FINDING OUT WHY FROGS' FEET STICK

Tropical tree frogs owe their adhesive ability to a 'Dutch' principle, Van der Waals forces, says PhD candidate Julian Langowski.

How is it possible that tree frogs seem to climb effortlessly and can even hang upside down on wet surfaces? Langowski has gone some way to solving the mystery. He recently got his PhD with distinction in the Experimental Zoology group. The doctoral student mainly focused on the subcutaneous structures of the frogs' adhesive toe pads, about which very little was known. 'The surface of the pads is where the interaction with the substrate takes place,' says Langowski. 'But what also matters is how the adhesive surface is connected to the rest of the animal.'

A layer of connective tissue that links the epidermis of the pads to the frog's finger bones turned out to be crucial. This connective tissue appears to be oriented in such a way that it helps the pads to cope with the frictional forces that act on a frog on a vertical surface. According to Langowski, this is an important indication for the adhesive mechanism.

The skin of tree frogs is covered in mucus. Until now, the adhesive capacity of tree frogs' feet was mainly attributed to wet adhesion, in which capillary action plays an important part. The surface structure of the adhesive pads seems to support this assumption at first glance. The pads consist of a pattern of small hexagonal pillars (10 micrometres in diameter), which in turn are covered with pillars at the nanoscale (0.3 micrometres).

'The morphology of the foot indicates a significant role for Van der Waals forces'

The spaces between the pillars, which are filled with mucus, ensure a capillary effect and thus adhesion. But such capillary forces only act perpendicular to the surface. That does not fit with the subcutaneous collagen that seems to help take up the vertical forces parallel to the surface. Van der Waals forces, weak electromagnetic forces between atoms or molecules that are named after the Dutch Nobel Prize winner Johannes Diderik van der Waals, can explain the orientation of the collagen. Langowski: 'I am not implying that wet adhesion does not occur, but the morphology of the foot indicates a significant role for Van der Waals forces.' From that viewpoint, the pillars serve as a drainage structure. 'When the frog sets its the foot down, the layer of mucus is squeezed out through the channels between the pillars, to allow as close contact with the substrate as possible.'

The idea is that the study of tree frog feet will lead to new materials and instruments, for example for surgeons and robots with grippers. RK

▲ Wet adhesion cannot fully explain the adhesive capability of frogs' feet, says PhD candidate Julian Langowski.

PHOTO: SHUTTERSTOCK