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

NO EXCESS BAGGAGE: BODY CHANGES IN MIGRATING BATS

Rather than hibernate during the cold Canadian winter, hoary bats prefer to undertake an impressive migration to their wintering grounds in Southern USA and Mexico before returning home to Canada during the spring. These bats are not the only winged animals to undertake such mammoth journeys, with many birds also migrating similar distances to escape harsh winters. However, as Liam McGuire from the University of Western Ontario, Canada, points out, ‘We know quite a lot about bird migration, but migratory bats haven’t been studied to any extent at all.’ Do bats use the same strategies as birds to fuel their long-haul trips? McGuire decided to investigate, and travelled to New Mexico, USA, and Saskatchewan, Canada, to capture bats at the beginning and end of their spring migration (p. 800).

On his return to the lab, McGuire compared the mass of different organs and the fatty acid composition of adipose and muscle tissue in the two different groups of bats, helped by his co-advisors, Brock Fenton and Christopher Guglielmo. They found that migrating bats had higher levels of fatty acids that can be easily burnt to fuel flight and that they had larger exercise organs (for example the heart and lungs). However, to the team’s surprise they had smaller digestive organs. McGuire explains that in avian migrants, reduction of digestive organs only occurs when they travel long distances without the chance to eat and refuel – they don’t want to lug around excess baggage. However, hoary bats have plenty of pit stop opportunities on their route and McGuire says that he ‘expected that the bats would have increased the size of their digestive organs so that they could take advantage of opportunities to refuel quickly’.

Does this mean that bats are abstaining for the duration of their migration like their fasting feathered friends? McGuire doesn’t think so. He found that most bats had in fact eaten something prior to their capture. Instead, he finds it helpful to think of the bats’ fat energy store like a car’s petrol tank, which they fill up at the beginning of their migration, but rather than letting it run completely dry they drain it a little every day and top it up frequently with small meals. Therefore they don’t need increased digestive capacity. This fits with their nocturnal nature, points out McGuire, who suspects that, ‘They may fly at night and as the sun’s coming up they go down to where they’re going to spend the day, grab a quick bite to eat, before roosting somewhere’.

McGuire also found that there were differences between the sexes, with female bats reducing more of their lean body mass (mass that isn’t fat) to increase the amount of relative body fat that they carry. Furthermore, when McGuire looked specifically at the types of fatty acids that make up the muscle membrane, he found variation in the ratios of omega-3 and omega-6 fatty acids between males and females. McGuire suspects that these differences mean that males use torpor – reduction of body temperature and metabolic rate – during their daily roosts to conserve energy. Females cannot profit from torpor to save energy, as during the spring migration they are pregnant and cannot drop their body temperature without harming their future offspring. They thus need to fill up their ‘tank’ even more than male bats before the spring migration.

Migration represents a real challenge for these bats. However, it seems that they plan differently to birds to cope with this demanding journey, using strategies that are tailored to individual bats’ needs – namely, a dislike of daylight and the possibility of being pregnant.

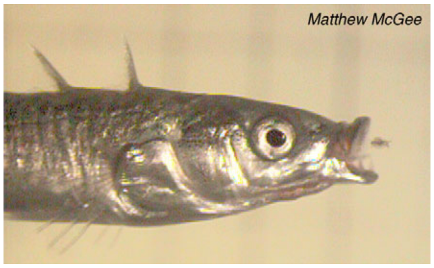
10.1242/jeb.084640

McGuire, L. P., Fenton, M. B. and Guglielmo, C. G. (2013). Phenotypic flexibility in migrating bats: seasonal variation in body composition, organ sizes, and fatty acid profiles. *J. Exp. Biol.* **216**, 800-808.

Nicola Stead

FEEDING DIFFERENCES IN MALE AND FEMALE STICKLEBACKS

Many fish make the intrepid migration from sea to freshwater to breed; however, some of these visitors enjoy their trips so much that they stay and evolve to live full time in freshwater. But how do marine sticklebacks make this evolutionary transition? Intrigued, Matthew McGee, a PhD student from the University of California, Davis, USA, captured marine sticklebacks from a nearby bay to begin to find out. While filming them snacking on crustaceans, he noticed something unusual: ‘The males and females were striking at their prey in different ways’, remembers McGee. This observation was surprising and when McGee told his advisor, Peter Wainwright, McGee recalls, ‘He didn’t believe me at first because sexually dimorphic feeding movements had not been



seen before in any fish species'. Nonetheless, McGee persisted and decided to investigate further the different feeding habits of the two sexes (p. 835).

Feeding in fish mainly occurs by sucking prey into an open mouth, which involves many bones and muscles explains McGee: 'Fish can protrude their jaws forward from their head to move their suction flow closer to a prey item and hyoid [bone] depression causes the floor of the fish's mouth cavity to drop down to expand the area of the cavity and suck more water in'. To characterise differences in feeding mechanisms between the sexes, he filmed the feasting fish at 500 frames s^{-1} before analysing the exact jaw and hyoid movements. He found that females were able to both protrude their jaw and depress their hyoid more than males. However, males struck prey at a much closer distance and reached maximum jaw protrusion 11 ms faster than their female counterparts. When he measured some of the same traits in preserved sticklebacks from another marine location in Washington, USA, he again saw jaw protrusion was larger in female fish.

McGee believes that these differences between the sexes mean that males are less capable of capturing prey by suction feeding, as their mouths open less than females'. Instead, he suggests that their jaws are more suited to biting. Explaining that males construct nests, and the ability to bite is particularly useful for collecting building materials from the lake floor, McGee suggests that it is possible that the males have traded their prowess as hunters to become homemakers.

But McGee also wondered whether this sexual dimorphism might also help sticklebacks make the transition from being a marine inhabitant to a freshwater resident. As the male-like jaw is better for biting rather than sucking, it is also well suited to capturing non-evasive prey on the lake floor, which rely on armour and burrowing to evade predators, whereas a female-like jaw would be suited to capturing evasive free-swimming prey from a further distance. McGee reasoned that if one particular prey was more abundant in a new freshwater environment, it would be useful to already have the two different feeding traits within the population for selection to act upon. Luckily, McGee had already scouted out freshwater sticklebacks in Canada, and was able investigate his theory by measuring the jaw protrusions in these sticklebacks. Sure enough, males and females that inhabited open water away from the sides and bottom of the lake had female-like jaw protrusions irrespective of sex, whereas another population, which forages along the lake floor, had a more male-like jaw protrusion.

McGee suspects that probably many fish species display sexual dimorphism in feeding movements and that this dimorphism provides them with the important ability to adapt to new situations or tasks, be it at sea or in a lake.

10.1242/jeb.085258

McGee, M. D. and Wainwright, P. C. (2013). Sexual dimorphism in the feeding mechanism of threespine stickleback. *J. Exp. Biol.* **216**, 835-840.

Nicola Stead

TO BITE OR NOT TO BITE? LEARNING IN *RHODNIUS* BUGS

It's not easy being a blood-sucking insect – you've got to find a host and quickly drink its blood before the unwilling victim realises and retaliates. With these challenges, it's easy to understand why bloodthirsty insects choose to snack on some hosts and not others, choosing less defensive prey for mealtimes. How they learn to discriminate remains unknown and so Claudio Lazzari, from the Université François-Rabelais, France, decided to investigate learning in the bloodsucker *Rhodnius prolixus* (p. 892).

Learning and memory have been well characterised in insects with more appetising diets, such as honeybees, but we know little about the cognitive abilities of blood-sucking critters. Studies investigating learning in non-blood-sucking insects take advantage of the proboscis extension response – a characteristic behaviour where the proboscis (the insect's food-sucking tube) extends when the insect is presented with something tasty. Lazzari realised that he could also use this same behaviour in *R. prolixus* to study learning, explaining that: 'We know that they have this very well-characterised response to heat, and we can use this stimulus to train them to associate this information [with specific consequences]'.

To begin the study, two of his students, Clément Vinauger and Hélène Lallement, set out to first establish whether *R. prolixus* has the ability to learn a simple task: not to extend their proboscis when tempted. They starved the insects for 2 weeks to make sure that they were famished before placing them in front of a heated plate. Then they ramped the temperature up to 35°C for 10 s, hoping to fool the insect into thinking that it was close to a warm-blooded animal. The cooperative bloodsucker extended its proboscis, only to be disappointed when it touched the plate instead of the tasty treat it had expected. After allowing the dejected insects to recover, the team tested them again repeatedly and after 26 training sessions the insects finally began to realise that they'd been duped. And when the team dropped the hotplate's temperature to 30°C, to check the insects weren't just getting tired, most of the bugs started responding again. So, the insects were capable of learning not to extend their proboscis.

Next, the team tested how the insects learnt to react to an unpleasant stimulus. They punished the insects after they had extended their proboscis, by whacking the temperature up to 50°C. The bugs learnt very rapidly, and after five trials half of the insects had already stopped extending their proboscis altogether. The team then asked whether the educated insects could remember their lesson. After an hour's break the insects were again placed in front of the heating element and this time they stopped responding to the warm plate after just three trials. They obviously remembered their previous lesson. In addition, by increasing the time between experiments, the team were able to establish that this memory persisted for at least 72 h.

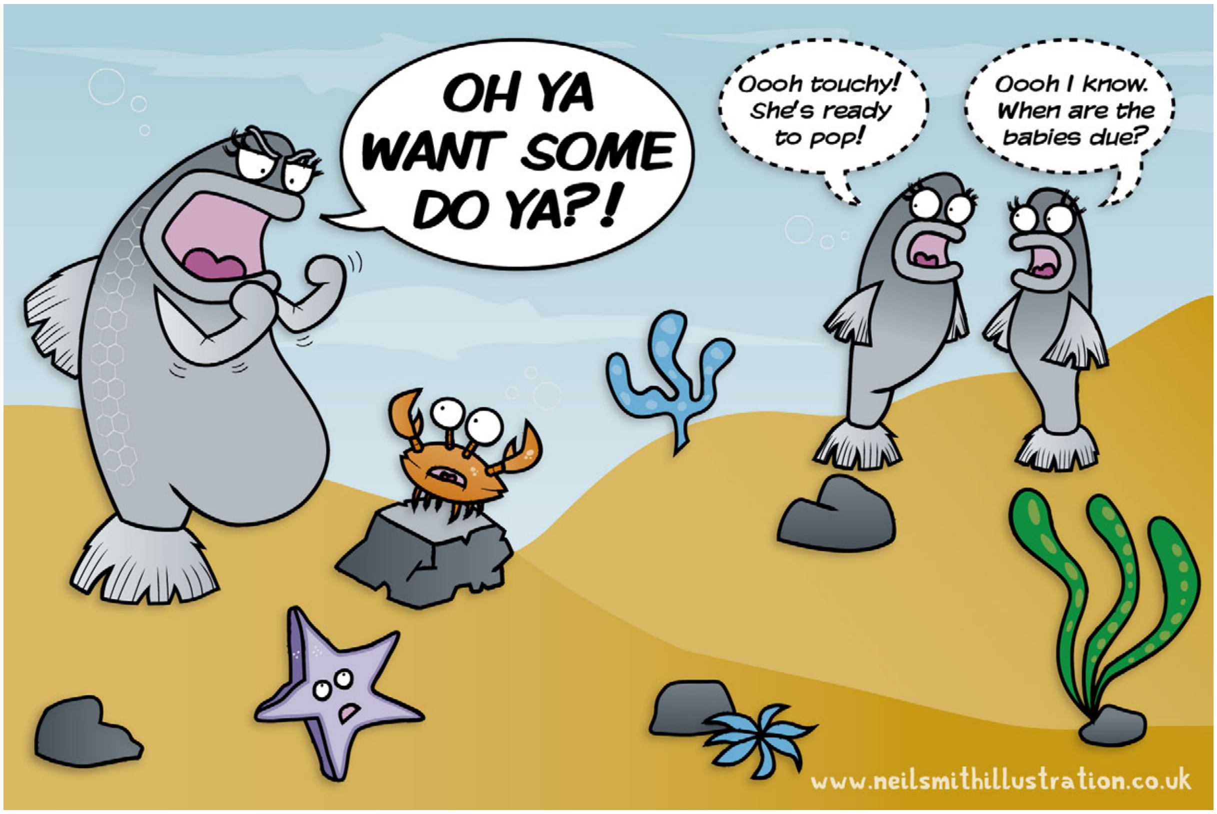
'We didn't expect that they would be able to learn so quickly, or that they would remember it for so long – that was a great discovery', recalls Vinauger. But perhaps the most important aspect of the study, says Lazzari, is that it provides experimental tools to further investigate this bugs' cognitive ability and ask what other things affects the insect's host choices and memory. As *R. prolixus* transmits the Chagas disease-causing parasite, how it chooses and remembers hosts has important consequences for how the disease spreads.

10.1242/jeb.084657

Vinauger, C., Lallement, H. and Lazzari, C. R. (2013). Learning and memory in *Rhodnius prolixus*: habituation and aversive operant condition of the proboscis extension response (PER). *J. Exp. Biol.* **216**, 892-900.

Nicola Stead

SOON-TO-BE MOSQUITOFISH MUMS GET AGGRESSIVE



Pregnancy is a tiring affair and as you reach full-term you could be forgiven for avoiding confrontation to conserve energy. However, picking your battles does not seem to be a priority for live-bearing female mosquitofish, *Gambusia holbrooki*: according to Frank Seebacher from the University of Sydney, Australia, they get more aggressive towards the end of their pregnancy (p. 771).

Female mosquitofish are naturally feisty, vying to become dominant over other fish in order to attract more suitors. However, this behaviour is energetically costly, especially when confrontations can escalate into high-speed chases with the two fish nipping at each other. Seebacher reasoned that given the amount of energy needed to fuel these aggressive encounters, females in the late stages of pregnancy would become more docile as most of their energy would be needed to support the increasing metabolic burden of their growing offspring.

Teaming up with Ashley Ward from the University of Sydney and Robbie Wilson from the University of Queensland, Australia, Seebacher set out to investigate his theory. The trio placed two female fish, one in the early stages of pregnancy and the other in the later stages, in a tank and recorded the outcome of these tense encounters. In contrast to the original theory, the team found that late-stage pregnant females were far more likely to chase their opponents than females that had only recently become pregnant. Consequently, the soon-to-be mums won over 77% of fights. However, this display of superiority did come at a cost, with females in the later stages of pregnancy squandering the remaining resources left over after supporting their unborn young.

Spending all their energy squabbling for dominance could be a risky strategy, as fighting mums-to-be may lack enough energy to defend themselves against predators or even forage for food. However, Seebacher explains that there may also be benefits to fighting. He points out that gaining dominance over other females may increase the victor's access to resources as well as preventing subordinate females from reproducing, thus giving the dominant mum's offspring a better chance of survival. So perhaps soon-to-be mosquitofish mums do know which battles to pick after all!

10.1242/jeb.084632

Seebacher, F., Ward, A. J. W. and Wilson, R. S. (2013). Increased aggression during pregnancy comes at a higher metabolic cost. *J. Exp. Biol.* **216**, 771-776.

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