Fruit fly maggots are easy to please: just give them a piece of rotting fruit to tuck into. Matthew Cobb at the University of Manchester explains that the little larvae are ‘very stupid and very simple: their only job is to eat and turn into a fly.’ But their simplicity is precisely what makes them so appealing. While adult fruit flies have 1300 olfactory neurons, maggots make do with a measly 21 neurons. So for Cobb, who is fascinated by the sense of smell, maggots present a unique opportunity to get to grips with how smells are encoded by an olfactory system (p.3483).

Maggots’ olfactory systems have the same basic structure as those of other animals, so they are a perfect model system. The only problem is their diminutive size – for a long time it was technically impossible to put an electrode into their tiny ‘nose’. ‘Instead, we approach maggots as a black box’, Cobb explains. Watching maggots respond to smells could teach us a thing or two about their olfactory system. Maggots are somewhat challenged when it comes to locomotion, but this is yet another advantage. ‘They just wriggle’, Cobb says, ‘so it’s easy to study their behaviour.’

To study how smells are coded in the maggot brain, Cobb teamed up with Jennefer Boyle. The pair examined cross-adaptation in maggots. The concept is simple: if you sniff an odour for a while, you’ll stop responding to it. If you can then sniff out a second odour, you conclude that the two odours are processed by different receptors or pathways. But if you can’t smell the second odour, the two odours are assumed to have similar processing pathways. Cobb and Boyle tested maggots’ responses to seven fruity smells found in their favourite food – rotting fruit. To adapt some maggots to a particular smell, Cobb and Boyle placed 50 maggots on a dish and wafted one of the seven strong scents over them until the worms stopped wriggling towards the smell. Then they gave the adapted maggots a whiff of each of the six other odours and measured how the animals responded to the new smells by counting how many maggots gravitated away from or towards the new smell.

Cobb and Boyle recorded a complex mix of responses. They noted some cases of cross-adaptation, where the maggots didn’t respond to the second smell, but also some cases where there was no cross-adaptation. They identified one basic odour that seemed to be detected by all pathways, and two others that had similar effects to each other. But Cobb and Boyle were astonished to find that in a few select cases, sniffing a particular odour resulted in the maggots being repulsed by a second odour that they had previously found attractive! After mulling this over for a few weeks, Cobb realised that a possible explanation is that the maggots increased the sensitivity of their olfactory system, so that the previously attractive odour became overpowering. ‘It’s a bit like spilling a bottle of perfume’, Cobb suggests. He adds, ‘it makes sense for a maggot to be sensitive to changes in the attractiveness or concentration of an everyday odour’, because when the patch of fruit that a maggot is gobbling up has decayed beyond even the maggot’s questionable tastes, it’s a clear signal that it’s time to move on to fresher chomping grounds.

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**BUSY BEES**

One of the perks of being a biologist is the opportunity to travel to far-flung places to study animals in their exotic homes. So when Charles Darveau, Raul Suarez and Kenneth Welch found themselves in the depths of a jungle in Panama collecting reams of information on orchid bees, it was all in a day’s work. Their mission, Darveau recounts, was to ‘explain the variation in metabolic rate’ seen in these brightly coloured tropical insects (p. 3581 and p. 3593).
The team’s interest was piqued by reports indicating that insect body size, metabolic rate and wingbeat frequency are all linked. They decided to investigate how insect metabolic rates scale with body size across species. Selecting the multitude of closely related orchid bee species as their subjects, they flew to the Smithsonian Tropical Research Institute in Panama, where David Roubik joined the team. With Roubik’s field expertise, the team soon tracked down around 30 orchid bee species. They measured the bees’ wingbeat frequencies, metabolic rates, body sizes, wing sizes and wing loading, a measure of the body mass supported by a given wing area. Collecting DNA samples from 32 orchid bee species, Darveau constructed a molecular phylogeny so the team could account for the bees’ shared evolutionary past. When they examined the relationships between all these variables, they discovered that wing loading explains most of the variation they saw in wingbeat frequency, and this in turn is highly correlated with metabolic rate. In other words, wing morphology explains more of the differences in metabolic rate among these bee species than body size alone.

The team then turned its attention to energetics on a much smaller scale, delving into the effect of body mass on the design of energy production pathways. They had already found that orchid bees fuel their flight entirely with glucose, so they were keen to examine enzymes involved in glucose oxidation. To see how biochemical pathways have evolved in relation to metabolic rate, they plotted flight muscle enzyme activity (a measure of the amount of enzyme) against metabolic rate for 28 orchid bee species. To their surprise, they discovered that only one enzyme is highly correlated with metabolic rate: hexokinase, which catalyzes the reaction allowing glucose to enter the glycolytic pathway. Suarez explains that the control of flux (the rate at which a metabolic pathway runs) is thought to be distributed among many enzyme-catalyzed reactions, and not restricted to just one ‘rate-limiting’ step near the start of a pathway. ‘So why has evolution targeted hexokinase as the enzyme that varies across species in the same manner as metabolic rate?’ Suarez wonders.

More studies are required to fully answer this question, but the team’s results suggest that the evolution of orchid bee body size, flight metabolic rate and hexokinase activity are all closely correlated. For example, they saw that tiny bees need to beat their wings 250 times per second in order to hover, but big bees only have to beat their wings 80 times per second to perform the same aerodynamic trick. Surprisingly, the team spotted that hexokinase activity follows exactly the same scaling pattern as the one for wingbeat frequency. Darveau concludes that ‘examining the connection between wing design and the design of biochemical pathways might help us understand the evolution of insect flight energetics.’


FEEDING FRENZY

As any diver knows, hungry fish roaming the oceans display an astonishing array of ways to fill their stomachs. ‘How can we explain the tremendous variation we see in the oceans?’ Aaron Rice at the University of Chicago wondered. He decided to take a closer look at the dining habits of two vegetarian parrotfish species, the bucktooth parrotfish (Sparisoma radians) and Quoy’s parrotfish (Scarus quoyi). Working with Mark Westneat, Rice investigated how parrotfish coordinate the movements of their jaws, fins and eyes as they munch on their dinners (p. 3503).

We know a lot about visual, locomotor and feeding systems in isolation. Rice explains, but a fish really needs to coordinate all three systems to ensure that it doesn’t go hungry. ‘You need jaws to eat your food,’ Rice says, ‘but a set of jaws can’t get to food on its own.’ To understand how a fish feeds, we need to understand how its jaws, fins and eyes operate in relation to each other.

So Rice and Westneat set out to study how parrotfish coordinate these systems.
While watching two dogs risk life and limb during a fight in his kitchen, David Carrier began to ponder how the artificial selection pressures that humans have imposed on dogs have affected the limb bones of different breeds. Carrier suspected that there is a trade-off between properties that make limb bones suitable for fighting and those that make bones suitable for running. Teaming up with Travis Kemp, Kent Bachus and John Nairn, Carrier compared the limb bones of stocky pit bulls, bred for fighting prowess, with those of slim greyhounds, bred for high-speed running (p. 3475).

The team expected greyhounds to have stiff bones that can transmit muscular forces, and pit bulls to have tough bones that resist breaking. To find out how canine limb bones hold up under pressure, Carrier and his team placed greyhound and pit bull bones into a loading machine and measured the forces and deformation exerted on each bone until each bone snapped. The team found that greyhound limb bones were much stiffer and coped with higher stress before deforming than pit bull bones. But pit bull bones were more circular in shape and absorbed more than twice as much energy as greyhound bones before breaking; their limb bones are tougher than those of greyhounds. The team’s results suggest that the limb bones of animals specialized for running are shaped differently and composed of bone tissue with different mechanical properties than are the limb bones of animals specialized for fighting. ‘There appears to be a trade-off between bone requirements for running versus fighting’, Carrier concludes.

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