© 2014. Published by The Company of Biologists Ltd | The Journal of Experimental Biology (2014) 217, 3387-3388

INSIDE JEB

Harvestmen use glue to catch their dinner

Glue droplets on the pedipalps of a harvestman. Photo credit: Axel Schönhofer.

A few years ago, Jonas Wolff stumbled across a high-definition photograph of a harvestman on the internet and was puzzled by the arachnid's pedipalps; they were covered in hairs carrying tiny droplets of fluid at their tips. 'It [the harvestman] reminded me of a carnivorous plant, the sundew, which uses sticky tentacles to capture insects', he recalls. Papers dating back a century suggested that the arachnids might use their sticky organs to capture small soil-dwelling arthropods, like springtails. Wolff teamed up with Clemens Schaber and Stanislav Gorb, at the Christian Albrecht University of Kiel, and Axel Schönhofer, at the Johannes Gutenberg University Mainz, Germany, to show how these secretions can trap prey (p. 3535).

First, they took a close look at harvestmen eating. Schönhofer, a harvestman expert, helped Wolff collect several species and their springtail prey. Placing the animals in plastic dishes, Wolff filmed them using a high-speed video camera to find out how the harvestmen attack. Fortunately, one species (*Mitostoma chrysomelas*) obliged and Wolff recorded 38 instances where harvestmen used their sticky pedipalp secretions to glue their prey, half of which resulted in a meal for the harvestmen. 'This species successfully attacked springtails larger than themselves', Wolff says. And the unlikely predators' spindly legs also help them to capture prey. Wolff explains that springtails can generate high forces using a special jumping organ, the furca, which works like a spring, when trying to escape, and the harvestmen's ungainly build seems to help them absorb collisions. 'On high-speed video, you can see that the harvestman works like a wobbly wire ball buffering the strong impacts', he explains.

Next, the team tested the adhesive properties of the secretions, which was tricky, because the pedipalp hairs are tiny. Working with Schaber, Wolff constructed a very fine glass pipette tip with a microscopic glass bead at the end to use as a force sensor. The duo carefully mounted a pedipalp on to a table that could be moved in minute increments in three dimensions, attached a single pedipalp hair to the glass bead and then pulled the pedipalp back at different speeds while measuring the pipette tip's deflection with high-speed video. They found that the adhesive force of just a single hair was sufficient to hold the body weight of an average springtail. Wolff was also excited to find that, the faster they pulled the pedipalp away, the stronger the droplet's attachment force was. 'This shows that the secretion is a non-Newtonian fluid', he explains. 'It behaves like a solid under high impact, like corn starch solutions.' So, the more the prey struggles, the more stuck it gets: 'A deadly trap', Wolff concludes.

Wolff also adds that attaching glue to a springtail is not a trivial feat, as their cuticles are covered in complex microstructures that repel liquids and should prevent glue from taking hold. To investigate whether harvestman secretions can wet a springtail's cuticle, Wolff used liquid nitrogen to snap freeze harvestmen glued to springtails and then used cryo scanning electron microscopy to see how the secretion spread. To his surprise, he saw that the secretion completely wets the springtail cuticle, allowing the glue to get a grip.

The team concludes that harvestman pedipalp secretions are used as a sticky trap for prey, and notes that their viscoelastic properties closely mirror those of spider capture threads and insect-trapping plants. 'This convergence is exciting, and suggests that viscoelastic solids are an effective, and presumably highly economic, means of prey capture,' Wolff concludes.

doi:10.1242/jeb.114041

Wolff, J. O., Schönhofer, A., Schaber, C. F. and Gorb, S. N. (2014). Gluing the 'unwettable': soil-dwelling harvestmen use viscoelastic fluids for capturing springtails. *J. Exp. Biol.* **217**, 3535-3544.

Yfke Hager

for mutation produces voracious maize pests

Sesamia nonagrioides larvae feeding inside a young maize cob. Photo credit: Jean-François Silvain.

Munching their way through ears and stems of maize, the larvae of the cereal stem borer (*Sesamia nonagrioides*) harm maize harvests from southern Europe to sub-Saharan Africa. 'The level of damage inflicted on a crop by an agricultural pest species depends on the pest's ability to colonise the field area', says Laure Kaiser and colleagues from the Institut de Recherche pour le Développement (IRD) at CNRS of Paris Sud, Gif sur Yvette, France. So, understanding the molecular mechanisms of how an insect seeks out food is an essential step in the ongoing war between agriculture and hungry pests. Explaining that one gene, *for*, which encodes a cGMP-dependent kinase (PKG) in *Drosophila*, has been shown to play a crucial role in that insect's foraging behaviour, Kaiser and her colleagues decided to investigate whether the same gene could be identified in the cereal stem borer and whether it lies at the heart of the pest's voracious appetite (p. 3465).

Knowing the sequence of the *for* gene in a few other moth species, the team was able

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.

to identify the gene in the larvae of the cereal stem borer and build a family tree showing that the gene is extremely similar to *for* genes in other closely related moth species. The team then compared the *for* gene sequences of 15 individual larvae and found one point mutation in some of the larvae, which substitutes a serine amino acid for a glycine in the protein sequence. And when they identified the location of the mutation in the PKG protein encoded by the gene, they found that it occurred in the region that regulates cellular functions.

Having confirmed that the *for* gene exists in the maize pest, Floriane Chardonnet then tested how the protein that is encoded by the gene affects larval behaviour. Using a drug that activates the *for* gene's PKG protein, Chardonnet monitored how often larvae that had been fed low levels of the drug foraged and moved between two plates of food. She found that these larvae foraged much more than the larvae that had not received the drug. The team also tested how the mutation in the protein affected the larvae's behaviour and found that the larvae that had two copies of the serine mutation switched between the plates of food more than larvae that had only one copy of the serine mutation or no copies. They point out that this is similar to the behaviour patterns found in *Drosophila*, where flies carrying one form of the *for* gene (rovers) roam between well-stocked plates of food when food is plentiful. When food is scarce, rovers also fare better than flies that carry the other form of the gene, known as sitters, which remain stationary while eating.

doi:10.1242/jeb.114033

Chardonnet, F., Capdevielle-Dulac, C., Chouquet, B., Joly, N., Harry, M., Le Ru, B., Silvain, J.-F. and Kaiser, L. (2014). Food searching behaviour of a Lepidoptera pest species is modulated by the foraging gene polymorphism. *J. Exp. Biol.* **217**, 3465-3473.

Kathryn Knight

High carb diet alters trout metabolism in later life

Rainbow trout (*Oncorhynchus mykiss*). Photo credit: S. Kamalam.

Thanks to the aquaculture revolution, fish such as trout and salmon are no longer a luxury available to the wealthy alone. However, modern cultivation techniques require that we plunder the oceans to provide the fish-oil and -protein diet that sustains output. 'In order to improve the sustainability of the aquaculture production for trout (and other farmed fish), it is essential to develop alternative aquafeeds', say Stephane Panserat and colleagues from the INRA and IFREMER in France. Intrigued by the possibility of developing new carbohydrate-rich fish diets to wean the industry off its dependence on marine fish stocks, the team decided to find out whether the diet experienced by trout larvae could alter their metabolism in later life – in much the same way as adult mammals benefit from the effects of early diet. Could he convert trout that utilise carbohydrates poorly into animals that thrive on a carbohydrate-rich diet by feeding them carbohydrates when young (p. 3396)?

Supplying trout larvae with a high or low carbohydrate diet for 5 days, the team then switched the fish back to a commercial trout feed diet for 100 days before testing their responses to a high carbohydrate diet (28%).

Although the team found alterations in glucose metabolism in the livers of the young fish – known as alevins – that allowed them to process carbohydrates, these changes were not carried through into the juveniles. And when they tested glucose metabolism in the muscles of the juvenile fish, they found that the fish that had been fed a high carbohydrate diet in early life had altered their glucose metabolism, but, paradoxically, the change had left them less able to use glucose as a muscle fuel. The team also tested the effect of the high carbohydrate diet on the gut flora of the fish and found changes in the fungi in the larvae's intestines. Considering the results together, the team concludes that dietary reprogramming is possible, but more work needs to be done to understand the mechanisms of change.

doi:10.1242/jeb.114058

Geurden, I., Mennigen, J., Plagnes-Juan, E., Veron, V., Cerezo, T., Mazurais, D., Zambonino-Infante, J., Gatesoupe, J., Skiba-Cassy S. and Panserat, S. (2014). High or low dietary carbohydrate: protein ratios during first-feeding affect glucose metabolism and intestinal microbiota in juvenile rainbow trout. *J. Exp. Biol.* **217**, 3396-3406.

Kathryn Knight
kathryn@biologists.com