OUTSIDE JEB

Locusts take a break to observe and move with their friends

Have you ever watched or participated in a mosh pit dance? Essentially, every person is moving together while bumping into each other and getting hit. There are plenty of animals that move in groups, such as shoals of fishes, flocks of birds, or swarms of locusts, but most manage to proceed without continually bumping into one another. One of the unique behaviours that has been observed when animals are in groups is when individuals stop before coordinating their movement with that of the animals that surround them. This behaviour is known as intermittent motion. Some scientific work has suggested that the use of intermittent motion is linked to an energy saving response; it has also been associated with a way for animals to gather and analyse information about the environment to guide their movement when in a crowd. Knowing this, Yossef Aidan, Itay Bleichman and Amir Ayali from Tel Aviv University, Israel, decided to find out more about how locusts process visual information from their surroundings and then act on it when moving in a swarm.

The team collected wingless desert locust (*Schistocerca gregaria*) nymphs – before the final moult when they transform into adults – from a colony at Tel Aviv University. Each locust was tethered so that it could walk on a large rotating ball, essentially a treadmill that allowed the locust to walk in any direction. The ball and insect's movements were tracked using a mouse sensor and a camera located above the insect while the locusts watched a movie of four dots played on monitors in front of them, either moving forward or backward, to simulate the view of nearby insects in a swarm. Aidan and colleagues then created three artificial visual situations for the locusts and monitored how they moved in response to the dots' movements. In the first experiment, the dots moved continuously, regardless of whether the locust was walking or not. In the second experiment, the dots moved when the locust moved, but stopped when the locust was static. In the third experiment, the dots on the screen moved while the locust was stationary but were motionless when the locust walked on the treadmill.

What the researchers found was very interesting: the locusts moved the most when the moving dots appeared to be going backwards and they moved the least when the dots on the display moved forward continuously. In addition, the team discovered that locusts moved their body to the sides more when the display was moving backwards, and the greatest side movement was observed when the display was moving and the locust was static.

In summary, when a locust is not moving and its surroundings appear to move backwards, it triggers a change in the direction of their movement to stay within the group. This suggests that taking a small break can provide animals with time to process visual information about the movements of neighbouring locusts so they can adjust their own movements accordingly. At the same time, it may also help explain how other animals use the 'pause-and-move' response. For example, shoals of fish might use a break to assess the environment and move in time with each other if a predator is approaching. Lastly, the growing field of insect-inspired robotics has produced robots that can fly in formation, but they are not typically programmed to use intermittent motion to help them to remain in sync. Implementation of this behaviour in robots may be beneficial for their performance, so long as they don't get too smart and try to take over the world.

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Aidan, Y., Bleichman, I. and Ayali, A. (2024). Pausing to swarm: locust intermittent motion is instrumental for swarming-related visual processing. *Biol. Lett.* **20**, 20230468. doi:10.1098/rsbl.2023.0468

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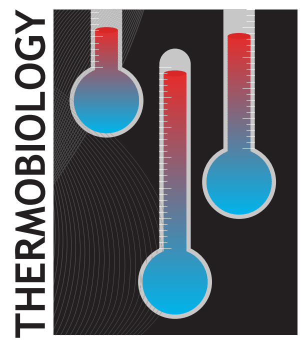
Plight of the bumblebee



In a colony, worker bees play many roles: providing food, taking care of the young and even managing the nest's heating and air conditioning systems. Bumblebees (*Bombus impatiens*) do this exceptionally well, generating their own body heat to keep the nest toasty, and 'fanning' the nest with their wings to cool it down. However, making sure the nest temperature is not too cold or too hot – but just right – takes quite a bit of energy. As climate change causes heatwaves to happen more often and for longer periods of time, more worker bees may need to help fan the nest, taking them away from vital jobs such as foraging for food. So, Tiffany Bretzlaff, Jeremy Kerr and Charles-A. Darveau from the University of Ottawa, Canada put bumblebees to the test, keeping colonies under high heat for 2 weeks to understand whether 'fanners' could cool down their nest and still

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maintain the other jobs required to keep their colony going.

Bretzlaff and the team tagged 43 worker bees from each colony and placed them with their queen in a 'nest' made from a Styrofoam cooler, a substitute above-ground nest with a convenient clear top for monitoring the colony. The researchers placed a total of 15 bumblebee colonies into three different environmental chambers, where five colonies were held at 25°C, 30°C or 35°C for 2 weeks. Each Styrofoam 'nest' was connected to a flight cage by a secret tunnel (clear tubing with a tag reader) that cleverly allowed the scientists to identify who was coming and going, and for how long. The flight cages allowed the bees to forage freely. A worker bee was considered a 'forager' if they logged 10 or more trips between 3.5 and 25 min long and considered a 'fanner' if, when in the nest, they stayed still and beat their wings continuously for at least 10 s.

Contrary to what they predicted, bees foraged at the same levels at 30°C and 35°C as they did at 25°C. However, the number of fanners each day was dramatically higher in colonies at 35°C (14 fanners) compared with colonies at 25°C (4 fanners), just to try to keep the nest cool. Unfortunately, these fanners weren't entirely successful. The scientists also measured the temperature inside the nest, and while colonies at 25°C and 30°C could keep their nests mostly within optimal nest temperatures (30–33°C), colonies incubated at 35°C remained at ∼35°C throughout the 2-week trial. And by the end of the 2 weeks, colonies at 35°C had produced less than one-quarter of the larvae and pupae found in the colonies at 25°C, suggesting that high heat may reduce the number of eggs laid or how well the eggs are developing.

On top of that, high heat caused nearly three-quarters of the bees to abandon their nest rather than stay in the heat. Although the bees couldn't fully escape from the heat, in these instances, they preferred remaining in the flight cage over their nests. Even at 30°C, Bretzlaff and the team found that 19 of the original 43 worker bees would rather abandon their nest than continue with the valiant effort of fanning. No one yet knows if these bees would have chosen to return to their nests if the 'heatwave' concluded, or whether they would move on to a new colony. While fanning didn't take away from other jobs such as foraging, high heat resulted in greater nest abandonment and fewer young, indicating bumblebees just can't cope with the cost of keeping cool.

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Night-light illuminates wasp behaviour

Do you ever have a hard time falling asleep if there is light streaming into your bedroom, which you cannot block out? You could say that your biological sleep cycles are disrupted by uninvited light. The same thing happens to animals and plants, particularly as artificial light pollution at night (e.g. city light glow, streetlamps etc.) has been increasing since the 19th century. Lots of living things use natural light as a cue for biological activity, such as feeding and mating. In addition, some animals that are usually active during the day are now becoming active at night because of artificial light. Elisa Gomes and colleagues at the University of Lyon, France, were particularly interested in figuring out if artificial light impacts the feeding and mating rituals of a parasitic wasp, *Venturia canescens.* A previous study by Gomes showed that this wasp species, which is usually active during the day, also became active at night when exposed to artificial light. Knowing this, Gomes wondered whether artificial light might lead the wasps to feed and lay eggs at night, instead of during the day, as well as altering their lifespans.

To test this, Gomes housed the wasps in plastic boxes at a constant temperature (25°C) with periodic access to food (sugar water) and Mediterranean flour moth larvae, the hosts upon which the parasitic wasps lay their eggs. The team then recreated the natural light patterns of 12 h of light followed by a dark night. While some of the insects experienced low intensity light pollution overnight, comparable to city skyglow, others had their nights disturbed by high intensity light (comparable to a streetlamp). Over a 2-week period, the team monitored the food eaten by the wasps and counted how many eggs they laid in the moth larvae. The researchers also recorded when the wasp offspring emerged from the parasitized moths to determine if artificial light impacted the wasp larvae's development.

Gomes found that the wasps fed more and laid more eggs at night when exposed to nocturnal light pollution. The wasps also lived longer when the artificial light that they experienced at night was more intense, which Gomes speculates might be because the wasps had more time to feed. Despite laying more eggs in artificial light at night, the wasps did not produce more eggs over the entire course of their lifetime. This may have been because the wasps that were experiencing nocturnal light pollution laid fewer eggs during the day. Finally, older wasps that had been exposed to artificial light at night laid eggs that developed faster than eggs laid in total darkness. However, this did not seem to impact the offspring's ultimate development – they grew to be the same size as the offspring produced by parents that experienced complete darkness at night, which developed slower.

Gomes suspects that the offspring exposed to artificial light may have other physiological differences caused by nocturnal light pollution, which were not tested in this study. She also highlights several factors that need to be investigated further, such as what happens when the wasps experience the temperature falls that occur naturally at night. It is also not known if these wasps are sensitive to different colours or shades of artificial light, which could be an intriguing direction for future research. Ultimately, it is clear that artificial light alters the wasp's behaviour, although it remains a mystery whether this is for better or worse.

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Infected ants prefer protein-packed diet

FOOD PREFERENCE

Whether it's a new taste for salt or a sudden hunger for sugar, animals infected with parasites often develop new cravings. But it's not always clear whose cravings the animal is responding to. On the one hand, the parasite could be an overly pushy guest manipulating its host to achieve its own needs. On the other, the animal's own body could prioritize an immune system-boosting diet to fight the infection. That's why Enikő Csata from the University of Toulouse, France and an international team of scientists explored the dietary preferences of Argentine ants (*Linepithema humile*) and a fungus (*Metarhizium brunneum*) that infects them. They wanted to know if the dietary choices of infected ants reflected the preferences of the fungus and if the fungus itself was responsible for its host's choices.

First, the researchers had to figure out what kind of diet the fungus liked best; does the fungus like something high in protein, or does it prefer a high-carbohydrate diet? After whipping up different mixtures of nutrients with varying ratios of sugars and amino acids, the scientists grew the fungus in Petri dishes containing one of each of the mixtures. For a month, they let the fungus spread over the nutrients on each dish. As it grew, the fungus produced spores, the reproductive cells that make more fungi and also infect the ants. At the end of the experiment, Csata and her team compared the growth of the fungus and the number of spores in each Petri dish. They found that the fungus grew best and produced the most spores when there was a 1:4 ratio of amino acids to sugar molecules, making this protein-heavy meal the optimal fungal diet.

This diet was far from optimal for the ants, though. The researchers fed individual ants either the optimal fungal diet or a high-carbohydrate diet for 2 months and found that the ants tended to die sooner when they ate only the optimal fungal diet. However, this protein-packed diet did not make fungal infections any more deadly. During the same period, the researchers applied fungal spores to the exoskeletons of a different group of ants and compared the effects of the two diets on the ants. The infected ants generally died sooner than their uninfected peers, regardless of what they ate. Infected ants even developed a taste for the ordinarily unhealthy, protein-heavy diet. When the scientists allowed worker ants to forage for food in a spore-ridden environment, the insects preferred bringing the optimal fungal diet back to their colonies, rather than carbohydrate-heavy meals. At first glance, this dietary choice would appear to benefit the infectious fungus. While the parasite could be manipulating its host's food choices, an ant's immune system also relies heavily on amino acids to make all the proteins it uses to recognize and kill parasitic invaders.

To figure out which party was in charge, Csata and her team injected individual ants with a piece of the fungus that was incapable of growing or reproducing to fool the ants' immune systems into making defensive proteins. Then, they let the ants choose what to eat. Even though the ants weren't truly infected, the needs of their amino acid-hungry immune systems still drove their cravings towards the protein-rich optimal fungal diet. The researchers concluded that the infected ants ate more protein despite their parasite's preferences. Whole colonies ate more protein when their workers were infected, suggesting that ants use food to self-medicate and limit the spread of infection. Bringing more protein back to the colony may not cure what ails any one worker, but it could give the rest a fighting chance.

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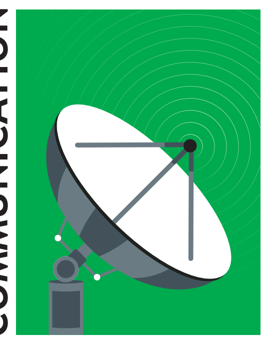
Speaking whale: how to talk under water

COMMUNICATION



We all know that humans cannot breathe under water, but have you ever tried to talk or even make a sound while swimming under the surface? This seems almost impossible as we need air to flow through our larynx to create the vibrations that transmit sound. To protect themselves from drowning, baleen whales evolved nasal and oral plugs to keep the water out of their respiratory system while diving and feeding. In addition, they have an air sac, which might recycle air from the lungs during vocalization, but it wasn't clear how they use air to produce sound in the larynx and whether the larynx was modified in some way to allow these residents of the deep to sing while cut off from the surface. Coen Elemans, from University of Southern Denmark, and a team of international collaborators investigated the structures of the larynges of several baleen whale species, to reveal how they use air to produce their enigmatic sub-marine moans.

The researchers obtained the larynges – the section of the windpipe that produces vocal sounds in most mammals – from three different species of baleen whales (sei, common minke and humpback whales) – and used high-resolution 3D X-ray scans to visualize the larynges' internal structures. To test whether and how the vocal structures produce sound the team pushed air through each larynx and recorded the resulting sounds with microphones. In addition, the team built a computer simulation of the whales' voice boxes to understand how air flows through the structure, how muscular contractions change the shape of the larynx to modify the sound, and how tissues in the structure vibrate to produce sound.

The team discovered that baleen whales have several novel laryngeal structures that have never been seen before: muscularized fold structures (which are unlike conventional sound-producing vocal folds and are known as the transverse arytenoid folds) that run along the arytenoid cartilage in the larynx; and a large wedge-shaped pad of fat attached to the cricoid cartilage. The team discovered that when the whales are calling, the arytenoid cartilage in the larynx rotates, closing the gap between the transverse arytenoid folds and the fat pat so that when air is forced out of the lungs through the gap between the two structures, mucus membranes covering them both begin to vibrate, producing sounds pitched at ~42 Hz in the minke whale and ~33 Hz in the humpback whale. And when the team took a closer look at the humpback whale's transverse arytenoid folds, they realized that they could also vibrate like conventional mammalian vocal folds in a voice box, probably extending their frequency range to 6000 Hz.

This study shows that baleen whales evolved unique structures in their larynges that enable them to produce sounds powered by air while living in the opaque ocean environment. And the team predicts that baleen whales can only produce calls lasting 15 s at a depth of 30 m because air is compressed under pressure and unable to provide sufficient flow through their larynges to produce long calls at greater depths. These findings are consistent with whale calls recorded in the ocean, suggesting that the majority of baleen whale communication is limited to shallower depths, meaning that whales may not be able to continue singing as they dive deeper to stop the sound pollution generated by sea vessels muffling their messages.

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