoil, like a bow and arrow, and if so, they should be doing a lot better than they appear to be doing in lab.' What's more, *The Guinness Book of World Records* documents the achievements of 'Rosie the Ribeter' a wild bullfrog who, in 1986, at the annual Calaveras County Jumping Frog Jubliee, jumped a colossal 2.2 m. Was Rosie's jump just a once in a million fluke or were bullfrogs indeed able to jump this far? If so, why weren't they performing to their maximum potential in the lab? Astley decided it was time to find out (p. 3947).

Along with other lab members, Astley made the trip out to Angels Camp, CA, USA, for the 84th session of the fair. Over the course of 4 days, the team filmed jumps from both 'rentals' (frogs rented from the fair organisers) and 'professionals' (frogs hand-selected from the wild by teams that competed annually). During the breaks, the team would lay down a measuring grid for calibration purposes, but on the whole the team were able to sit back and soak up the atmosphere. 'It's a tremendously fun fair to go to and everyone was so enthusiastic about the frogs', says Astley, jokingly adding, 'Plus, how often do you have fieldwork were you eat funnel cake and hot dogs?'

Back in the lab, however, the work began in earnest, and several undergraduate students were recruited for the daunting task of digitising over 3000 jumps. Astley was then able to calculate take-off velocities and angles, and estimate the power used during the jumps. However, what really stood out was that most of the frogs outperformed frogs in the lab; rental and professional frogs' jumps averaged at 1.1 and 1.5 m, respectively. Even more impressive was just how close some frogs came to Rosie's world record – clearly bullfrogs are capable of enormous jumps. So, what was the trick? Astley explains that professional competitors are secretive about their 'trade secrets' of where to collect frogs and how to look after them and motivate them to jump on stage. However, overall they didn't look dramatically different to the rental frogs and the only change was that professional frogs were kept at warmer temperatures.

Astley wondered whether it was just a matter of probability, so he randomly took samples of frog jumps to find out what the chance of seeing a long jump was. He revealed a non-linear relationship between sample size and jump distance. For example, a sample size of 10 rental frogs (the equivalent of the lab frogs, which aren't selected by 'professionals' with decades of experience) gives you just a 14% chance of seeing a jump over 1.6 m, while increasing the sample size to 50 frogs gives a 56% chance. In conclusion, Astley says researchers would have to process a large number of frogs to stand a chance of seeing an impressive jump, but as he jokes: 'We can order a dozen frogs from our supplier, but a hundred frogs? The animal care bills would bankrupt us!' So, perhaps, fairs like the one at Calaveras represent an underused resource in the field of animal performance.

10.1242/jeb.095968

Astley, H. C., Abbott, E. M., Azizi, E., Marsh, R. L. and Roberts, T. J. (2013). Chasing maximal performance: a cautionary tale from the celebrated jumping frogs of Calaveras County. *J. Exp. Biol.* **216**, 3947-3953.

Nicola Stead

THE SAME BUT DIFFERENT: HUMAN-LIKE ELEPHANT CALLS

Up until a year ago, how an elephant made its guttural infrasonic calls was still a matter of debate, as Christian Herbst, from the University of Vienna, Austria, points out: 'Some people suggested it's just like in us humans, so a passive, flow-induced vibration of the tissue in the larynx, and others suggested it's like purring in cats [requiring neural control].' Unfortunately, unlike in humans, it's a little difficult to slide an endoscope down an elephant's vocal tract to see what's happening. However, in 2010 an opportunity to settle the mystery arose, when an African elephant sadly passed away at Berlin Tierpark zoo. A collaborator based in Berlin, Germany, quickly seized the opportunity and collected the larynx from the elephant on behalf of Herbst and Angela Stoeger, also from the University of Vienna. Back in Austria, Herbst and

Stoeger were then able to reproduce elephant-like sounds by simply blowing air through the voice box, causing the two vocal folds on either side of the trachea to flap passively in the air, just as they would in humans. Their results were published in 2012 in *Science*; however, as elephant larynxes are few and far between, Herbst decided to dig a little deeper to find out just how similar they are to ours (p. 4054).

From the outset of his second study, Herbst could already clearly see that the elephant's vocal folds were very different to ours. Comparing CT-scans of both the elephant's larynx and a human's, Herbst noted that the elephant's vocal folds were orientated at a very acute angle in relation to the air stream, whereas in humans the vocal folds were almost perpendicular to the air stream. This meant that the anterior two-fifths of the vocal folds were sheltered from the airflow. What's more, even when normalised to tracheal diameter, the elephant's vocal cords were much longer than a human's and 180% thicker.

Herbst then went on to film how the two vocal folds moved and clapped together as warm humidified air was blown through them, correlating the vibrations with sound production. As before, he saw that, just as in humans, the vocal cords were vibrating passively in the airflow, and as expected, most of the time the vocal folds vibrated within the infrasonic range (anything below 20 Hz). However, the timing of sound generation was unusual: 'In humans, most of the sound is created when the vocal folds clap together, but we observed that in the elephant, interestingly, most of the sound was generated when the vocal folds separated', explains Herbst.

This wasn't the only difference; the patterns of vocal fold vibration also varied compared with human vocal folds. Herbst explains that as the air pressure builds up beneath the closed vocal folds, they will eventually pop open, and in humans this usually produces two transverse travelling waves that travel back and forth in opposite directions along the length of the vocal folds. In doing so, they become superimposed on each other to form a standing wave. In elephants, whilst this happened most of the time, when the vocal fold was taut only a single isolated travelling wave was observed, which moved back and forth along the vocal folds. 'Looking at transverse travelling waves offers us an alternative way to study and appreciate the physical phenomenon that is going on in voice production', says Herbst.

In short, Herbst's study has shown that although elephants are in some ways the same as us when it comes to sound production, they can also be subtly different, but these differences may in turn help us understand how our own vocal folds make our human repertoire of sound.

10.1242/jeb.096016

Herbst, C. T., Svec, J. G., Lohscheller, J., Frey, R., Gumpenberger, B., Stoeger, A. S. and Fitch, W. T. (2013). Complex vibratory patterns in an elephant larynx. *J. Exp. Biol.* **216**, 4054-4064.

Nicola Stead

IS IT A BIRD? IS IT A PLANE? NO, IT'S A MANGROVE RIVULUS


Benjamin Perlman

A mangrove swamp may not seem like an ideal hangout – after all, it's often dirty and smelly – but to the small mangrove rivulus fish it's home sweet home. Nonetheless, at times even this well-adapted fish can find the swamp uninhabitable, for example when rotting vegetation causes sulphur levels to spike or when oxygen levels dip. To escape, they will often venture on to land, where they can survive for up to 2 months at a time, breathing through their skin instead of their gills. What's more, they can travel a fair distance inland, as the recent discovery of wooden log, several metres from the water's edge, crammed full of these tiny fish indicates. When Benjamin Perlman, a PhD student in Miriam Ashley-Ross' lab, at Wake Forest University, USA, heard about this at one of the lab's weekly meetings it made him wonder: how on earth did they get there? After all, these fish don't have limbs or specialised appendages like other amphibious fish, and just look like any other bony fish. When undergraduate Alexander Pronko joined the lab and wondered the same thing, the duo decided it was time to investigate how these fish can move on to land (p. 3988).

The duo began by training their fish to traverse a small clay barrier in the middle of the fish's tank, as Perlman explains: 'We'd put a little cricket on the other side of the tank and we conditioned these fish to go over this barrier to feed. Initially, the barrier was flush with the water surface, so it barely had to get out of the water, it just had to glide over it. After a number of weeks we kept increasing the width of the clay barrier until eventually the barrier took up most of the tank and was sloped at 15 deg to represent the slope at the land–water interface in the mangrove swamps.'

Having accustomed their fish to crossing the barrier, the duo then set about patiently waiting for the fish to perform their movements in front of two high-speed cameras. After months of filming, they found that the fish were able to perform three types of manoeuvres – the launch, the squiggle and the pounce. The duo found that the fish predominantly used launches to get over the barrier, propelling themselves at 27 body lengths per second ($1\ \mathrm{m\ s^{-1}}$), but in other cases, they squiggled their way up on to land. The squiggle is almost like an army crawl, as Pronko explains: 'Their tail meets their head and then as they push off the ground, their body moves through a S-shape, and [the tail] then comes back to the other side of head in a C-shape. As this happens, they're propping themselves up on their pectoral fin using it as a pivot point, while the other fin arcs up into the air as the fish yaws a bit.' The third movement, the 'pounce', was used to capture crickets placed near the water–land interface. After pouncing they would then drag their dinner underwater. Perlman explains that, during eating, the gill filaments become exposed and by dining underwater the risk of them drying out is avoided.

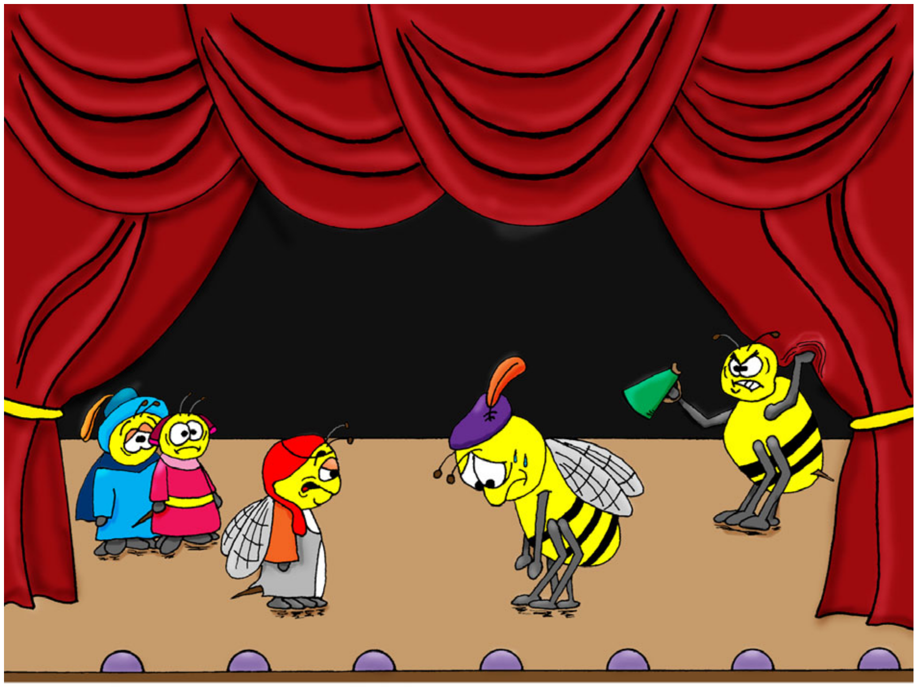
By using these different modes of locomotion, the mangrove rivulus can move across land without the need for specialised appendages, and this has important implications, as Perlman points out: 'It makes you think, what about all these other animals in the fossil record that have a certain structure but you wouldn't necessarily think that they would be able to move into a different habitat?' And it just goes to show – you can't judge a fish by its cover.

10.1242/jeb.096008

Pronko, A. J., Perlman, B. M. and Ashley-Ross, M. A. (2013). Launches, squiggles and pounces, oh my! The water–land transition in mangrove rivulus (*Kryptolebias marmoratus*). *J. Exp. Biol.* **216**, 3988-3995.

Nicola Stead

LEARNING IN WORKERS AND DRONES



The teacher was losing her patience with Alfred, who kept forgetting his line "Who knows not where a wasp does wear his sting?" during the rehearsal of the school play, The Taming of the Shrew.

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The world can be a pretty dangerous place, and a worker honey bee not only needs to learn how to carry out her specific tasks as a nurse or forager but also to avoid and/or escape threats such as pesticides and predators. However, these risks aren't limited to female workers; male drones also have to learn to identify and be wary of potential dangers. It's therefore surprising that there are very few studies on aversive learning in honey bees, so Charles Abramson, from Oklahoma State University, USA, decide to investigate with the help of Christopher Dinges, an undergraduate student (p. 4123).

Abramson and Dinges started by testing how well worker and drone honey bees learnt to escape an aversive stimulus. To do this, the duo put the insect students into a shuttlebox, which was split into two halves by a light beam across the centreline. Every 30 s a little jolt of electricity was administered to the entire shuttlebox, and the bees could only terminate the shock by 'escaping' and crossing the central light beam, which deactivated the shock. While both workers and drones learnt that 'escaping' stopped the disagreeable zaps, workers had higher response rates and responded faster than their male relatives.

Next, the pair turned to a punishment setup, where the electric shock was continuously administered to one-half of the shuttlebox. Abramson wanted to see whether the bees would recognise that entering one half resulted in this electric punishment and whether they would accordingly stop shuttling back and forth along the length of the shuttlebox. Again, workers performed better than the drones, and avoided shock for longer. Nonetheless, the drones did seem to be learning. Tinting the shock side with blue light did not help the drones improve their learning skills, but when the shock was paired with a yellow backdrop, drones and workers did as well as each other.

While male drones didn't seem to learn as well as the workers, it might not just be down to sex. Workers are highly social, whereas drones are more solitary. By using males and females in learning studies, Abramson hopes that we can begin to work out the relationship between sociality and complex behaviours such as learning.

10.1242/jeb.096339

Dinges, C. W., Avalos, A., Abramson, C. I., Craig, D. P. A., Austin, Z. M., Varnon, C. A., Nur Dal, F., Giray, T. and Wells, H. (2013). Aversive conditioning in honey bees (*Apis mellifera anatolica*): a comparison of drones and workers. *J. Exp. Biol.* **216**, 4123-4133.

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