Keeping track of the literature isn't easy, so Outside JEB is a monthly feature that reports the most exciting developments in experimental biology. Short articles that have been selected and written by a team of active research scientists highlight the papers that JEB readers can't afford to miss.

Outside JEB

SPIDER SILK

SPIDER SILK VARIES IN RESPONSE TO PREY

Cobwebs are an annoyance that most of us only face when tracking something down in the loft or basement. We rarely pay any attention to their sophisticated architecture and silk thread structure as we brush them aside. But scientists have long been intrigued by the enigmatic material's plastic structure, which is dependent on both intrinsic and extrinsic factors. Previous work has indicated that cobweb weaving spiders can control the mechanical performance and material properties of their silk, but whether they can tune structural or material properties of silk threads to the prey they intend to capture remains unknown. To address the question of whether common house spiders, *Achaearanea tepidariorum*, respond to different prey by altering their cobweb silk, Cecilia Boutry and Todd Blackledge from the University of Akron in Ohio tested whether a spider's diet affected the style and structure of the web it built.

First of all, Boutry and Blackledge assigned 29 wild house spiders to two groups and kept them on different diets for 1 week before analysing their cobweb silk both structurally and mechanically. One group was fed crickets; large, fast prey items, which would require significant restraint by a web. The other group was kept on pillbugs, which are small and slow and would need much less restraint. The duo suspected that the cobweb's architecture, as well as the silk's composition, thread diameter and mechanical properties could be affected by the spider's diet.

The team observed that spiders fed on a cricket diet spun threads that had up to a 20% larger diameter than the pillbug-fed spiders. These differences were equally pronounced in silk threads from two different functional regions of the cobweb; the sticky gumfooted threads that adhere directly to prey and anchor the web to solid structures, and supporting threads that maintain the web's integrity. Boutry and Blackledge also tested the silk's mechanical properties by exerting loads on the silk until it broke and found out that cricket-fed spiders produced a silk which broke at higher loads and was over 40% tougher than the pillbug's silk. Next, the researchers observed that the spiders that had been fed on heavy crickets were heavier and also had a better body condition than spiders supplied with pillbugs, even though the two groups were offered the same amount of food. When comparing the amount of ingestible biomass it turned out that pillbugs contained 16% less digestible energy and, thus, the spiders on the pillbug diet may not be able to afford the energy required to produce high quality silk.

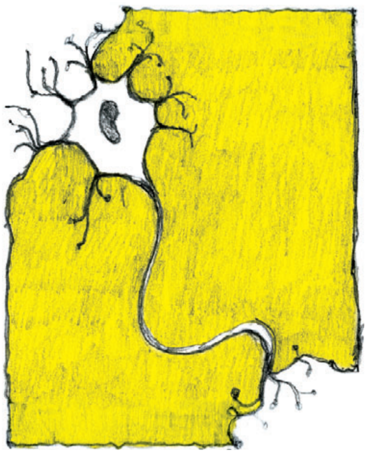
Based on their findings, Boutry and Blackledge offer two alternative, non-exclusive, hypotheses for the way that spiders may tune their silk to different prey types. House spiders may either spin silk threads in response to the physical deformation inflicted on their cobwebs by their prey or they may adjust silk composition and structure in response to their own body mass and body condition. For the spiders in our attics these new findings indicate that their cobweb quality depends on their diet, so if we starve them their webs may be weak and easier to brush aside. However, if you wish to encourage your local spider population you should probably consider feeding them properly.

10.1242/jeb.011684

Boutry, C. and Blackledge, T. A. (2008). The common house spider alters the material and mechanical properties of cobweb silk in response to different prey. *J. Exp. Zool.* **309A**, 542-552.

Teresa Valencak
Veterinary University Vienna
teresa.valencak@vu-wien.ac.at

PHEROMONE DETECTION



THE SMELL OF FEAR

For many of us, when faced with a dangerous situation, our first reaction might be to yell and scream or in some way vocally communicate the danger to others. However, unbeknownst to us, we are also likely communicating the danger in a more subtle way. Plants and animals have evolved a highly specialized mechanism for alerting their own kind to the presence of a predator, injury or stress. The distress signal is emitted in the form of airborne molecules known as alert pheromones. In mammals, the release of these pheromones is correlated with specific ‘alarm’ behaviour such as freezing, attacking or scattering. While this behaviour is well characterized and has often been observed, the source of the signal, the precise chemical and the sensory system used to detect the signal remain a mystery. A recent study from Julien Brechbühl, Magali Klaey and Marie-Christine Broillet from the University of Lausanne, published in *Science* in August 2008, characterized and identified a region of the mouse olfactory (smell) circuit that acts as the detection centre for alert pheromones and, as such, is the first step to initiating aversive behaviour.

A recently discovered subregion of the olfactory system named the Grueneberg ganglion, located right at the tip of the nose, contains a neuronal population with morphology and molecular components unique amongst olfactory neurons, suggesting that they possess distinct chemosensory functions. Using alert pheromones, isolated from other mice, the investigators used calcium imaging techniques together with behavioural analyses and found that this specialized neuronal population specifically responds to alert pheromones released from other members of the same species.

Calcium concentration within the cell body is commonly used as a measure of cell activation; when a cell is activated, the calcium level increases. Using fluorescent calcium dyes, so that rises in intracellular calcium can be imaged through special lenses on a camera, the authors found that the neurons in the Grueneberg ganglion were strongly activated when exposed to alert pheromones collected from other mice. Previous speculation about the function of the neurons in this region proposed an involvement in mother–pup recognition. However, these cells were unresponsive to either mouse milk or mammary secretions, nor did they respond to mouse urine or other known mouse pheromones other than alert pheromones. This indicates a specific role for sensing intraspecies stress signals.

Next, the authors performed behavioural experiments in which they surgically cut the neuronal projections from the cells in the Grueneberg ganglion thereby disabling their mode of communication. Normally, exposure to alert pheromones stimulates a freezing reaction in rodents but, in experimental animals with impaired signaling in the Grueneberg ganglion cells, exposure to alert pheromones elicited no such reaction and the animal was content to continue exploring.

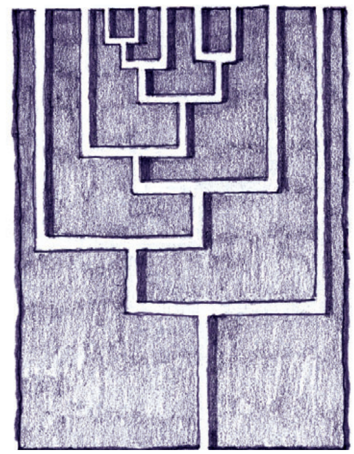
The authors concluded that neurons in this olfactory region are specialized to act as a warning system, dedicated to rapidly responding to stress signals. Pheromones are an integral form of communication in many diverse organisms but perhaps this tiny region at the tip of our nose has played a more important role in our survival as a species than we could ever have imagined.

10.1242/jeb.011726

Brechbühl, J., Klaey, M. and Broillet, M. C. (2008). Grueneberg ganglion cells mediate alarm pheromone detection in mice. *Science* **321**,1092-1095.

Sarah Hewitt
University of Calgary
sahewitt@ucalgary.ca

LUNG DEVELOPMENT



SIMPLE STEPS TO BUILDING A LUNG

Just as breathing is essential to life, a well-developed lung is needed for getting the oxygen from the air we breathe into the bloodstream. Our lungs are composed of millions of branching airway tubes, which form a bronchial tree that brings inspired air to the terminal gas exchange units called alveoli. Perhaps due to this organ’s complexity, the series of developmental events that create lungs were not well understood. However, Ross Metzger and colleagues from Stanford University hypothesized that a simple pattern may underlie this complexity, and decided to examine how airways develop in the lungs of mice.

Lung development cannot be visualized in living embryos, so the authors decided to examine the pattern of airway branching in fixed embryos under the microscope. In doing so, they realized that the bronchial tree contains only three unique types of branching, which they called domain branching, planar bifurcation and orthogonal bifurcation. In domain branching, multiple daughter branches form in rows stemming from a single parent branch, like the rows of bristles on a bottle brush. Planar bifurcation occurs when a parent branch splits into two daughter branches, which can themselves split, and all the branching occurs in a single two-dimensional plane. Orthogonal bifurcation is similar to planar bifurcation, except that each successive split occurs at right angles to the one before it. The highly complex lung is therefore generated by just three simple modes of branching!

The next question was how the developmental sequence of these three types of branching determines the overall lung structure. Metzger and colleagues reconstructed the branching sequence by observing embryos at multiple developmental stages. They found that the three branching modes occurred in a remarkably consistent and stereotyped manner: there were only three specific sequences, each containing seven or more series of branching modes. Domain branching is generally used first in the sequence to create the overall shape of the lungs, followed by planar bifurcation to form the thin edges between different lobes and orthogonal branching to fill the interior.

Because the programme of lung development is simple and stereotyped, this process may be controlled by a relatively small number of genes. As a first step towards finding the genes that control lung development, the authors examined how the development programme is altered in mouse strains with lung defects. Knocking out one gene, called *sprouty 2*, increased the number of branches within the domains in some regions of the lung, so this gene may normally control domain branching. Disruption of other genes altered the stereotyped branching sequence or had global effects on overall lung design.

The meticulous work of Metzger and colleagues suggests that the complexity of the lung is based on a simple developmental pattern. With this new detailed information, a much better understanding of the molecular and genetic basis for lung structure is within reach. Although much has yet to be discovered, these authors have added a breath of fresh air to the topic of how lungs develop.

10.1242/jeb.011700

Metzger, R. J., Klein, O. D., Martin, G. R. and Krasnow, M. A. (2008). The branching programme of mouse lung development. *Nature* **453**, 745-750.

Graham R. Scott
University of British Columbia
scott@zoology.ubc.ca

STRIDULATORY SWEET SOMETHINGS

A warm summer night in many places is often accompanied by a symphony of insect songs and calls. The chirps of crickets and the buzz of katydids are usually made by a process known as stridulation where the insect scrapes a ‘pick’ across a series of ridges on its body. Male insects use sounds to announce their presence, their species and their abiding interest in mating. But, with a boisterous song comes the risk of attracting unwanted attention from rival males, predators or parasites. Now, researchers have found a secret world of quiet stridulatory communication occurring privately between mating moths. The sound is imperceptible to the human ear, hardly traveling beyond its recipient, and is picked up by the insect’s highly specialized tympanic ear. Ryo Nakano at the University of Tokyo and his colleagues in Japan and Denmark have discovered that the male Asian corn borer moth, *Ostrinia furnacalis*, makes low-intensity ultrasound at frequencies beyond human hearing by rubbing specialized scales on the wing and thorax together. By doing this the males suppress the escape behavior of otherwise skittish females.

According to Nakano and his colleagues, butterflies and moths usually employ several structures to make sounds – such as stridulation scraping of leg spurs across thickened wing veins, and percussive wing clapping – but none of the previously known means of sound production are found in *O. furnacalis.* Nakano and his colleagues first recorded vibrations generated by the male moth and realized that the insect was emitting sounds in the ultrasound range of frequencies. Having recorded the sounds, the team searched for their source and discovered sex-specific scales on the male’s forewing that rub against similar scales on the thorax. These had not been noticed before, because the sex-specific scales are hidden when the moth is at rest. Scanning electron micrographs that the team gathered show that the morphology of the scales is different from that of ordinary scales on the moth’s body, with ridges that are significantly thicker and more narrowly spaced. Removing the sex-specific scales reduced the level of ultrasound considerably, and the insects’ mating success decreased as well, indicating the importance of these ultrasonic whispers.

Using high-speed videography and recordings of courting pairs, the team showed that the ultrasound pulses generated by the males correspond with the vibrations of the forewings. The wings also move faster than they do in flight, suggesting that this mode of communication, though subtle, is energetically costly. And finally the team showed that the right and left wings never touch each other, but contact the region of the thorax coated in the specialized scales.

Having discovered this novel stridulatory behavior*,* the authors checked courting behavior in other moth families and found that they also detect ultrasonic noise above the background level.

This work adds ‘ultrasonic production’ to the varied functions of moth scales and will likely lead others to find similar cryptic systems among singing insects. The tympanic ear, once tuned to help the insect avoid predators, is now used in more intimate conversations.

10.1242/jeb.011718

Nakano, R., Skals, N., Takanashi, T., Surlykke, A., Koike, T., Yoshida, K., Maruyama, H., Tatsuki, S. and Ishikawa, Y. (2008). Moths produce extremely quiet ultrasonic courtship songs by rubbing specialized scales. *PNAS* **105**, 11812-11817.

Stan Rachootin and April Dinwiddie
Mount Holyoke College
srachoot@mtholyoke.edu