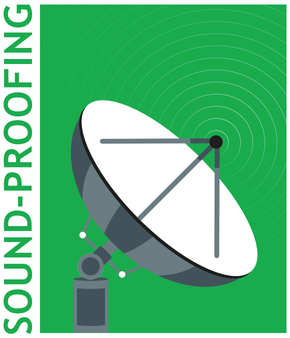
OUTSIDE JEB

Moths use a fuzzy muffler to deaden bat sonar



The night skies are a dangerous place for moths: they make tasty, nutritious snacks for hungry bats. But first the agile mammals must detect their prey, guided in for the capture by the high-pitched sounds they emit, which reflect off objects back to their ears when hunting in the dark. This skill, called echolocation, is especially dangerous for moths without ears that cannot detect bat calls. However, earless moths may have come up with some surprising defenses against attack. Moths use colored hair-like scales arranged in patterns on their body for visual camouflage, and it turns out these same scales can also deafen a bat searching for its next meal.

Thomas Neil and co-authors at the University of Bristol, UK, compared the scales of two species of bat-deaf moths and two species of butterflies – which fly during the day and probably cannot hear bat echolocations – using a scanning electron microscope. They noticed that the arrangement of the moths' layer of hair-like scales on the thorax was similar to the fibrous materials used for noise insulation; the scales are stacked in parallel like long hairs on a pelt, with porous spaces between them to trap air. To test whether this fuzzy layer of scales absorbed bat echolocation calls, the team built a model bat using a speaker for the mouth and a microphone that recorded the echoes for the ears. They then placed the moths and butterflies in different positions around the simulated bat to measure what the bat would hear when approaching its prey from different directions. Next, they removed the hair-like scales from the moths and butterflies and repeated the measurements to test the effect on the echolocation reflections, before finally using the microphone recordings to recreate the soundscapes that the bat should hear.

It turned out that the descaled moths made better targets for bat echolocation calls than the fully fuzzed insects. The bats had to be about 10–20% closer to a moth when its scales were intact to detect it, which gives the insects a better chance of flying by unnoticed. Unlike for the moths, removing the hair-like scales from the butterflies had little effect on the strength of the sonar signals they generated, likely because they have no need to conceal themselves from bats while active during the day. In addition, when the scientists compared their scale layers, they found that the butterflies' layer was too thin to deaden bat calls, but that of the moths was just thicker than necessary, absorbing up to 67% of the sound. More surprisingly, they found that the moths' sound-deadening scales outperformed most commercial fiber-based noise-proofing materials.

Even though some moths cannot hear, they still manage to elude the sneaky sonar of bats by donning a thick coat of hair-like scales to absorb and deaden their echoes. Locked in an evolutionary arms race with their lethal foe, moths have produced a bio-material that muffles sound better even than many of the engineered sound absorbers we use today. Maybe one day engineers will be able to take the lessons learned from the moths' unconventional fuzzy muffler to design better noise proofing for us all.

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Most salamanders glow: now what?

Jellyfishes, fireflies and many deep-sea creatures are famously bioluminescent, harnessing specialized chemical reactions to emit an eerie glow. The biological flashlights may be involved in camouflage, hunting and even enhanced communication in low-light environments. However, other animals use a different mechanism to produce light – biofluorescence – by absorbing high-energy wavelengths of light (blue and UV) before re-emitting them as a blue, green or even red glow. Recent work has shown that a smattering of creatures, including chameleons, parrots, penguins and even some rodents, have added biofluorescence to their palette of colours. However, instead of looking for individual examples of glowing animals, Jennifer Lamb and Matthew Davis from St Cloud State University in Minnesota, USA, took a different, broader approach. They conducted a survey of amphibians, focusing on newts and salamanders, to find out how widespread the phenomenon is.

Lamb and Davis scoured the pet trade, the natural environment and the Shedd Aquarium in the USA for as many amphibians as they could find. Then, they gave each species its moment in a blue or UV spotlight, beaming the animals with enough light to bring out their hidden biofluorescent colours. The researchers then viewed their subjects through a filter that blocked light bouncing off the skin, revealing the subtle, inner gleam of biofluorescence.

Every amphibian examined (mostly salamanders, but also some frogs and a caecilian) glowed under the right conditions, even the aquatic larvae. Bold markings and colours, like the orange tummy of fire-belly newts or the yellow blotches of the tiger salamander, glowed bright green or greenish orange. Animals with demure patterns had a more subtle sheen to them. In a few cases, species fluoresced from unusual places: some had glimmering bones and others shone from a coating of glowing mucous.

Taking stock of their diverse collection of shimmering specimens, Lamb and Davis reasoned that biofluorescence is widespread in amphibians and probably appeared early in their evolutionary history. The next logical questions are exactly how do salamanders and their relatives glow and why did they do it in the first place?

The authors suggest that the amphibians' light shows might originate from pigments in the skin, such as carotenoids, pterins and structures with guanine crystals, which all fluoresce. Alternatively, the glow could have nothing to do with pigments, relying instead on something like the green fluorescent protein common in jellyfish and molecular biology labs worldwide, or hyloins – compounds produced by the mucous glands of neotropical frogs. Which, if any, of these mechanisms apply to salamanders and their cousins remains uncharted territory.

And the team suspects that these amphibians probably use their glowing abilities in much the same way as other biofluorescent animals. Like a neon sign, the green blotches and markings could send messages. Perhaps female salamanders judge their suitors by their 'glow up', tolerating only the brightest mates. The fact that some species show strong biofluorescence around the cloacal region, a part of the anatomy that many species investigate during courtship, makes this possibility especially intriguing. Bizarrely, glowing in the dark could also be a form of camouflage, if the patterns mimic those of other fluorescent predators, yet how biofluorescence impacts the daily life of amphibians remains a mystery.

As is often the case, good science can lead to more questions than it answers and the results of this study reveal how little we know about the hidden world of amphibians.

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Unpredictability stresses out sea bass

Most mammals, including humans, get stressed when something unpredictable happens. A lack of control or certainty sets off a cascade of reactions throughout our bodies known as the 'stress response'. This can include not only changes in our behaviours but also fluctuations in our hormone levels and, in some cases, alterations even to the activity of our brains. Recent work by Marco Cerqueira and colleagues from universities in Portugal, France and the UK suggests that this sort of response to erratic environments is not limited to mammals – fish seem to experience it, too.

The team raised European sea bass in the lab to see whether the fish would change their behaviours depending on whether they could anticipate a stressful event – in this case, being briefly confined by a net to a small area of their tank. The researchers initially split the fish into groups. In the first group, they repeatedly showed the sea bass a yellow and black striped picture right before trapping them in the net. In the second group, the researchers showed the fish the same image, but at a random time either before or after the net started moving towards them. The idea was that fish from the former group should be able to anticipate the net's arrival while members of the latter group should not be able to tell when they would be trapped. Cerqueira and colleagues then set up cameras to watch how the fish responded to seeing the menacing yellow and black stripes.

The sea bass that could predict when they would be trapped seemed less stressed upon seeing the ominous striped picture, spending much less time either frozen in place or trying to escape. This idea was further supported when the researchers realized that these fish also spent much more time swimming around their tanks, ready to explore rather than cowering in fear. These differences in behaviour suggest that sea bass are less stressed when they are in predictable environments.

To confirm this, Cerqueira and colleagues looked to see whether the fish that anticipated the arrival of the nets had lower levels of a stress hormone, cortisol, in their blood. They collected blood samples from both groups and discovered that, as expected, there were lower levels of cortisol in the blood of sea bass that could foresee their incarceration.

As predictability seems to affect both the behaviours and hormone levels of sea bass, Cerqueira and colleagues had a hunch that stress could also affect their brains. The researchers looked specifically at a couple of different brain areas in the sea bass. One area they examined is just like the mammalian amygdala, sometimes referred to as the 'fear centre', which appears important for processing emotions and perceptions, in addition to detecting things in the environment that stand out from the surroundings. To determine the activity of this brain area, the team measured the expression of certain genes that turn on when the brain is active.

They discovered that sea bass that couldn't predict the appearance of the net showed more activity in this section of the brain. This suggests that this amygdala-like brain region functions the same way in fish as it does in mammals to perceive threats in the environment.

The fact that stressed sea bass show differences in their brain activity depending upon whether they can anticipate a stressor highlights that fish have feelings too. Like humans, predictability appears crucial for the fish stress response and the more predictable something is, the less stressed out the fish will be.

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Ingenious ants reinvent the wheel

Ants face a choice when danger confronts them: do they stay put and take up the fight or flee for safety? Some have been particularly ingenious and developed various specialized avoidance strategies: certain species snap their jaws on a hard surface to catapult themselves to safety, while a selection of tree-dwelling ants drop from the canopy to glide down safely to the forest floor. In a recent study, Donato Grasso and colleges from the University of Parma, Italy, report on a strategy that had previously not been described. When threatened on a sloping surface, *Myrmecina grainicola* ants curl into a ball and roll away. The team decided to analyze the behavior in their laboratory and tested the idea that ants only use this strategy in situations where they know it will get them out of a tight corner.

The researchers collected colonies of *M. grainicola* ants from natural nests and housed them in the laboratory. The team then provided the ants with a sequence of small platforms to roll off, so that they could investigate the fine details of the insects' maneuvers. First, to understand which circumstances would trigger the ants to perform a roll, the researchers put the insects on a sloping surface, which they tilted gradually from horizontal to 45 deg, while they lightly tapped the surface to scare the ants into rolling. Next, the team tested how far the rolling motion would take the ants on different surfaces, ranging from earth and leaves to stone, which the ants encounter in their natural environment. Finally, the team performed a detailed step-by-step video analysis of the ants as they rolled down a slope inclined at 25 deg.

The researchers found that the ants only used the rolling strategy when the surface they were walking on was inclined at an angle of 10 deg or steeper. This suggests that the ants only began rolling when the slope made rolling an effective strategy to get away from danger. What's more, the surface affected the effectiveness of the roll: on stone and leaves, the ants rolled distances of 17 and 8 cm, while rolling on earth only carried them a distance of 2 cm. To begin rolling, the ant put its head followed by its bulbous hind-segment on the ground, then its entire body curled up before it finally kicked its hindlegs to speed up the roll. Most impressively, the ants achieved an extraordinary speed of 40 cm s^{-1} while rolling, compared with their leisurely walking pace of just 0.5 cm s^{-1}.

In an effort to find out how the ants used rolling to their advantage when under attack, the team pitted an ant against a competitor of another species in an arena that was either flat or inclined at 25 deg. After the pitched battles, it was clear that the incline allowed the *M. grainicola* ants to roll away from their opponents, improving their chances of living to fight another day: only 10% of the ants suffered injuries on the sloped surface, while 63% sustained injuries on the horizontal surface. As the ants only began rolling on the inclined surface, this suggests that the ants only resort to rolling when they know it provides an effective form of escape.

Grasso and colleagues have reported an unusual strategy that *M. grainicola* ants employ to get away from danger. These ants join a select group of only a few other animals, including some spiders, caterpillars and salamanders, that use rolling as a form of motion. This provides us with the opportunity to gain a better understanding of how rolling is used by a range of ingenious animals that have all reinvented the wheel by becoming one themselves.

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